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LTR-NRC-19-29

June 17, 2019

Subject: Transmittal of the Pre-Submittal Meeting Slide Package for Draft Westinghouse Topical Report WCAP-18446-P, "Incremental Extension of Burnup Limit for Westinghouse Fuel with ZIRLO Cladding and Optimized ZIRLO Cladding" (Proprietary / Non-Proprietary)

Enclosed are proprietary and non-proprietary versions of the Pre-Submittal Meeting Slide Package for Draft Westinghouse Topical Report WCAP-18446-P, "Incremental Extension of Burnup Limit for Westinghouse Fuel with ZIRLO Cladding and Optimized ZIRLO Cladding." The Pre-Submittal Meeting with the NRC Staff will be held on June 27, 2019. It is anticipated that another pre-submittal meeting will be requested in October 2019 as the Topical Report development nears completion. The Topical Report will be submitted for NRC review in December 2019.

This submittal contains proprietary information of Westinghouse Electric Company LLC ("Westinghouse"). In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Nuclear Regulatory Commission's ("Commission's") regulations, we are enclosing with this submittal an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the this submittal or the Westinghouse Affidavit should reference AW-19-4902 and should be addressed to Camille T. Zozula, Manager, Infrastructure & Facilities Licensing, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 1, Suite 165, Cranberry Township, PA 16066.

Korey L. Hosack, Manager
Product Line Regulatory Support

cc: Ekaterina Lenning (NRC)
Dennis Morey (NRC)

Enclosures:

1. Affidavit AW-19-4902
2. Proprietary Information Notice and Copyright Notice
3. LTR-NRC-19-29 P-Attachment, Pre-Submittal Meeting Slide Package for Draft Westinghouse Topical Report WCAP-18446-P, "Incremental Extension of Burnup Limit for Westinghouse Fuel with ZIRLO Cladding and Optimized ZIRLO Cladding" (Proprietary)
4. LTR-NRC-19-29 NP-Attachment, Pre-Submittal Meeting Slide Package for Draft Westinghouse Topical Report WCAP-18446-P, "Incremental Extension of Burnup Limit for Westinghouse Fuel with ZIRLO Cladding and Optimized ZIRLO Cladding" (Non-Proprietary)

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

COUNTY OF BUTLER:

(1) I, Korey L. Hosack, have been specifically delegated and authorized to apply for withholding and execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse).

(2) I am requesting the proprietary portions of LTR-NRC-19-29 be withheld from public disclosure under 10 CFR 2.390.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged, or as confidential commercial or financial information.

(4) Pursuant to 10 CFR 2.390, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse and is not customarily disclosed to the public.

(ii) Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

(5) Westinghouse has policies in place to identify proprietary information. Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

AFFIDAVIT

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage (e.g., by optimization or improved marketability).

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(6) The attached documents are bracketed and marked to indicate the bases for withholding. The justification for withholding is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (5)(a) through (f) of this Affidavit.

AFFIDAVIT

I declare that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 4/17/19

Korey L. Hosack, Manager
Product Line Regulatory Support

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are the proprietary and non-proprietary versions of a document, furnished to the NRC in connection with the future submittal of WCAP-18446-P, "Incremental Extension of Burnup Limit for Westinghouse Fuel with ZIRLO Cladding and Optimized ZIRLO Cladding," for NRC review.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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Pre-Submittal Meeting Slide Package for Draft Westinghouse Topical Report WCAP-18446-P, "Incremental Extension of Burnup Limit for Westinghouse Fuel with ZIRLO Cladding and Optimized ZIRLO Cladding"

(Non-Proprietary)

June 2019

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

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Incremental Extension of Fuel Rod Burnup Limit: Topical Report Submittal Outline Discussion

June 27, 2019

Westinghouse

Agenda

- Program Overview
- Topical Report Overview
- Key Topics
  - Mechanical Design and Materials
  - Fuel Rod Performance
  - Source Term
  - LOCA Rupture Calculations
  - Non-LOCA Transients

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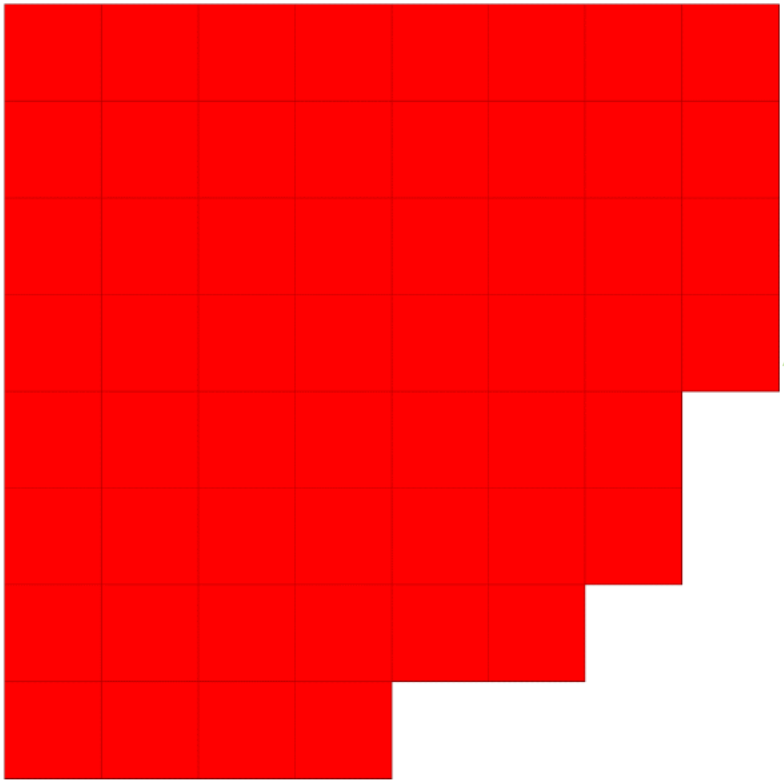
Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Overview of Burnup Extension Program



