U.S. NUCLEAR REGULATORY COMMISSION

FINAL SAFETY EVALUATION FOR

TOPICAL REPORT WCAP-15942-P-A/WCAP-15492-NP-A,

SUPPLEMENT 1, REVISION 1, "MATERIAL CHANGES FOR SVEA-96

OPTIMA2 FUEL ASSEMBLIES" (EPID: L-2018-TOP-0032)

WESTINGHOUSE ELECTRIC COMPANY

1.0 INTRODUCTION

By application dated September 9, 2010, Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-15492-P-A/WCAP-15942-NP-A, Supplement 1, Revision 0, "Material Changes for SVEA-96 Optima2 Fuel Assemblies" (Ref. 1) to the U.S. Nuclear Regulatory Commission (NRC) for review and approval. This supplement describes the introduction of Low Tin ZIRLO^{TM} as an alternative material for the outer channel and the watercross of the SVEA fuel channel. Also, the end plug material is extended to include **[** **]** The information in the TR was supplemented by letter dated August 29, 2012, which contained responses to the NRC staff's request for additional information (RAI) and a revision to the original TR – Revision 1 (Ref. 2). In addition to making changes based on RAI responses, this revision also describes the difference in mechanical properties of Low Tin ZIRLO compared to the currently used Zircaloy-2 channel material and the resulting difference in mechanical design analysis compared to the original submittal.

A closed audit was held on September 30 through October 2, 2014, to discuss, in part, the revised TR and gather more information regarding the surveillance plan. Westinghouse provided the requested information via letter dated July 16, 2015 (Ref. 4). Because the TR was revised during this review, this safety evaluation (SE) will focus on the technical suitability of Revision 1 (Ref. 3). Each of the RAI questions and the questions from the audit will be discussed in this SE. The NRC staff was assisted in its review by Pacific Northwest National Laboratory (PNNL), and its report contained the evaluation on the acceptability of Optima2 fuel design for batch application.

By letter dated June 13, 2016 (Ref. 6), Westinghouse requested the NRC to suspend its review of the TR for 24 months in order to enable Westinghouse to submit additional irradiation test data. Westinghouse believed that this additional effort will support its goal of broadening the applicability of the previous version of the draft SE associated with the TR under review. On July 1, 2016, the NRC issued a suspension of the review letter (Ref. 6). By letter dated June 13, 2018 (Ref. 8), Westinghouse requested a continuation of the NRC review of WCAP-15942-P/NP-A, Supplement 1, Revision 1. Along with this letter, Westinghouse submitted proprietary and non-proprietary versions of the slides to support its request for continuation of review of this TR. The slides were presented to the NRC staff at the pre-submittal meeting to discuss restart of the review held on June 14, 2018 (Ref. 8).

As a follow-up to Reference 8, Westinghouse submitted two appendices to Reference 3, Appendix 1 to WCAP-15942-P-A, "Effects of Corrosion on Mechanical Design Analyses of Low Tin ZIRLO Channels," and Appendix 2 to WCAP-15942-P-A, Supplement 1, Revision 1, "Operation Limits on Low Tin ZIRLO Channels" (Ref. 9). The NRC staff reviewed Appendices 1 and 2 and made appropriate changes to the conditions and limitations contained within the previous draft SE.

The previous draft SE is revised to reflect the submitted appendices containing supplemental information to the revised TR and the appropriate changes were made to the conditions and limitations.

2.0 REGULATORY EVALUATION

The NRC staff used the guidance of Standard Review Plan (SRP), NUREG-0800, Section 4.2, "Fuel System Design," to review WCAP-15942-P-A, Supplement 1, Revision 1. SRP Section 4.2 acceptance criteria are based on meeting the requirements of General Design Criteria (GDC)-10, GDC-27, and GDC-35 of Appendix A of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50.

GDC-10 states:

> The reactor core and associated coolant, control, and protection systems shall be designed with the appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

GDC-10 establishes specified acceptable fuel design limits to ensure that the fuel is not damaged. This means that fuel rods do not fail, fuel system dimensions remain within operational tolerances, and functional capabilities are not reduced below those assumed in the safety analysis.

GDC-27 states:

> The reactivity control systems shall be designed to have a combined capability, in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained.

