NRC Pre-Submittal Meeting
Implementation of Framatome CE16HTP Fuel
Palo Verde Units 1, 2, and 3

April 5, 2018

Discussion Topics

Overview

Framatome Fuel Design Features

Analytical and Licensing Changes

- Safety Limit 2.1.1 – DNBR and Peak Fuel Centerline Temperature Safety Limits
- Technical Specification 4.2.1 – Design Features
- Technical Specification 5.6.5.b – COLR Methodologies
- 10 CFR 50.12 Permanent Cladding Exemption Request

Implementation Schedule

Summary

Introduction of Personnel

- Thomas Weber – Acting Director, Regulatory Affairs, APS
- Michael Dilorenzo – Department Leader, Regulatory Affairs, APS
- Matthew Cox – Section Leader, Regulatory Affairs, APS
- Sean McCormack – Engineer III, Regulatory Affairs, APS
- Thomas Remick – Department Leader, Nuclear Fuel Management, APS
- David Ricks – Section Leader, Nuclear Fuel Management, APS
- David Medek – Consulting Engineer, Nuclear Fuel Management, APS
- Charles Karlson – Section Leader, Nuclear Fuel Management, APS
- Shawn Gill – Senior Engineer, Nuclear Fuel Management, APS
- Bradley Sutton – Senior Engineer, Nuclear Fuel Management, APS
- Jill Magnusson – Engineer III, Design Engineering, APS
- Greg Kessler – Project Manager, Framatome
- Rick Williamson – Contract Manager, Framatome
- Vick Nazareth – Director, Nuclear Fuel Technology, Structural Integrity
- Mark Drucker – Associate, Nuclear Fuel Technology, Structural Integrity

Purpose of Pre-Submittal Meeting

- Present planned license and methodology changes to implement the Framatome Advanced CE-16 High Thermal Performance (HTP™) fuel design product (CE16HTP)
- Similar to submittal for SONGS Units 2 and 3, ML11215A090 (July 2011)

Desired Outcomes

- Communicate plan for submittal of Framatome CE16HTP fuel license amendment
- Gain an understanding of NRC staff perspectives that need to be addressed proactively in the submittal
- Discuss approval timeline for Framatome topical report currently under review by the NRC staff

Background

- APS is planning on using Framatome CE16HTP fuel in the Spring 2020 refueling of Unit 2
  - Estimated 100 CE16HTP fuel assemblies to be loaded into the reactor core
  - Essentially the same design as that of the Framatome lead test assemblies (LTAs)
- NRC approval is required for the Palo Verde methodology changes to address Framatome fuel

Why Implement a New Fuel Design

- Security of Supply
  - Reliable fuel designs
  - Multiple fuel vendors
  - Geographically diverse manufacturing
  - Commercial considerations

