NuScale Power™

LO-0815-17032

Enclosure 1:

"Codes and Methods Applicability Topical Report," PM-0815-17029, Revision 0, nonproprietary version

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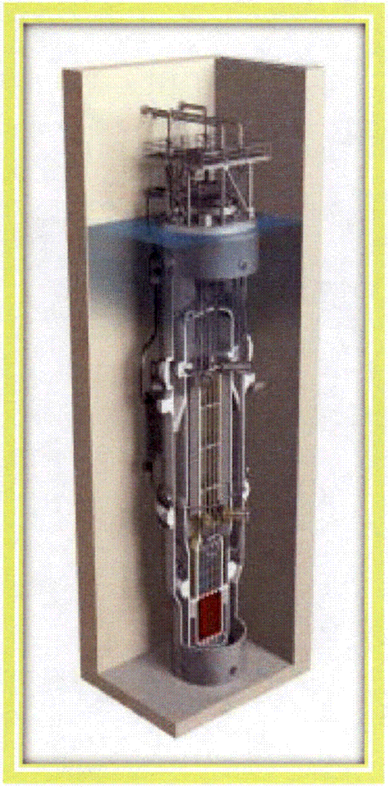
Codes and Methods Applicability Topical Report



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AREVA

September 9, 2015

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Acknowledgement & Disclaimer

"This material is based upon work supported by the Department of Energy under Award Number DE-NE0000633."

Agenda

- Follow up from previous interaction
- Licensing strategy
- Progress update
- Applicability topical report overview
- Applicability details
- Summary
- Next steps

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Previous Interaction

- March 19, 2015, fuel and CRA update
- Codes and Methods Applicability topical report
- Referencing of AREVA topical reports in the NuScale DCA

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Topical Report Referencing

- NuScale DCD will reference necessary AREVA topical reports and applicability reports as "secondary references"
  - consistent with past practice
  - referenced reports would be treated as requirements and considered matters resolved to the extent portions of the report "in context, are intended as requirements in the generic DCD"
  - reports would not be "incorporated by reference" in the Federal Register
- Where reports are not intended as requirements, they will be referenced as general references, only

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Previous Licensing Strategy

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}}2(a)

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Current Licensing Strategy

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}}2(a)

Fuel and Control Rod Design Assembly

Glen Thomas, AREVA

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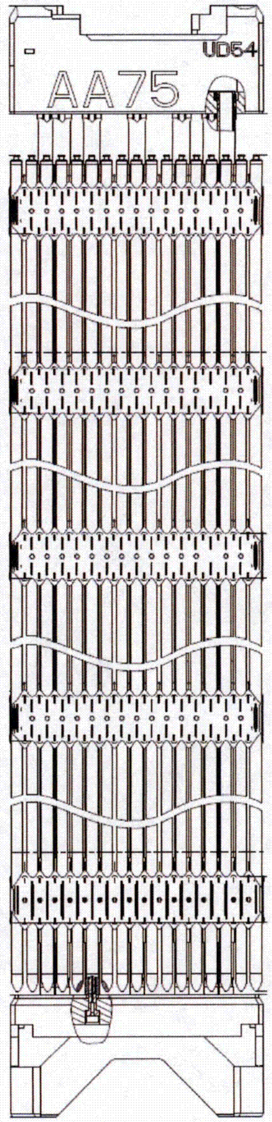
NuScale Fuel Assembly Design

- NuScale design based on AREVA's proven US 17x17 PWR technology
- NuScale design features
  - Zircaloy-4 HTP™ upper and intermediate spacer grids
  - Inconel 718 HMP™ lower spacer grid
  - coarse-mesh filter plate on bottom nozzle
  - Zircaloy-4 MONOBLOC™ guide tubes
  - quick-disconnect top nozzle
  - Alloy M5® fuel rod cladding