Step 1: Increase burnup limit for rods which do not rupture to [ ]a,c

Step 2: Increase burnup limit for entire core to [ ]a,c

Step 1: Expected Topical Report Envelope

- Lower power assemblies
  - No cladding burst under LOCA / RE accident conditions
- Current fuel products
  - **ZIRLO®** cladding / **Optimized ZIRLO™** cladding
  - UO_2 fuel pellets
- Average rod burnup limit of [

]a,c

- Limit on assembly and rod power for assemblies as a function of burnup

Current Schedule

- 2018 FPUM Discussion — July 2018
- EPRI High BU / Enrich Workshop — December 2018
- Submittal Outline Discussion w/ NRC — Today

[a,c]

Implementation

- Two parts to implementation

- 1: Generic topical report
  - Address burnup-related limitations and conditions on existing topical reports
  - Describe any required method updates
  - Justify applicability of existing designs and methods for high burnup

- 2: Site-specific effort
  - Execute analyses, evaluations, and requirements of generic topical report
  - Plant-specific LAR submittal as appropriate

Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Topical Report Overview

[a,c]

Topical Report Overview (continued)

[a,c]

Site-Specific Implementation

[a,c]

Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Fuel rod peak oxide thickness as a function of burnup

[a,c]

Sufficiently well behaved oxide data at high burnup is available

ZIRLO Cladding Oxide Measurement vs Prediction

[a,c

Data Extends Past Criteria of ~ 75 um

Optimized ZIRLO Cladding Measured Oxide vs TRD

[a,c]

Data trends indicate existing models over-predict oxide at high TRD compared to measured values

Cladding Hydrogen as a function of Oxide

[a,c]

Fuel rod growth as a function of fast fluence

a,c

Sufficiently well behaved fuel rod growth data at high burnup is available

Creep & Growth (C&G) growth vs fluence to high exposure

[a,c]

C&G Creep vs fluence
Well behaved to high exposures

a,c

Fuel Assembly Growth as a function of burnup

a,c

Sufficiently well behaved fuel assembly growth data at high burnup is available

Spacer Grid Growth Data

a,c

Max Oxide vs BU for Structure Materials

a,c

Max Structural Material Thinning vs BU

[a,c]

Material Summary

- Existing database extends past the requested burnup extension
- For ZIRLO, Optimized ZIRLO and LT ZIRLO data indicates acceptable performance and ability to predict behavior with existing models to ensure reload design criteria are met

Current database supports requested burnup extension

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Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Functional Area Review
Fuel Rod Design

- Not LOCA PAD5 implementation is pre-requisite for this topical report
  - TCD requirement
- PAD5 high burnup capability
  - PAD5 was approved for rod average burnup of 62 GWd/MTU
  - PAD5 provided technical basis and requested for rod average burnup of [ ]^{a,c} in PAD5 submittal

PAD5 will be the basis for high burnup FRD analysis

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Fuel Rod Design
PAD5 High Burnup Database

- Halden Project experiments provide measured fuel temperatures for UO_2 and Gd_2O_3-UO_2 fuel to high burnup [ ]^{a,c}
- Commercial irradiation programs provide measured fission gas release (FGR) and rod growth data for up to [ ]^{a,c} rod average burnup as well as early in life clad creep data
- Joint International test programs provide data on high burnup [ ]^{a,c} fuel power ramp behavior
- Plots of power vs. burnup were provided in the response to RAI 1 (set 2) for various calibration database

PAD5 added many high burnup and high duty data points

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Fuel Rod Design
PAD5 High Burnup Database

- Plots of power vs. burnup were provided in the response to RAI 1 (set 2) for various calibration database
  - Example – UO2 FGR Database

[a,c]

Fuel Rod Design
PAD5 High Burnup Models

[a,c]

Technical bases for rod average burnup of [ ]a,c are provided in PAD5 topical

Fuel Rod Design Methodology

- FRD Design Criteria
  - Design criteria and application methodology in PAD5 topical remain applicable
  - Reduced design margin can constrain the operation of the high burnup rods but all design criteria will be satisfied
- Safety Analysis Interface
  - No changes expected in data format for input data to SA
  - Conservative power histories are used to generate fuel temperatures and rod internal pressures (RIPs)
  - Core stored energy (CSE)
    - Dependent on core average burnup
    - No significant impact expected