This means that the reactivity control system is designed with appropriate margin and, in conjunction with the emergency core cooling system, is capable of controlling reactivity and cooling the core under post-accident conditions.

GDC-35 states:

> A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that (1) fuel and clad damage that could interfere with continued effective core cooling is prevented, and (2) clad metal-water reaction is limited to negligible amounts.

In accordance with SRP Section 4.2, the objectives of the fuel system safety review are to provide assurance that:

- The fuel system is not damaged as a result of normal operation and anticipated operational occurrences (AOOs),
- Fuel system damage is never so severe as to prevent control rod insertion when it is required,
- The number of fuel rod failures is not underestimated for postulated accidents, and
- Coolability is always maintained.

The main focus of the SRP guidance with respect to boiling water reactor (BWR) fuel bundle channels is control blade interference and insertability. SRP Section 4.2.II.1.A.v states:

> Control blade/rod, channel, and guide tube bow as a result of (1) differential irradiation growth (from fluence gradients), (2) shadow corrosion (hydrogen uptake results in swelling), and (3) stress relaxation, which can impact control blade/rod insertability from interference problems between these components. For BWRs, the effects of shadow corrosion should be considered for new control blade or channel designs, dimensions (e.g., the distance between control blade and channel is important), or materials. The effects of channel bulge should also be considered for interference problems for BWRs. Design changes can alter the pressure drop across the channel wall, thus necessitating an evaluation of such changes. Channel material changes can also impact the differential growth, stress relaxation, and the amount of bulge and therefore must be evaluated. If interference is determined to be possible, tests are needed to demonstrate control blade/rod insertability consistent with assumptions in safety analyses. Additional in-reactor surveillance (e.g., insertion times) may also be necessary for new designs, dimensions, and materials to demonstrate satisfactory performance.

With respect to control blade insertability under externally applied loads, such as, safe shutdown earthquake and loss-of-coolant accident, SRP 4.2 Appendix A, Section IV states:

> For a BWR, several conditions must be met to demonstrate control blade insertability—(1) combined loads on the channel box must remain below the allowable value defined above for components other than grids (otherwise, additional analysis is needed to show that the deformation is not severe enough to prevent control blade insertion) and (2) vertical liftoff forces must not unseat the lower tie plate from the fuel support piece such that the resulting loss of lateral fuel bundle positioning could interfere with control blade insertion.

It is to be noted that the NRC staff requested that Westinghouse provide information on the seismic evaluation that showed the impact of using Low Tin ZIRLO channels. Westinghouse responded that the channel design is not evaluated for seismic loads in this TR but is done on a plant specific basis using another approved methodology. Therefore, the impact of using Low Tin ZIRLO channels on the seismic evaluation is addressed by Condition and Limitation #2 in Section 5.2, “Conditions and Limitations,” of this SE.

The NRC staff's review of WCAP-15942-P-A, Supplement 1, Revision 1, ensures that the introduction of Low Tin ZIRLO does not adversely impact the ability of existing BWR channel designs to satisfy the above requirements.

3.0 TECHNICAL EVALUATION

This SE summarizes the NRC staff's review of TR WCAP-15942-P-A, Supplement 1, Revision 1, and includes the following items:

- Verification that the fuel channel design requirements and guidelines are consistent with the regulatory criteria identified in Section 4.2 of SRP and 10 CFR Part 50 Appendix A.
- Verification of material composition and properties of SVEA-96 Optima2.
- Verification of the changes made to the methodologies used to evaluate component performance.
- Verification of compatibility with other fuel types and reactor internals with respect to the new materials in Optima2.
- Definition of the range of applicability and allowed manufacturing tolerances.
- Definition of future surveillances and reporting requirements.
- NRC conclusions, limitations, and conditions.

3.1 Boiling Water Reactor Channel Design Requirements

One of the design requirements for BWR channels under normal operating conditions is that the control blade interference due to combined effects of channel bow and creep will be sufficiently low during the life of the fuel bundle to ensure with high confidence the maximum SCRAM insertion times for operable rods given in the technical specifications are not exceeded.

3.2 Optima2 Composition and Microstructure

Section 2.5 of Reference 1 describes the material composition of Low Tin ZIRLO fuel channel for BWR fuel assemblies. **[ ]**

Zircaloy-2 is a currently approved material that has specifications in American Society for Testing and Materials for B 811. **[ ]**

[ ] The Kearns texture factor are widely used for quantifying texture information of hexagonal materials such as zirconium-based alloys as structural materials in the nuclear industry.