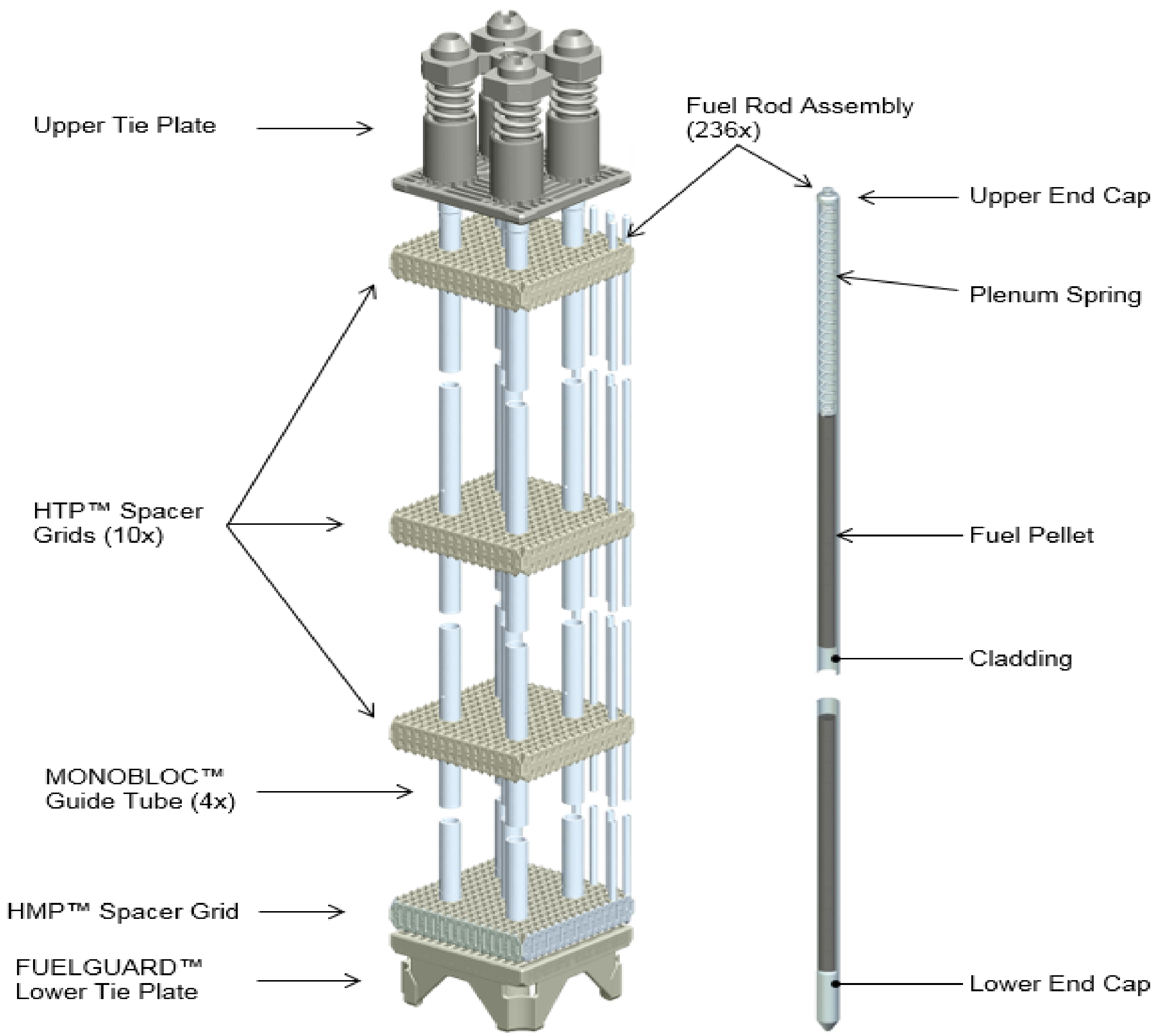
Key Differences with CE16HTP
(with respect to CE16STD and CE16NGF)

- Burnable absorber change (to gadolinia)
- Cladding material change (to M5®)
- Grid design
- Fuel assembly structure

CE16STD refers to the Westinghouse standard fuel design

CE16NGF refers to the recently approved Westinghouse Next Generation Fuel design

CE16HTP Fuel Assembly



CE16HTP Mechanical Design

- Fuel Assembly Structure
  - Upper tie plate design is the standard Framatome CE-type reconstitutable design
  - Cage or skeleton design includes:
    - four (4) M5® MONOBLOC™ corner guide tubes
    - one (1) M5® center guide tube / instrument tube
    - ten (10) M5® HTP™ spacers
    - one (1) Alloy 718 HMP™ spacer at the lowest spacer position
  - Lower tie plate design is the FUELGUARD™ structure

CE16HTP Lead Assembly Program

- Temporary M5® exemption approved for CE16HTP Lead Assembly Program (ML082730003 and ML082730006, October 2008)
- Lead Assembly Program implemented in Unit 1 for three reload cycles beginning in 2008, completed in 2013
- Lead Assemblies met all acceptance criteria based on post-irradiation examination

Submittal Highlights

- Reload Methods addressed in the submittal
  - Update NRC approved APS reload methods to address Framatome fuel
  - Use of NRC approved Framatome Mechanical Design and LOCA methods
  - Use of NRC approved Framatome COPERNIC methods for fuel behavior analysis (addresses Thermal Conductivity Degradation)
- 10 CFR 50.12 Permanent Cladding Exemption Request
- Based on previous submittals
  - Similar to SONGS submittal (ML11215A090)
  - Builds on APS NGF submittal (ML16188A336)

