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EATF and AFM Status

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AGENDA

- Introduction and Background ……. Holm
- Status
  - Enhanced Accident Tolerant Fuel (EATF)
    - Near term
      - Chromia doped fuel …….. Qi
      - Chromium-coated cladding ……. Lane
      - LTAs …… Reed
    - Longer term
      - EATF – BWRs …….. Long
      - Silicon carbide cladding …….. Nimishakavi
  - Advanced Fuel Management (AFM)
    - Increased enrichment …….. Guzzardo
    - Increased burnup – current designs …….. Jones
    - Increased burnup – Cr-Cr design ……... Seals
- Schedule Update …….. Holm
- Next Steps …… Holm

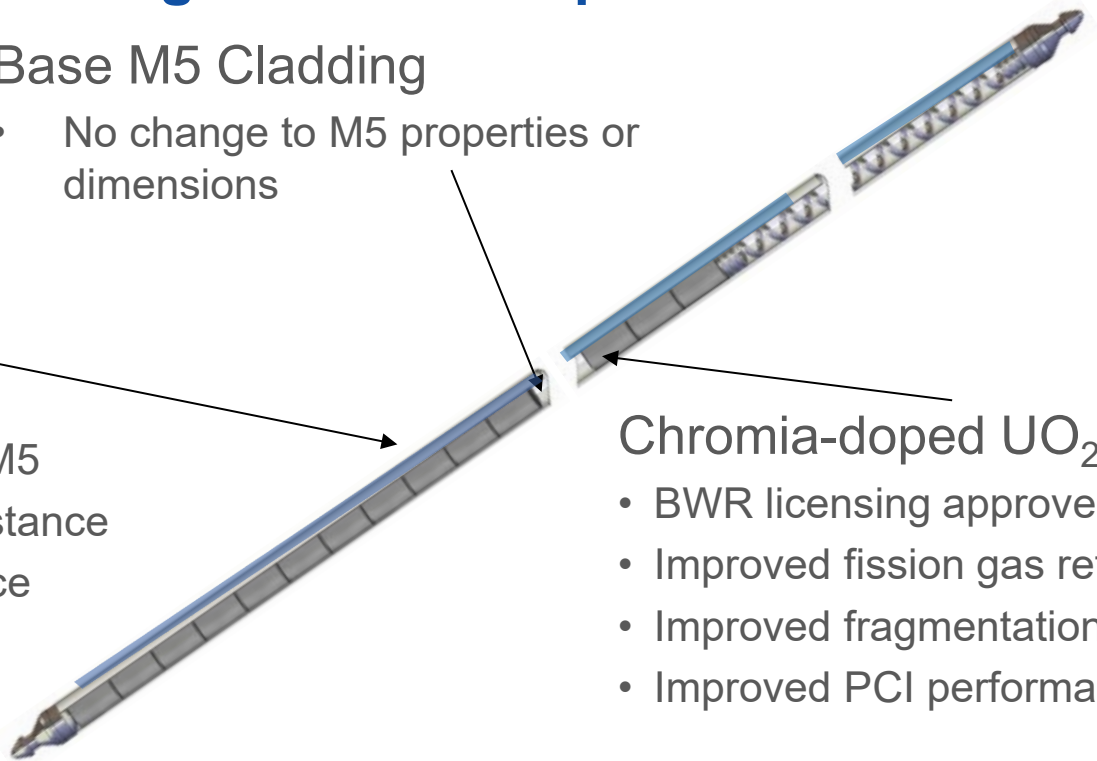
Introduction and Background

Jerry Holm

EATF Solution
Cr-Coated Cladding / Chromia-doped Pellets

Base M5 Cladding

- No change to M5 properties or dimensions



Cr-coating

- 10-20 µm
- Does not change base M5
- Improved oxidation resistance
- Improved wear resistance
- Reduced LOCA rupture

Chromia-doped UO_2 pellets

- BWR licensing approved
- Improved fission gas retention
- Improved fragmentation behavior
- Improved PCI performance