Section 2.2.2 of References 1 and 3 lists the **[**

] These differences in the texture factors will be discussed in Section 3.4 of this SE.

3.3 Material Properties of Low Tin ZIRLO

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The **[**

] were used in the stress analyses discussed in Section 3.5.5 of this SE. Westinghouse provided discussion of how the **[**
] The NRC staff agrees with this assessment and finds the use of the appropriate **[**
] for Low Tin ZIRLO acceptable.

[ ]

Westinghouse uses a **[**

] in Low Tin ZIRLO. The original TR (Revision 0) did not present much justification for this statement, but the NRC staff asked a number of questions (RAI-3, RAI-6, and audit question 6) that requested more justification for this claim.

Westinghouse provided responses that are discussed in detail in Section 3.5.1. Based on the data provided and the surveillance plan that will be discussed in Section 4.0 of this SE, the NRC staff agrees with the assessment that the use of the **[ ]** will be conservative for Zircaloy-2 and Low Tin ZIRLO.

Growth and Bow

Westinghouse made the claim that the channel growth will be lower for Low Tin ZIRLO than for Zircaloy-2 channels. **[**
] Revision 0 of the TR did not present much justification for this statement, so the NRC staff requested more justification for this claim (RAI-3, RAI-5, and RAI-7). Westinghouse provided responses that will be discussed in detail in Section 3.5.1. Based on the data provided and the surveillance plan that will be discussed in Section 4.0 of the SE, the NRC staff agrees with the assessment that the use of **[ ]** value will be conservative for Zircaloy-2 and Low Tin ZIRLO.

Bow is primarily controlled by growth and the differential neutron fluence on the sides of the channel next to a control blade and away from a control blade. As with growth, Westinghouse made the claim that the channel bow will be lower for Low Tin ZIRLO than for Zircaloy-2 channels. **[**

] Revision 0 of the TR did not present much justification for the statement that channel bow will be lower for Low Tin ZIRLO than Zircaloy-2 channels, but the NRC staff requested more justification for this claim (RAI-3, RAI-8, and audit question 7). Westinghouse provided responses that will be discussed in detail in Section 3.5.1. Based on the data provided and the surveillance plan that will be discussed in Section 4.0 of this SE, the NRC staff agrees with the assessment that the use of **[**
] of the Zircaloy-2 and Low Tin ZIRLO will be acceptable for Zircaloy-2 and Low Tin ZIRLO.

Corrosion

For the analyses that require the corrosion of the channel, Westinghouse uses **[**

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The original TR (Ref. 3) did not present much justification for these values, but the NRC staff requested more justification for these values (RAI-3, and more material in the audit). Westinghouse provided a response to this RAI. Westinghouse also submitted the appendices (Ref. 9) that contain **[**

] The latest results from Reference 9 will be discussed in detail in Section 3.5.8. Based on the data provided and the surveillance plan that will be discussed in Section 4.0 of this SE, the NRC staff agrees with the assessment that the use of **[** **]** will be acceptable for Zircaloy-2 and Low Tin ZIRLO.

[**]**

The NRC staff asked in RAI-1, what the primary benefit of Low Tin ZIRLO over Zircaloy-2 was for channel material. Westinghouse responded that the advantage was the **[**

] The NRC staff finds these values acceptable for Low Tin ZIRLO.

3.4 Material Properties of **[ ]**

Corrosion Resistance

Historically, end plugs were made from β-quenched Zircaloy-2 to improve the nodular corrosion. However, with modern advances in composition control and control of second phase precipitate size and distribution, it has been possible to get good nodular corrosion from **[**

]

Growth

Westinghouse acknowledged that the growth of **[**

] The NRC staff agrees with this assessment.

3.5 Component Performance and Methodology

This section evaluates the changes made to the methodologies that will be used to assess component performance to account for the introduction of the new material presented in the TR. Westinghouse states that the **[**

] PNNL and the NRC staff evaluated the Westinghouse's methodology that assesses the component performance. The NRC staff finds this methodology to be acceptable for the proposed application.