>>Proven features with significant US operating experience

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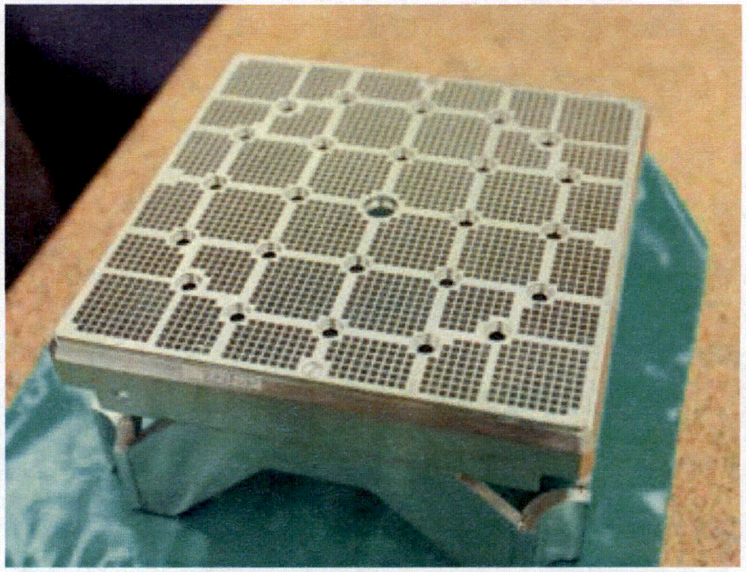
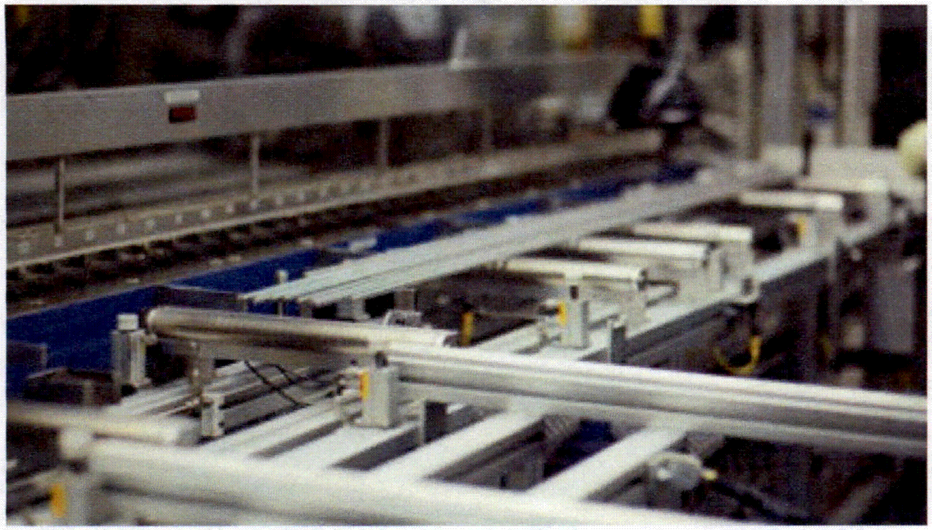
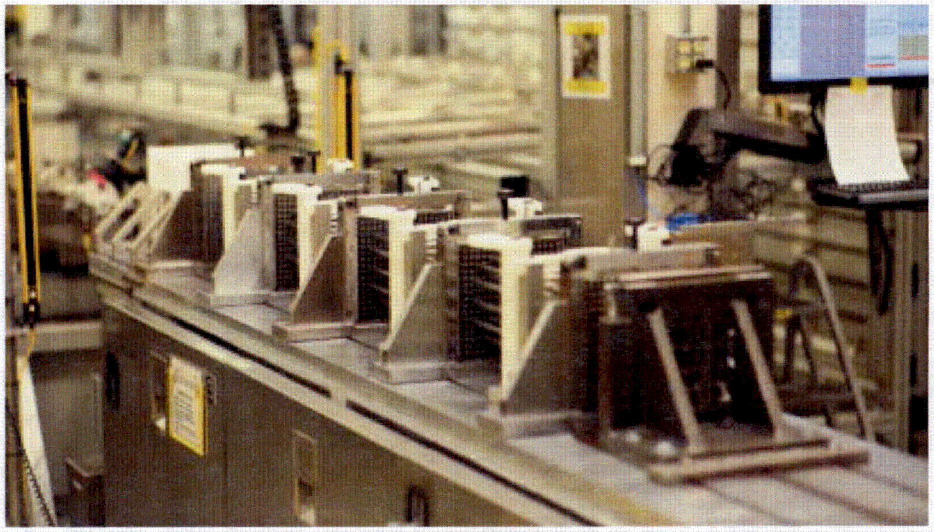
NuScale Fuel Assembly Design

- Successfully completed two fuel fabrication campaigns
  - May 2015 test fuel assemblies (2)