Background – Advanced Codes and Methods

Neutronics	ARCADIA (ANP-10297P-A and S1P-A)
Thermal–Hydraulic	COBRA-FLX (ANP-10311P-A Revision 1)
CHF	GAIA CHF (ANP-10341P-A)
Non-LOCA	ARITA (ANP-10339P) and AREA (ANP-10338P-A)
SB LOCA	S-RELAP5 (EMF-2328P-A and S1P-A)
LB LOCA	S-RELAP5 (EMF-2103P-A Revision 3)
SB and LB LOCA	with GALILEO (ANP-10349P, submittal October 2020)
Fuel Performance Code	GALILEO (ANP-10323P Revision 1)
External Loads	ANP-10337PA and Supplement 1P
Fuel Design topical report	GAIA (ANP-10342P-A) with Q12 (ANP-10334P-A)
$M5_{Framatome}$	BAW-10227P Revision 2
Liftoff	BAW-10243P-A (statistical holddown)
Cladding Collapse	BAW-10084P-A Revision 3 (CROV)
Bow	XN-75-32P-A

Background – Building Blocks for Increased Burnup

ANP-10323P Revision 1 – New fuel performance code GALILEO

BAW-10227P Revision 2 – $M5_{Framatome}$

Start of Proprietary Information

Advanced Fuel Management (AFM)

- Increased enrichment — Submittal [ ]
- Increased burnup — Submittal [ ]

Range of Applicability

EATF –Near Term

- Chromia-doped pellet topical report supplement (ANP-10340P) report to extend material properties to PWR methodologies

  Submittal [ ]

- Topical report to incorporate chromium-coated cladding and chromia-doped pellets (addressing base methods)

  Submittal [ ]

Status – EATF Near Term Chromia Doped Fuel

Yusen Qi

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EATF – Chromia Doped Fuel

- Supplement to ANP-10340P-A
  - The impact on fuel properties due to chromia-doped fuel is defined in base topical report. Supplement does not change the conclusion.
  - Implementation into BWR codes and methods is defined in base topical report. Supplement implements fuel properties into PWR codes and methods.
- GALILEO code modifications complete – Mainly, chromia-doped fuel specific thermal conductivity model, fission gas release model, and intra-granular gaseous swelling models are added.
- Pre-submittal meeting will be held when preliminary data available

Status – EATF
Near Term
Chromium-Coated Cladding

Ronda Lane

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Overview of Protect (Cr-Cr) Plan

Base Topical Reports for Advanced Methods

- ANP-10323P, Revision 1, “GALILEO Fuel Rod Thermal-Mechanical Methodology for Pressurized Water Reactors”
- ANP-10339P, “ARITA - ARCADIA/RELAP Integrated Transient Analysis Methodology”
- BAW-10227P, Revision 2, “Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel”
- ANP-10349P, Revision 0, GALILEO Implementation in W/CE LOCA Methods

Extension to Advanced Products (Cr-Cr)

- Chromia-doped fuel topical report supplement (ANP-10340P) report to extend material properties to PWR methodologies
- New topical report to address impact of Chromium-coated cladding (with and without chromia-doped fuel) on base methods

Models Summary (1/3)

Models	Model changes	Comments

Models Summary (2/3)

Models	Model changes	Comments

Models Summary (3/3)

Models	Model changes	Comments

Status – EATF Longer Term

Corey Long

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EATF –BWRs

Status – EATF
Near Term
LTAs

Jeff Reed

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Vogtle LTA Program

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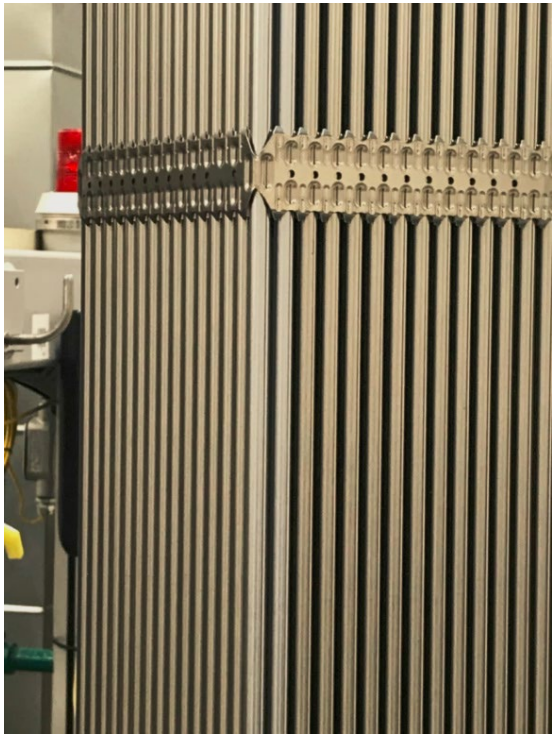
- Four LTAs began operation in March 2019
- Four full length Cr-coated rods per bundle
- All fueled rods contain Chromia-enhanced pellets
- Advanced GAIA Fuel Assembly Design