The methodology and application for fuel assembly components was changed with the introduction of these new materials. The largest change is due to the fact that Low Tin ZIRLO sheet material has a **[**

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The following sections discuss these changes in detail and provide an evaluation of the acceptability of these changes for the introduction of the new material presented in the TR.

3.5.1 Compatibility with Other Fuel Types and Reactor Internals

Even though conclusions regarding compatibility are unchanged from those in the original submittal (Ref. 7), the sections listed below have been updated in the latest submittal (Ref. 3):

- Methodology for creep deformation
- General sample application
- Sample application for channel bulge
- Sample application for channel bow
- Compatibility with storage positions

This section discusses each of the above listed items.

Methodology for Creep Deformation

Westinghouse states that it will apply its generic cladding creep model for either Zircaloy-2 or Low Tin ZIRLO channels. In the response to RAI-3, Westinghouse stated that for cladding material **[**

] Based on the information presented, the NRC staff agrees that this approach is acceptable.

General Sample Application

This section of the TR discusses the geometric compatibility with other non-SVEA assemblies. Westinghouse states that the **[**

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The NRC staff has determined that the **[** **]** is conservative for Zircaloy-2 and Low Tin ZIRLO channels, and that the general sample application is acceptable.

Sample Application for Channel Bulge

This section of the TR gives a sample calculation of channel bulge. **[** **]** The NRC staff finds this sample application and the models applied to be acceptable.

Sample Application for Channel Bow

This section of the TR gives a sample calculation of channel bow. Channel bow is caused by differential growth between opposite sides of the channel. Differential growth is caused by lower neutron fluence and **[** **]** on the channel side adjacent to the control blade relative to the opposite side where no control blade is present. Because Low Tin ZIRLO has less growth than Zircaloy-2, it is expected that it will also have less channel bow. Westinghouse provided data from symmetric lattice plants in response to RAI-3 that demonstrate that Low Tin ZIRLO channels have equivalent or lower bow than Zircaloy-2 channels. Westinghouse also provided data from asymmetric lattice plants that demonstrate that Low Tin ZIRLO channels have equivalent or lower bow than Zircaloy-2 channels. Therefore, the use of **[** **]** is conservative for Low Tin ZIRLO channels.

In response to RAI-8, Westinghouse stated that its channel bow methodology uses **[** **]** The NRC staff finds this sample application and the models applied to be acceptable.

Compatibility with storage positions

This section of the TR discusses the analysis performed to confirm geometric compatibility with storage facilities. Due to the fact that that sample application for **[** **]**

The sample calculation showed sufficient margin between the **[** **]** and the allowed storage space. The NRC staff finds this acceptable.

3.5.2 Geometric Changes in the Assembly during Operation

No changes were made to this analysis for the introduction of the new material presented in the TR from Reference 7. The NRC staff finds this acceptable.

3.5.3 Transport and Handling Loads

[**]** The methodologies for evaluating the shipping and handling loads have not changed. In addition, the sample evaluation of response to shipping loads has not changed because the [ ]

[ ]

PNNL and the NRC staff evaluated the transport and handling of loads for the Optima2 fuel design. The NRC staff finds the evaluation acceptable.

3.5.4 Hydraulic Lifting Loads during Normal Operating and AOOs

There are no changes made to this analysis for the introduction of the new material presented in the TR (Refs. 3 and 7). The NRC staff finds this acceptable.

3.5.5 Assembly Stress and Strain during Normal Operation and AOOs

Revision 0 of the TR (Ref. 1) used the Zircaloy-2 strength specification for all the sample evaluations. The NRC staff noted that [ ] the channel stress and strain analyses for normal operation and AOOs involving cases of channel overpressure (RAI-11). Westinghouse responded by issuing Revision 1 of the TR that describes the [ ] This method will be used when evaluating the channel stress and strain due to internal overpressure during normal operation and AOOs.

Revision 1 of the TR (Ref. 3) does not contain enough information about the FEMs or analysis methodology to determine if the models meet the requirements of the SRP in regard to design bases or design evaluation. In order to get details of the sophisticated finite element analysis (FEM), the NRC staff decided to conduct an audit that provided reviewers with interactive access to the models and results. A closed audit was conducted on September 30, 2014, to October 2, 2014 (Ref. 6).