Fuel Rod Design
Summary and Conclusion

- PAD5 will be the basis for FRD analysis for burnup up to [ ]a,c
  - PAD5 database and models supports extension to [ ]a,c
  - Same set of design criteria and application methodology
- High burnup fuel will be shown to satisfy all FRD design criteria

Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Source Term

- Regulatory Guide 1.183 / 1.195 Gap Fraction Limits of Applicability
  - Peak burnup up to 62 GWd/MTU
  - For > 54 GWd/MTU, LHR < 6.3 kw/ft peak rod avg. power

[a,c]

Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Loss-of-Coolant Accident Analysis
Introduction

[a,c]

Loss-of-Coolant Accident Analysis
Cladding Rupture Models

a,c

Loss-of-Coolant Accident Analysis
Cladding Rupture Models

[a,c]

Loss-of-Coolant Accident Analysis
Cladding Deformation Models

a,c

Loss-of-Coolant Accident Analysis
Decay Heat

[a,c]

Loss-of-Coolant Accident Analysis
Fuel Conductivity

[a,c]

Loss-of-Coolant Accident Analysis
Transient Rod Internal Pressure Behavior

a,c

Loss-of-Coolant Accident Analysis
Transient Rod Internal Pressure Behavior

[a,c]

Loss-of-Coolant Accident Analysis Method for High Burnup Rupture Calculations

a,c

Compliance with 10 CFR 50.46

[a,c]

- Research findings of 10 CFR 50.46c rulemaking indicate that compliance with 10 CFR 50.46 alone is not sufficient for high burnup fuel

10 CFR 50.46c Rulemaking

a,c

Program Overview

Topical Report Overview

Key Topics

- Mechanical Design and Materials
- Fuel Rod Performance
- Source Term
- Loss-of-Coolant Accident Analysis
- Non-LOCA Transients

Non-LOCA Transients

Non-LOCA Transients have varying dependency on burnup

- Burnup dependency is part of existing analysis methods
- Majority only dependent on burnup relative to fuel temperatures used for fuel-to-coolant heat transfer inputs
  - Analyses most sensitive to these inputs are beginning-of-cycle limited; hence, impact due to extension of fuel rod burnup limit is negligible
- Long-term heatup events also dependent on burnup relative to decay heat modeled in the analyses
  - Loss of Normal Feedwater, Loss of AC Power, Feedline Break, and Inadvertent ECCS Actuation
  - Additional justification required to support higher burnup, though impact expected to be accommodated

Non-LOCA Transients
DNB Propagation Evaluation Method

- Continue to implement WCAP-8963-P-A Addendum 1-A Revision 1-A for Condition IV events as part of PAD 5 implementation
- No change in current criteria for higher burnup
  - Cladding strain < Critical Strain of [ ]^{a,c}
  - No fuel cladding failure due to rod burst prior to reaching Critical Strain

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Non-LOCA Transients
New RIA Criteria

- Rod Ejection analysis is most sensitive to burnup effects
  - Burnup dependency is part of existing 1D Rod Ejection analysis methodology
  - New RIA criteria to be clarified and finalized (DG-1327)
- Compliance with new RIA criteria may require implementation of 3DRE evaluation method
  - Accounts for burnup-dependent effects, including fuel thermal conductivity degradation, melting, and radial pellet power distribution
  - Addresses burnup-dependent requirements of new RIA analysis

Incremental increase in burnup limit can be accommodated with 1D method, but 3DRE may be required for new RIA criteria

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Questions

Acronyms

Acronym	Definition
3DRE	3-Dimensional Rod Ejection
AOR	Analysis of Record
BU	Burnup
CFR	Code of Federal Regulations
COLR	Core Operating Limits Report
CSE	Core Stored Energy
DNB	Departure from Nucleate Boiling
ECCS	Emergency Core Cooling System
ECR	Equivalent Cladding Reacted
EM	Evaluation Model

Acronyms

Acronym	Definition
ECR	Equivalent Cladding Reacted
EM	Evaluation Model
FFRD	Fuel Fragmentation, Relocation, and Dispersal
FGR	Fission Gas Release
FRD	Fuel Rod Design
FSLOCA	FULL SPECTRUM Loss-of-Coolant Accident
LAR	License Amendment Request
LBLOCA	Large-Break Loss-of-Coolant Accident
LHR	Linear Heat Rate
LOCA	Loss-of-Coolant Accident

Acronyms

Acronym	Definition
LT	Low Tin
NFI	Nuclear Fuels Industries
NRC	Nuclear Regulatory Commission
PAD	Performance Analysis and Design
PIRT	Phenomenon Identification and Ranking Table
RAI	Request for Additional Information
RE	Rod Ejection
RIA	Reactivity Insertion Accident
RIP	Rod Internal Pressure
SA	Safety Analysis

Acronyms

Acronym	Definition
SBLOCA	Small-Break Loss-of-Coolant Accident
SER	Safety Evaluation Report
T/H	Thermal-Hydraulic
TCD	Thermal Conductivity Degradation
TRD	Thermal Reaction Accumulated Duty