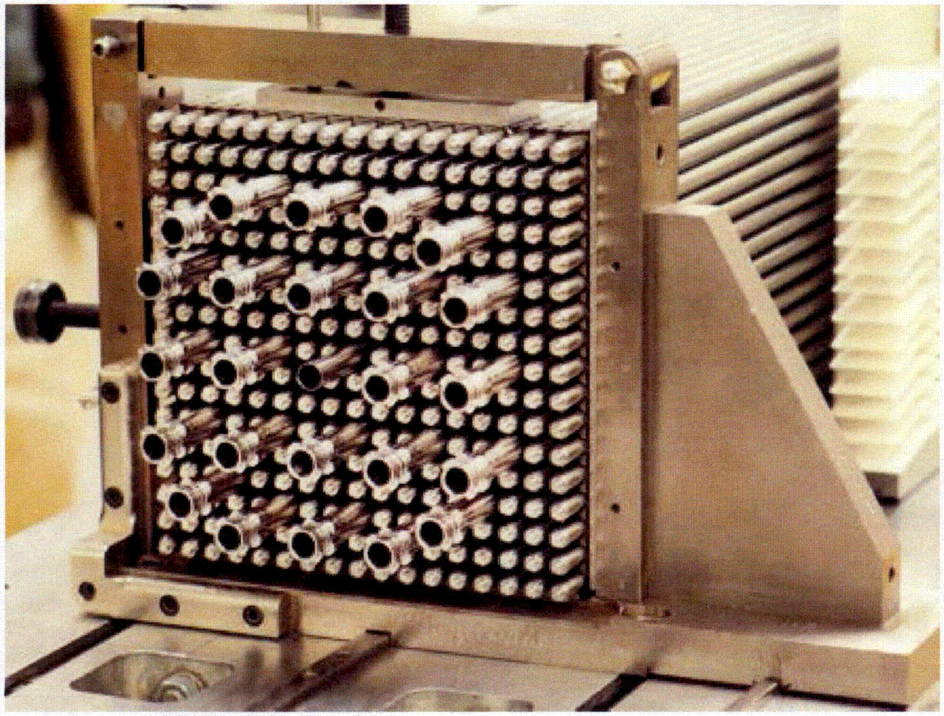


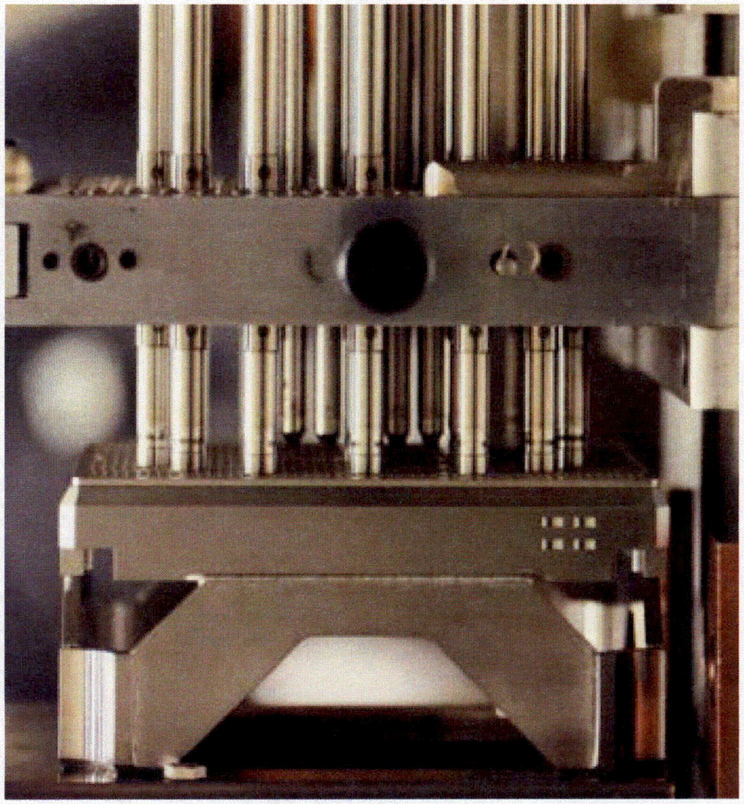




NuScale Fuel Assembly Design

- September test fuel assemblies (2) and CRAs (3)





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Fuel Test Program Status

- BOL and EOL testing to characterize the mechanical response of the fuel assembly for seismic calculations
  - all BOL and EOL mechanical testing is complete – preliminary results as expected
  - reports due to complete end of September
- Life and wear testing
  - 1,000-hour test to characterize the grid-to-rod fretting performance is complete – rod inspections pending
- Hydraulic flow testing to determine pressure drop and lift characteristics
  - flow lift testing and pressure drop testing complete – preliminary results as expected