Prior to the audit, an FEM model was constructed by the reviewers using linear-elastic methods and geometry information provided in the TR to estimate the stress levels. The preliminary estimate was that stresses could exceed typical ASME code stress limits, but more precise geometric data was needed to perform a full confirmatory analysis. The necessary geometric information was provided to the review team at the audit through access to the design drawings (audit question 1, Refs. 4 and 6). Ultimately, an independent confirmatory analysis was not performed in this review because the audit resolved all questions regarding the model and analysis methodology.

The channel collapse analysis model was reviewed interactively at the audit by the review team. It was established that Westinghouse's intent was to perform analysis to demonstrate compliance with ASME Boiler and Pressure Vessel Committee (BPVC) design criteria, not to propose a novel design criterion (audit question 2). Westinghouse's choice of location to define the limiting load-deflection relationship was found to be reasonable. The high stress location selected for fatigue evaluation was not a candidate for collapse load evaluation due to the influence of the surrounding geometry. The location of the channel section selected for analysis was found to be appropriate. In summation, all questions raised about specific analysis choices were found to be reasonable and in compliance with ASME code rules.

The NRC staff finds that Westinghouse's analyses demonstrate compliance with ASME BPVC NB-3000, which defines rules for the design of Class 1 components. Therefore, design bases and design evaluation for mechanical loads are found to be acceptable.

3.5.6 Fatigue of Assembly Components

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The NRC staff finds the evaluation and results for fatigue of assembly components appropriately accounts for all changes in parameters resulting from use of the Low Tin ZIRLO material, and therefore, acceptable.

3.5.7 Fretting Wear of Assembly Components

There are no changes made to this analysis for the introduction of the new material presented in the TR (Refs. 3 and 7). The NRC staff finds this acceptable.

3.5.8 Corrosion of Assembly Components

The sample application of corrosion of assembly components has been updated from Reference 7. Four areas are identified where the potential for corrosion must be specifically addressed. These areas are:

- Zircaloy-2 fuel rod cladding and end plugs.
- Zircaloy-2, Zircaloy-4, or Low Tin ZIRLO fuel channels,
- Spacer capture head weld, and
- Spacer.

The only areas that are impacted by the introduction of these new materials are the Zircaloy-2 end plugs, spacer capture heads, and the Low Tin ZIRLO fuel channels.

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Appendix 1 of Reference 9 provides a summary of the effects of recently measured, [

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The NRC staff finds this sample application and the [
] to be acceptable.

3.5.9 Hydriding of Zirconium Assembly Components other than Fuel Rods

Westinghouse updated the sample calculation with information on Low Tin ZIRLO. This section of the SE has been updated with Zirconium based components and materials replacing Zircaloy components and materials.

Reference 3 lists the measures taken by Westinghouse to [

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[

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The NRC staff agrees that if **[ ]** was an acceptable limit for Zircaloy-2 channels, then it is an acceptable limit for Low Tin ZIRLO channels. The NRC staff also agrees that the proposed hydrogen pickup fractions are acceptable for Low Tin ZIRLO.

3.5.10 Operational Limits on Low Tin ZIRLO Channels

Appendix 2 of Reference 9 presents a performance evaluation of Low Tin ZIRLO material channels using data that were obtained subsequent to the Reference 3 data and in response to RAI-1, -2, and -3. Based on the additional performance experience, operating limits for the Low Tin ZIRLO channels are to provide greater operational flexibility in terms of control rod presence, represented in total inch-days. Westinghouse requested to replace the term Effective Control Blade Exposure (ECBE) in the draft SE to the term “total inch-days.” Inch-days is termed as the unit for measuring the total exposure of control rod operation adjacent to fuel channels and is the integral value of inserted control blade length (inch) multiplied by the time of exposure (days). The ECBE value will be less than the corresponding inch-day value for a given operating condition if a channel was exposed to a control blade in the second, and/or third cycle of operation.

The proposed operating limit results from channel inspections and performance evaluation of Low Tin ZIRLO channels are presented in Appendix 2 of Reference 9. These operating limits include equivalent channel exposure, residence time and control blade exposure. These values are listed in Section 5.0 of this SE.

The NRC staff has reviewed the results and determined that the operational limits on Low Tin ZIRLO channels is acceptable, subject to limitations and conditions stipulated in Section 5.0 of this SE.