Reload Method Changes

- Update NRC approved reload methods to:
  - Add VIPRE-01 thermal-hydraulic code
  - Add Framatome BHTP critical heat flux (CHF) correlation
  - Add method for performing Framatome fuel behavior analysis (COPERNIC fuel performance code)
  - Add methods for performing Framatome Small and Large Break LOCA analyses
  - Modify methods for performing CEA ejection analysis, DNB propagation, and statistical convolution for fuel failure to address Framatome fuel

DNBR Safety Limit

- Same approach as used for Next Generation Fuel (ML16188A336)
- No change to Technical Specification (TS) 2.1.1.1 DNBR Safety Limit
  - Continue to use CE-1 DNBR correlation in Core Protection Calculator System (CPCS) and Core Operating Limit Supervisory System (COLSS)
  - This ensures consistency between the TS 2.1.1.1 DNBR Safety Limit value and DNBR monitoring in the Control Rooms
  - Analytical limit presented in TS Bases
- Submittal to include discussion on use of BHTP CHF correlation and how to equate the analytical DNBR limit to the CE-1 DNBR Safety Limit

DNBR Analytical Limit

- TS 2.1.1.1 DNBR Safety Limit remains at 1.34
- The DNBR analytical limit depends on fuel type
  - For a CE16STD core the DNBR analytical limit is 1.34 using CE-1 or ABB-NV
  - For a CE16NGF core the DNBR analytical limit is 1.25 using WSSV & ABB-NV
  - For a CE16HTP core the DNBR analytical limit is 1.25 using BHTP
- For a mixed core where multiple fuel types may be limiting, the more conservative DNBR analytical limit will be used in conjunction with the CHF correlation for each limiting fuel type

Peak Fuel Centerline Temperature Safety Limit

- Change to TS 2.1.1.2 Peak Fuel Centerline Temperature Safety Limit
  - Retain existing limit for Westinghouse supplied fuel
  - Add NRC approved limit for Framatome supplied fuel [consistent with COPERNIC Topical Report BAW-10231(P)(A)]

Peak Fuel Centerline Temperature Safety Limit

2.1.1.2 In MODES 1 and 2,

2.1.1.2.1 The peak fuel centerline temperature for Westinghouse supplied fuel shall be maintained < 5080°F (decreasing by 58°F per 10,000 MWD/MTU for burnup and adjusting for burnable poisons per CENPD-382-P-A).

2.1.1.2.2 The peak fuel centerline temperature for Framatome supplied fuel shall be maintained < 4901°F (decreasing by 13.7°F per 10,000 MWD/MTU for burnup).

TS 4.2.1 Changes

- TS 4.2.1 – Design Features of Fuel Assemblies
  - Update to allow use of M5® clad
  - Remove wording that requires an exemption for other cladding material to conform with NUREG-1432 Standard Technical Specifications

TS 4.2.1 Changes

4.2 Reactor Core

4.2.1 Fuel Assemblies

The reactor shall contain 241 fuel assemblies. Each assembly shall consist of a matrix of ~~Zircaloy or ZIRLO~~ ~~or Optimized ZIRLO~~ fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions. ~~Other cladding material may be used with an approved exemption.~~

zirconium alloy clad

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4.2.2 Control Element Assemblies

TS 5.6.5

- Existing TS 5.6.5.b methodologies are retained to support units operating with Westinghouse fuel
- Consistent with TSTF-363, TS 5.6.5.b is modified to:
  - Add VIPRE-01
  - Add Framatome methodologies applicable to CE16HTP fuel, including BHTP CHF correlation

Topical Reports Added to TS 5.6.5.b

27. EMF-2103P-A, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors." [Methodology for Specification 3.2.1, Linear Heat Rate]

28. EMF-2328(P)(A), "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based." [Methodology for Specification 3.2.1, Linear Heat Rate]