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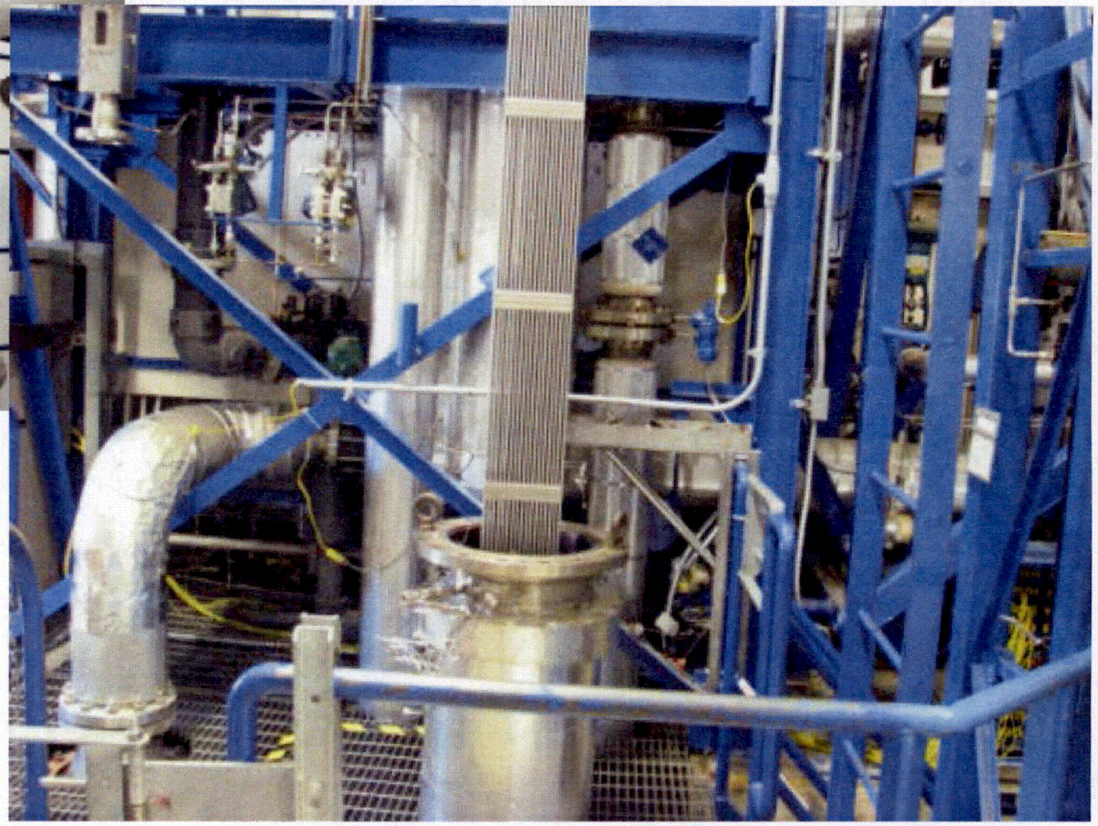
Fuel Test Program Status



Fuel Development Schedule

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}}2(a)

Ahead of project schedule – currently in analysis phase

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Fuel Analysis Scope

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}}2(a)-(b)

Thermal-mechanical results to date all support the NuScale fuel cycle designs – positive margins to all mechanical design criteria

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Fuel Analysis Scope

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}}2(a)-(b)

Mechanical results to date all show positive margin to mechanical design criteria

Fuel Analysis Scope

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}}2(a)-(b)

Thermal-hydraulics results show acceptable control rod impact velocity

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Control Rod Assembly (CRA) Design Overview