4.0 SURVEILLANCE PLANS

Westinghouse did not propose any additional surveillance in Reference 4 beyond what was in the original TR. Westinghouse did mention prototype testing that is updated for the addition of Low Tin ZIRLO channels. These include:

[

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The NRC staff asked in RAI-4 that Westinghouse provide a description of plants with lead test assemblies (LTAs) as well as subsequent plants with LTAs that have been limiting in terms of channel corrosion, growth and/or bow. Westinghouse responded with a table showing plants and conditions that LTA quantities of Low Tin ZIRLO have been delivered. Westinghouse stated that additional inspections will be performed to verify Low Tin ZIRLO channel performance in different operating conditions and environments (Ref. 2). The NRC staff finds this LTA experience acceptable.

In the audit plan for the regulatory audit conducted on September 4 through October 2, 2014, the NRC staff asked Westinghouse to provide a surveillance plan. Westinghouse provided a table that lists a summary of inspections that have been performed and are planned to be performed inspection at high burnup. The table indicated that two inspections were completed, and data would become available in September 2015, with five inspections to be completed in 2015, 2016, and 2017 respectively. Westinghouse also provided plots of **[**

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On August 25, 2015, Westinghouse informed the NRC staff about an issue regarding its inability to take channel bow measurements to provide the surveillance plan (Ref. 5) for the second cycle as outlined in the surveillance plan provided to address an audit item in letter LTR-NRC-15-65 (Ref. 4). Westinghouse indicated that it will submit a revised surveillance plan that omits channel bow measurements, but Westinghouse also stated that it will continue to take the identified measurement of the data for Cycle 3 as specified in Condition and Limitation 4 in Section 5.2, “Conditions and Limitations,” of this SE.

5.0 CONCLUSIONS, CONDITIONS, AND LIMITATIONS

The NRC staff concludes that the use of the requested new material in Optima2 fuel assemblies is acceptable over the following range of applicability with the following conditions and limitations (Sections 5.1 and 5.2).

5.1 Conclusions

1. The **[ ]** channel material, referred to as Low Tin ZIRLO, is approved for the alloy composition range provided in the table on page 2-5 of WCAP-15942-P-A, Supplement 1, Revision 1 (Ref. 3).

2. The **[ ]** Low Tin ZIRLO alloy channel material is approved for batch application to the SVEA-96 Optima 2 channel design.

3. The **[ ]** is approved for batch application to the SVEA-96 Optima 2 assembly design.

4. The materials mentioned above are approved for batch application to BWR plants with symmetric and asymmetric lattices.

5.2 Conditions and Limitations

Licensees referencing WCAP-15942-P-A, Supplement 1, Revision 1, must ensure compliance with the following conditions and limitations:

1. The lifetime of Low Tin ZIRLO channels is restricted to the following limitations. Any fuel channel projected to exceed any of these limitations shall be removed from the reactor except as allowed in accordance with Westinghouse's approved LTA program.

    a. Residence time shall not exceed **[ ]** (does not include outage time).

    b. [ ]

    c. Control rod presence shall not exceed **[ ]** limit due to unanticipated operating issues, e.g., when suppressing power due to fuel failure, the channel will be considered as a lead fuel channel if inserted for an additional cycle and will be subjected to additional inspections. This will only be valid for a maximum of 10 channels in the core.

    d. Channels shall not be re-used on different assemblies.

2. The range of applicability of Low Tin ZIRLO channels is limited to those items described above.

3. The channel design described in the TR is not evaluated for seismic loads in this TR but is done on a plant-specific basis using another approved methodology. Therefore, the impact of using Low Tin ZIRLO channels on the seismic evaluation is not addressed in this SE.

4. To ensure continued in-reactor performance and applicability of Low Tin ZIRLO models, Westinghouse must provide updates, addressed to the Director, DSS, NRR, if the Low Tin ZIRLO channel performance with respect to channel exposure (inch-days) channel

growth, channel bulge, or channel bow if they show degradation or reduction in margin less than reported in the References 3 and 9. The updates shall include the following information:

a. A plot of the current Low Tin ZIRLO channel irradiation database, expressed as inch-days versus exposure.

b. A plot of measured channel growth versus equivalent channel burnup, along with the [ ]

c. A plot of measured channel bulge versus equivalent channel burnup.

d. Plots of measured channel bow data versus equivalent channel burnup for symmetric and asymmetric plants. These plots should also include the [ ]

5. Based on the post-irradiation examinations and data collection as described in Condition and Limitation 4, Westinghouse may improve the channel growth model, bow and bulge models, and the shadow corrosion model to achieve an improved fit to the database. Any changes to these models must be documented within the update(s) described in Condition and Limitation 4.