29. BAW-10231P-A, "COPERNIC Fuel Rod Design Computer Code." [Methodology for Specification 3.2.1, Linear Heat Rate]

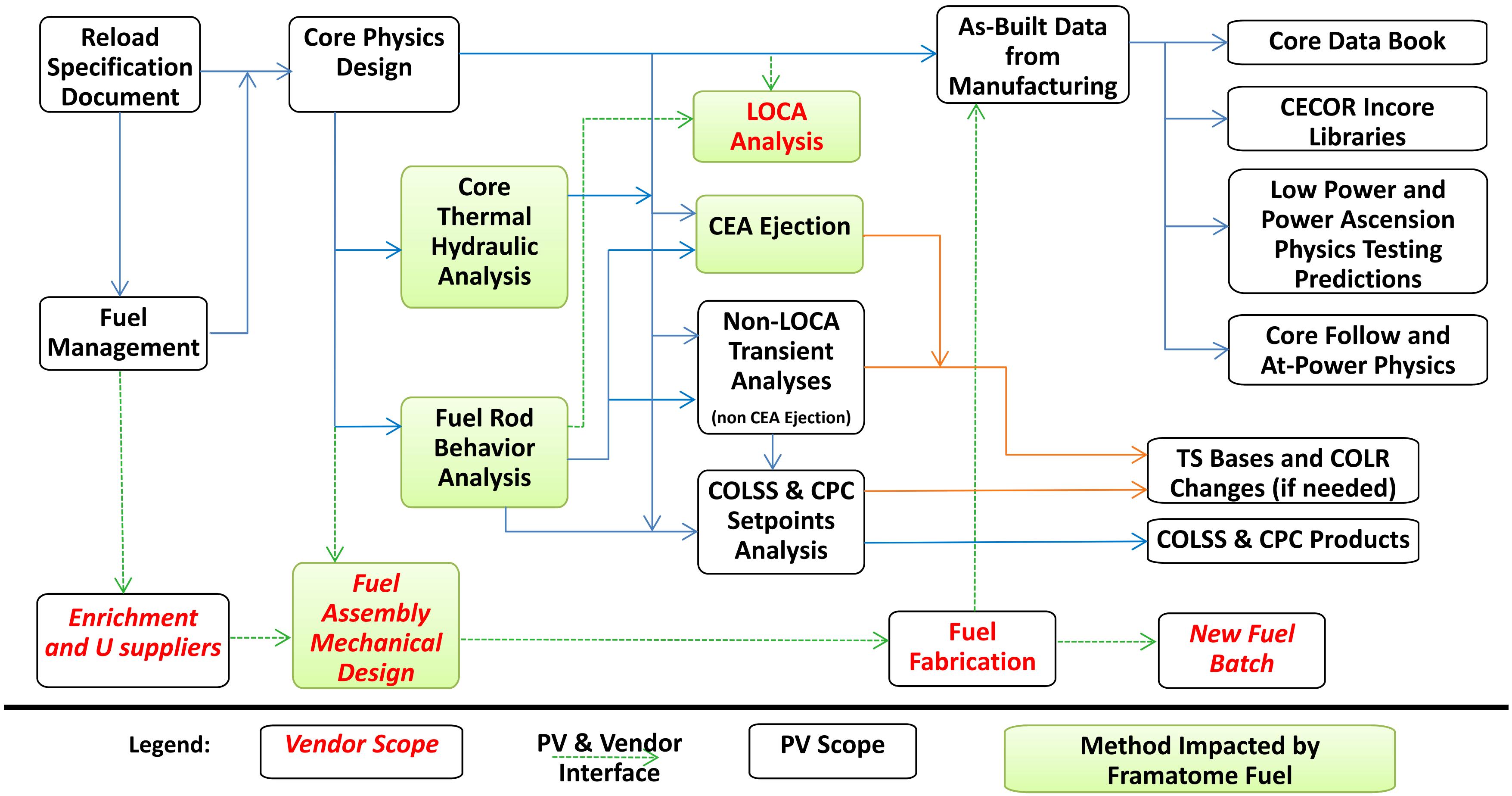
30. BAW-10241(P)(A), "BHTP DNB Correlation Applied with LYNXT." [Methodology for Specification 3.2.4, DNBR]

