Enclosure 3

Presentation Slides for the Westinghouse-NRC Pre-Submittal Meeting on Topical Report WCAP-18869-P/NP, "High Performance Cladding for Use in Boiling Water Reactor

(Non-Proprietary)

June 2023

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

Page left intentionally blank

NRC Pre-Submittal Meeting

“High Performance Cladding for Use in Boiling Water Reactor Fuel”

June 21, 2023

Safety Brief

- Nuclear Safety Culture Employee Behaviors
  - Show Respect for Others
  - Follow the Rules
  - Stop When Unsure
  - Promptly Report Problems
  - My Signature is My Word

Agenda

- Introductions
  - NRC
  - Westinghouse
- Meeting Scope
- Background
- Overview of Topical Report
- Testing Experience
- Impact on Fuel Design and Accident Analysis
- Summary & Actions

Meeting Scope

Meeting Scope

- Re-submittal of WCAP-18126-P, "HiFi™ Cladding for Use in Boiling Water Reactor Fuel" with new title
  - Review test data
  - Review NRC RAIs
  - Discuss Westinghouse responses to RAIs

- Pre-submittal goals
  - Mutual understanding between NRC & Westinghouse
  - Reduce formal RAIs for TR
  - Discuss NRC summary of audit results
  - Identify required follow-up actions for Westinghouse

Westinghouse

Background

Background

- In 2017 Westinghouse submitted a topical report to the NRC for review and approval of HiFi alloy, an improved alternative to Zircaloy-2 fuel cladding for use in boiling water reactors (BWRs).

- HiFi alloy is a zirconium-based alloy designed to maximize the safety margins for BWR fuel, amid increasing demands for higher fuel duties and burnup, by reducing the hydrogen uptake. [

]a,c

Background (contd.)

- This licensing topical report contains information supporting the application of a high-performance cladding with increased iron and chromium as fuel cladding in BWR nuclear fuel.
- Results of extensive testing reported in this document demonstrate that the properties of this high-performance cladding are equivalent or superior to those of Zircaloy-2 cladding.
- The purpose of submitting the TR is to obtain NRC approval for the application of this high-performance cladding as fuel cladding material in BWR fuel, [

 ]a,c

Westinghouse

Alloy definition

- The composition will be an extension of Zry-2, defined by:

[ ]a,c

  - The second item is a modification compared to WCAP-18126-P, supported by data provided in WCAP-18126-P and additional data provided in the new TR
- The current TR is intended to be used [ ]a,c
  - Extension to other components will be licensed separately
- The main manufacturing steps will be [ ]a,c

Westinghouse

Refresher on previous RAIs

- Q1: Please provide additional data that has been collected since publication of the submitted TR for any and all LTA/PIE programs for HiFi™ Cladding. When compiling this data please include the following:
  a) What is the range of primary coolant chemistry in US plants, specifically for O, H, Zn, sulfates and pH? What is the range of chemistry tested for HiFi™ cladding? Provide this for each testing program.
  b) Please provide the design basis linear heat generation rate limit (limiting design in terms of rod average power) versus peak pellet exposure for designs with HiFi™ Cladding.
  c) What is the uncertainty of HiFi™ cladding predicted oxide thickness that justifies using [ ]a,c
  d) Please provide comparison of hydrogen distribution and orientation between Zr-2 and HiFi™ in fuel rod cladding, spacers, end plugs and channels. Will the changes between Zr-2 and HiFi™ impact the stress level at which hydride reorientation will be experienced? Please provide data to verify this response.
- Q2: Please identify any and all fuel bundle components that will utilize HiFi™ material in the TR.

Refresher on previous RAIs

- Q3: The staff understands that the increase in Fe concentration has the potential to change the irradiated creep and lift-off characteristics as well irradiated growth rates. Please provide the following:
  - a) Please provide additional detailed information justifying the use of [ ]^{a,c} Additionally, please provide any FRAPCON comparisons that can be made for irradiated creep and lift-off of HiFi™ cladding.
  - b) If HiFi™ is to be used on fuel rods that are also tie rods, please provide irradiated growth measurement for rods that are under axial compression. Additionally, please provide any FRAPCON comparisons that can be made for irradiated creep and lift-off of HiFi™ cladding. If there is no plan to use HiFi™ material in fuel rods that are also tie rods now and the future, please make a declaration of such.
- Q4: The following are related to the impact of HiFi™ response to LOCA and associated analyses:
  - a) Have Equivalent Cladding Reacted (ECR) tests been performed on high burnup HiFi™ cladding with hydrogen present and oxide on inside diameter? If so, please provide any and all ECR data collected on HiFi™ material.
  - b) Please provide the data of iron impact on the $\alpha \rightarrow \alpha + \beta$ transformation temperature that justifies [ ]^{a,c}
  - c) Please compare the rupture strains compiled from the rupture tests associated with HiFi™ with those measured for Zr-2 to confirm that they are equivalent.
  - d) Also, please describe how flow blockage is determined from predicted rupture strains for HiFi™.
  - e) How does the introduction of HiFi™ bundle for fuel rod design impact the Emergency Core Cooling System performance?

Refresher on previous RAIs

- Q5: Please provide your future detailed surveillance program, including PIEs, for the use of HiFi™ material in fuel rod and bundle design in reload applications. The PIE should include, but is not limited to, the following elements in order to verify acceptable performance: visual, oxide thickness, hydrogen level, cladding creepdown, fuel rod and water rod growth, channel growth, channel bow, and shadow corrosion.
- Q6:
  a) What are the texture and SPP size distributions for the different LUA's cladding with HiFi™?
  b) What fabrication specifications will be applied to texture and SPPs for HiFi™ in production and how does these compare to current generation Zr-2 specifications for the fuel rods?

Overview of Topical Report

Overview of Topical Report

a,c

[ ]

Overview of Topical Report (contd.)

[ ]a,c

Overview of Topical Report (contd.)

a,c

[ ]

Testing Experience

Out-of-Reactor Test Experience

a,c

[ ]

Westinghouse

In-Reactor Test Experience

a,c

Updated through 2016

In-Reactor Test Experience

a,c

[ ]

Updated through fall 2019

Westinghouse

In-Reactor Test Experience

a,c

Updated through May 2023

Coolant chemistry

a,c

[ ]

In-Reactor Coolant Chemistry Experience

a,b,c

Westinghouse testing since TR submittal

a,c

[ ]

Westinghouse in-reactor testing

[ ]a,c

Westinghouse in-reactor testing

a,c

[ ]

Westinghouse in-reactor testing

a,c

Westinghouse in-reactor testing

a,c

Comparison to pre-irradiation

a,c

[ ]

Summary of In-Reactor Experience

a,b,c

Summary & Actions

Impact on Fuel Design and Accident Analysis

a,b,c

Impact on Fuel Design and Accident Analysis (contd.)

a,b,c

[ ]

Conditions and limitations

a,c

[ ]

Summary

a,c

[ ]

Schedule

- Submittal estimated in October 2023
- Approval is requested for October 2024 (12 month review)
  - A large part of this information has already been reviewed with an audit and responses to many of the audit items.
  - Westinghouse is planning to submit 4-5 additional LTRs during 2024 that will be required to support our **TRITON11™** fuel market entry.

Westinghouse

Follow-up Actions