6. Based on the data presented in Reference 9, the following limitations/conditions regarding corrosion in Low Tin ZIRLO are:

- [ ]
- [ ]
- [ ]

[ ]

6.0 REFERENCES

1. Letter from J. Gresham, Westinghouse Electric Company (Westinghouse), to U.S. Nuclear Regulatory Commission (NRC), "Submittal of WCAP-15942-P-A/ WCAP-15942-NP-A, Supplement 1, Revision 0, 'Material Changes for SVEA-96 Optima2 Fuel Assemblies' (Proprietary/Non-Proprietary)," September 9, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102590063).

2. Letter from J. Gresham, Westinghouse, to NRC, "Response to the NRC's Request for Additional Information on WCAP-15942-P-A, Supplement 1, 'Material Changes for SVEA-96 Optima2 Fuel Assemblies' and Submittal of WCAP-15942-P-A, Supplement 1, Revision 1, 'Material Changes for SVEA-96 Optima 2 Fuel Assemblies' (Proprietary/Non-Proprietary)," LTR-NRC-12-60, August 29, 2012 (ADAMS Accession No. ML12262A251).

3. Letter from E. Lenning, NRC, to J. Gresham, Westinghouse, "Request For Additional Information Re: Westinghouse Electric Company Topical Report WCAP-15942-P-A, Supplement 1, Revision 0, "Material Changes For SVEA-96 Optima2 Fuel Assemblies" July 18, 2013 (ADAMS Accession No. ML13161A316).

4. Letter from J. Gresham, Westinghouse, to NRC, "Additional Surveillance Plan Information in Support of the NRC Review of WCAP-15942-P-A, Supplement 1, Revision 1, 'Material Changes for SVEA-96 Optima2 Fuel Assemblies,'" LTR-NRC-15-65, July 2015 (ADAMS Accession No. ML15204A767).

5. WCAP-15942-P-A, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors, Supplement 1 to CENP-287," LTR-NRC-06-14, Westinghouse, March 31, 2006 (ADAMS Accession No. ML061110247).

6. Letter from J. Gresham, Westinghouse, to NRC, "Request for Suspension of Review of WCAP-15942-P-A/WCAP-15942-NP-A, Supplement 1, "Material Changes for SVEA-96 Optima 2 Fuel Assemblies," LTR-NRC-16-11, June 8, 2016 (ADAMS Accession No. ML16162A752).

7. Letter from K. Hsueh, NRC, to J. Gresham, Westinghouse, "Suspension of the Review of Westinghouse Electric Company Topical Report WCAP-15942-P-A/WCAP-15942-NP-A, Supplement 1, Revision 1, 'Material Changes forSVEA-96 Optima 2 Fuel Assemblies,'" July 1, 2016 (ADAMS Accession No. ML16172A185).

8. Letter from E. Mercier, Westinghouse, to NRC, "Request for Continuation of the NRC review of WCAP-15942-P-A/WCAP-15942-NP-A, Supplement 1, Revision 1, 'Material Changes for SVEA-96 Optima2 Fuel Assemblies,' and Submittal of Slides to Support a Closed Meeting on June 14, 2018 to Discuss Details of the Review," LTR-NRC-18-42, June, 2018 (ADAMS Accession No. ML18164A341).

9. Letter from E. Mercier, Westinghouse, to NRC, “Appendix 1 to WCAP-15942-P-A, Supplement 1, Revision 1, “Effects of Corrosion on Mechanical Design Analyses of Low Tin ZIRLO Channels,” and Appendix 2 to WCAP-15942-P-A, Supplement 1, Revision 1, “Operation Limit on Low Tin ZIRLO Channels,” LTR-NRC-18-57, August 28, 2018 (ADAMS Accession No. ML18164A341).

Attachment 1: Comment Resolution (Non-Proprietary)

Principal Contributors: Matthew M. Panicker - NRR/DSS
PNNL staff (Original draft SE)

Date: August 6, 2019