Glen Thomas, AREVA

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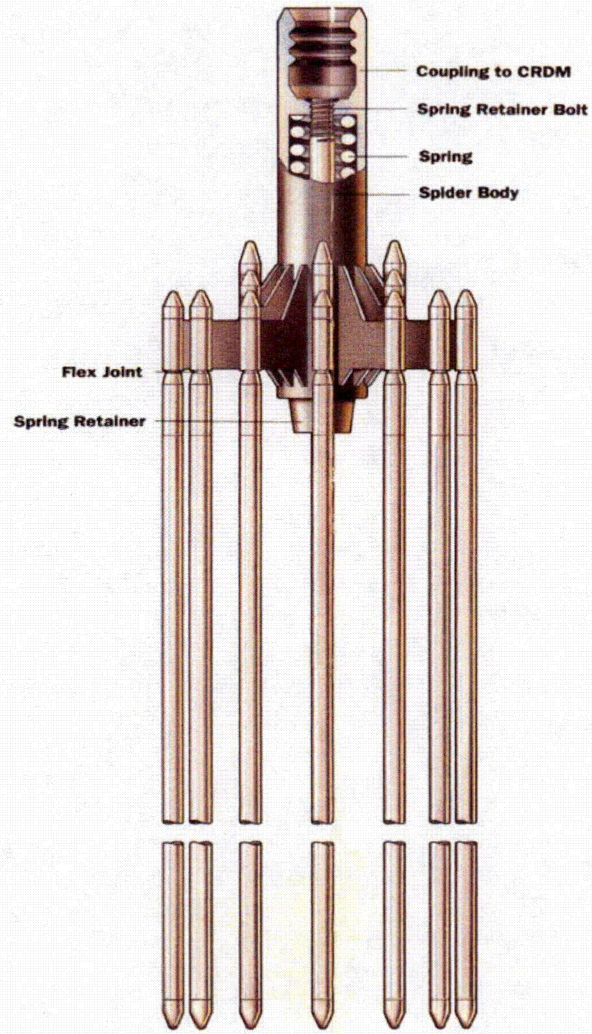
NuScale Control Rod Assembly Design

- CRA design based on AREVA's proven US 17x17 PWR technology
  - hybrid design – B_4C and AIC absorbers
  - 24 control rods with stainless steel cladding
  - one-piece cast stainless steel spider
  - flex joint formed by the combination of the pin, nut, upper end plug, and spider boss



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CRA Development Schedule

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}}2(a)

CRA analysis work on schedule to support 2016 DCA

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Summary

- AREVA fuel and CRA design work complete
- Fabrication of prototypes complete
- Project work on-track to support NuScale DCA

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NuScale Oversight

Larry Linik, NuScale Power

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NuScale Oversight

- Fabrication oversight
  - Weeks of 27 April and 4 May
  - Weeks of 24 August and 31 August
- Testing oversight
  - Week of 18 May
  - Week of 24 August
- Follow up audit
  - Focused on Software Quality Assurance
  - Week of 22 June
- Participated in the Preliminary Fuel Design Review Board
  - 25 June

Codes and Methods Applicability

- Discussion topics
  - topical report purpose and objective
  - topical report content
  - applicable AREVA codes and methods (C&M)
  - summary
  - next steps

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Codes and Methods Applicability

- Purpose: NuScale topical report will document the applicability of AREVA's codes and methods used to evaluate performance of the NuScale SMR fuel design
- Background: All of the AREVA codes and methods supporting the fuel design have been approved by the NRC for use on PWR fuel
- Objective: Obtain NRC's concurrence and approval that these AREVA codes and methods are also applicable to the NuScale SMR fuel design

Structure of Topical Report

1. Introduction
2. Background
3. Regulatory Requirements
4. EMF-92-116(P)(A), Revision 0, Generic Mechanical Design Criteria for PWR Fuel Designs
5. BAW-10227P-A, Revision 1, Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel
6. BAW-10231P-A, Revision 1, COPERNIC Fuel Rod Design Computer Code
7. BAW-10084P-A, Revision 3, Program to Determine In-Reactor Performance of BWFC Fuel Cladding
8. BAW-10133P-A, Revision 1, and Addenda 1 and 2, Mark-C FA LOCA-Seismic Analyses
9. XN-75-32(P)(A), Supplements 1 through 4, Computational Procedure for Evaluating Fuel Rod Bowing
10. Change Process

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AREVA Fuel Codes and Methods

1. EMF-92-116(P)(A), Revision 0, Generic Mechanical Design Criteria for PWR Fuel Designs
2. BAW-10231P-A, Revision 1, COPERNIC Fuel Rod Design Computer Code
3. BAW-10084P-A, Revision 3, Program to Determine In-Reactor Performance of BWFC Fuel Cladding
4. BAW-10227P-A, Revision 1, Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel
5. XN-75-32(P)(A), Supplements 1 through 4, Computational Procedure for Evaluating Fuel Rod Bowing
6. BAW-10133P-A, Revision 1, and Addenda 1 and 2, Mark-C FA LOCA-Seismic Analyses

EMF-92-116PA Applicability to NuScale

Glen Thomas - AREVA

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Design Comparison – NuScale vs W-type 17x17

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}}2(a)-(c)

NuScale fuel design parameters are identical, with exception of overall lengths

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Operating Parameter Comparison – NuScale vs W-type 17x17