31. EPRI-NP-2511-CCM-A, "VIPRE-01: A Thermal-Hydraulic Analysis Code for Reactor Cores." [Methodology for Specification 3.2.4, DNBR]

Core Operating Limits Report Changes

T.S. Ref.	Title	Report No.	Rev.	Date	Suppl.
27	Realistic Large Break LOCA Methodology for Pressurized Water Reactors	EMF-2103P-A	3	June 2016	N.A.
28	PWR Small Break LOCA Evaluation Model, S-RELAP5 Based	EMF-2328(P)(A)	0	March 2001	N.A.
28	PWR Small Break LOCA Evaluation Model, S-RELAP5 Based	EMF-2328(P)(A)	0	December 2016	1(P)(A)
29	COPERNIC Fuel Rod Design Computer Code	BAW-10231P-A	1	January 2004	N.A.
30	BHTP DNB Correlation Applied with LYNXT	BAW-10241(P)(A)	1	July 2005	N.A.
31	VIPRE-01: A Thermal-Hydraulic Analysis Code for Reactor Cores	EPRI-NP-2511-CCM-A	Mod 02 Rev 3	Volume 1-3 (August 1989), Volume 4 (April 1987), Volume 5 (September 1989)	N.A.

Palo Verde Reload Methodology



Technical Areas Reviewed in Submittal

- Fuel Mechanical Design
- Nuclear Design
- Fuel Rod Behavior (Performance)
- Core Thermal Hydraulic Design
- Non-LOCA Transients
- Emergency Core Cooling System Performance (i.e., LOCA)
- COLSS/CPCS Setpoints

Loss Of Coolant Accident (LOCA)

- LOCA analyses address the change in burnable absorber and clad material with CE16HTP introduction
  - Framatome Realistic Large Break LOCA methodology
  - Framatome Small Break LOCA methodology (Appendix K)
  - Thermal Conductivity Degradation (TCD) is addressed
  - Long Term Cooling analyses not impacted by fuel change
- The CE16HTP design utilizes M5® cladding which will be documented in a permanent cladding exemption request per 10 CFR 50.12

LOCA Analysis

	Westinghouse Fuel Analysis	Framatome CE16HTP Analysis
LBLOCA		
Peak Clad Temperature (F)	2129.6	1752
Local Maximum Oxidation (%)	15.78	2.37
Core Wide Oxidation (%)	0.813	0.020
SBLOCA		
Peak Clad Temperature (F)	1678	1620
Local Maximum Oxidation (%)	4.5	2.96
Core Wide Oxidation (%)	< 0.33	0.006

Impact on Other Analyses

- Radiological Consequence Analyses
  - No change in power level or plant systems
  - Accident analysis results expected to be maintained consistent with current input to the dose analyses
  - Therefore, the UFSAR dose analyses would continue to remain applicable
- Spent Fuel Pool (SFP) Criticality Analysis
  - SFP criticality analysis remains bounding
  - Framatome 16x16 fuel bounded by CE16NGF fuel design as modeled in the current SFP criticality analysis

Implementation Schedule

March 2018	Manufacturing of long lead fuel components began
April 2018	Pre-submittal meeting
May 2018	NRC approval of Framatome topical
June 2018	Submittal
July 2018	NRC acceptance review complete
Fall 2019	NRC Safety Evaluation with submittal approval, and approval of clad exemption request
January 2020	Delivery of Framatome fuel begins
Spring 2020	Refueling outage

Implementation Schedule (cont.)

- Topical Report required to be approved prior to submittal
  - ANP-10337P Revision 0, “PWR Fuel Assembly Structural Response to Externally Applied Dynamic Excitations”
- APS requests a 12 to 15 month NRC review to support the implementation date

Summary

- Palo Verde is implementing a proven CE16HTP fuel design
  - Excellent performance in previous LTA program
  - Reload methods adjusted for CE16HTP fuel design
  - Realistic Large Break LOCA analyses performed
  - Addresses thermal conductivity degradation
- Technical Specification Changes
  - Reactor Core Safety Limits
  - Fuel Design Information
  - Core Operating Limits Report
- Permanent Cladding Exemption
- First use in Spring 2020

Questions?