ANO Unit 1 LTA Program

- 32 full length Cr-coated rods provided
- 16 rods were installed in 8 irradiated fuel assemblies that will be reinserted into peripheral assembly locations which will reside in baffle locations that have exhibited past baffle/assembly interaction (leading to excessive rod wear)
- The remaining 16 rods were installed in fresh fuel
- Operation began in November 2019



Other PWR LTA Programs

- Inserted Cr-coated fuel rods for Gösgen reactor in June 2019
- Production of full-length Cr-coated rods for Calvert Cliffs completed
  - Producing one LTA with a full compliment of Cr-coated rods and Chromia-enhanced pellets
  - Fuel will be manufactured in late 2020

- By the end of 2020 Framatome will have manufactured EATF fuel for the three primary US PWR plant types (W, B&W and CE)

Gösgen - June

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Kernkraftwerk Gösgen

IMAGO-2016 : Visual Examination after 3 cycles

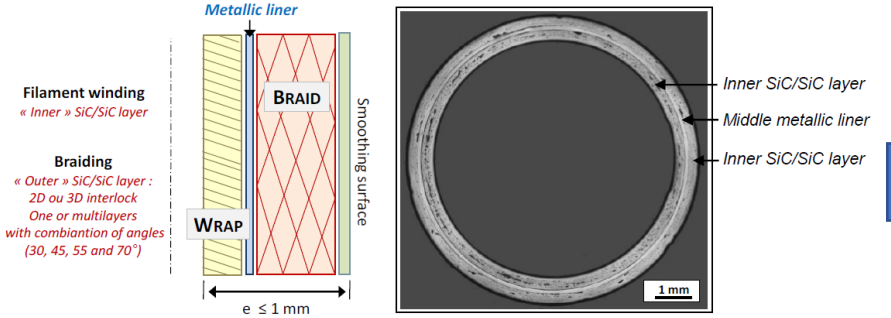
Overview of Framatome's Cr-coated Cladding Irradiation Plan

Status – EATF Longer Term Term Silicon Carbide Cladding

Kiran Nimishakavi

Silicon Carbide Cladding - Design

Original 'Sandwich' design for advanced reactors



Framatome and CEA jointly making systematic change to the sandwich design to address several key feasibility issues

SiC_f/SiC Composite

IMAGO Irradiation

MITR Irradiation

Summary

- Along with the near-term Cr-coated cladding and Chromia-doped fuel, Framatome is actively developing a revolutionary SiC-based cladding which provide outstanding benefits during normal operation and accident conditions.
- Framatome and CEA are making systematic changes to the sandwich design to address key technical challenges.
- Achievements

[ ]

- Completed four 1-year cycles of Irradiation in a commercial reactor.

Status – AFM
Increased Enrichment

Michelle Guzzardo

AFM – Increased Enrichment - Status

Key Dates:

- Pre-submittal meeting held on April 30, 2020
- Topical report submittal [ ]
- NRC approval requested for [ ]

AFM – Increased Enrichment - Status

AFM – Increased Enrichment - Status

Status – AFM Increased Burnup

Christina Jones

AFM – Increased Burnup - Status

Umbrella topical will validate and extend methodologies not previously addressed by building blocks.

Building Blocks for Increased Burnup

- ANP-10323P Revision 1 - New fuel performance code GALILEO, [ ]
- BAW-10227P Revision 2 – M5, [ ]

Key Dates:

- Pre-submittal meeting expected [ ]
- Topical report submittal [ ]
- NRC approval requested for [ ]

AFM – Increased Burnup - Status

AFM – Increased Burnup - Status

Status – AFM Increased Burnup Cr-Cr Design

Jeff Seals

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EATF-AFM Status: Cr-Cr Topical Report Supplement

Objective:

- Provide additional performance data and justification to allow for an increase in the enrichment and burnup limits for the PROtect fuel used in PWRs

Key Dates:

[ ]

Schedule Update

Jerry Holm

Schedule Update

Schedule Update

Next Steps

Jerry Holm

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Next Steps

Pre-submittal Meeting for increased burnup [ ]

Pre-submittal Meeting for chromia-doped fuel [ ]

Test Plan Update for chromium coated cladding [ ]

Trademarks

DOE Acknowledgment and Disclaimer

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