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}}2(a)-(c)

NuScale operating parameters are within AREVA licensing bases

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EMF-92-116PA Overview

- EMF-92-116PA "Generic Mechanical Design Criteria for PWR Fuel Designs" defines the NRC approved fuel mechanical design criteria (SAFDLs) for AREVA PWR fuel
  - the criteria correspond to those of Chapter 4 of the Standard Review Plan (NUREG-0800)
  - EMF-92-116PA also cites or describes the methodologies used to evaluate the fuel against each criterion

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EMF-92-116PA Overview

- EMF-92-116PA is being applied in part to the NuScale fuel design project
  - NuScale is performing many of the engineering calculations that will support DCA, including neutronics work, safety analysis, and a majority of the thermal-hydraulic analyses
  - for the sections of EMF-92-116PA that do apply to the AREVA work
    - EMF-92-116PA refers to individually approved methodologies that are summarized separately (i.e., XN-75-32A)
    - more contemporary codes and methods are replacing some older codes and methods referenced in EMF-92-116PA – they are summarized separately (i.e., COPERNIC)
    - the rest of the sections are applicable and being discussed in the following slides

EMF-92-116PA Overview

- The applicable sections of EMF-92-116PA are
  - Internal hydriding (3.2.1)
  - Normal operation stress analysis in the fuel assembly structure (3.3.1)
  - Fretting wear (3.3.3)
  - Axial growth addressing both fuel rod and fuel assembly (3.3.6)
  - Fuel lift analysis (3.3.8)
  - Shipping and handling stress analysis (3.3.9)

EMF-92-116PA Applications

- The fuel mechanical design criteria presented in EMF-92-116PA have been used to license several PWR fuel designs types in the US
  - W-type 17x17 and 15x15 fuel
  - CE-type 14x14, 16x16, and 15x15 fuel

- The NuScale fuel design is very similar to W-type 17x17 fuel and has a less severe operating environment

EMF-92-116PA Applications

- 3.2.1 Fuel Rod Internal Hydriding
  - Criteria: Fuel shall not experience cladding failure due to reduced ductility
  - Hydrogen content controlled by fabrication limits for fuel pellet moisture
  - Typical fuel manufacturing processes and fuel pellet specification {{ }}$^{2(a),(c)}$ will be maintained for NuScale fuel production
  - No change to the criteria or method as it will apply to NuScale
- 3.3.1 Stress, Strain, or Loading Limits on Assembly Components
  - Criteria: Fuel components shall remain within stress levels established by the ASME code
  - Methods of calculating component normal operating stresses use open-literature equations (ASME code) or finite element methods (such as ANSYS)
    - no specific range of applicability
  - NuScale normal operating conditions will create the same fuel assembly component stress conditions (with lower magnitudes) as a typical PWR
  - No change to the criteria or method as it will apply to NuScale

EMF-92-116PA Applications

- 3.3.3 Fretting Wear
  - Criteria: Fuel rod failures due to fretting shall not occur
  - In accordance with topical, fretting performance always predicted by testing
  - A 1000-hour fretting test specific to the NuScale fuel design has been performed at AREVA
  - Applicability of the testing is assured by the use of bounding test conditions and use of a prototypic test bundle
  - The method of demonstrating compliance is applicable to the NuScale SMR

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EMF-92-116PA Applications

- 3.3.6 Axial Growth Addressing Both Fuel Rod and Fuel Assembly
  - Criteria: Growth of the fuel rod and fuel assembly shall not exceed the clearance between top and bottom nozzles and between the upper and lower core plates, respectively
  - Empirical models used for fuel rod and fuel assembly growth analyses
  - Calculations assume the dimensional constraints specific to NuScale – the core plate to core plate gap and fuel dimensions and tolerances
  - Predicted growth rates are based on fluence values specific to the anticipated NuScale core designs and are within the range of the AREVA database

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}}2(a)-(d)

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EMF-92-116PA Applications

- 3.3.8 Fuel Lift Analysis
  - Criteria: Fuel assembly shall not lift off from hydraulic loads
  - Analysis accounts for the fuel assembly mass, hold-down spring loads (not applicable to NuScale fuel design), and hydraulic forces to predict fuel liftoff
  - Mass values and predicted hydraulic forces will be specific to the NuScale SMR
  - RCS flow rate (approximately 3.1 ft./sec) is well within the values used in AREVA PWR fuel lift analyses
  - The standard analysis method and limits apply to NuScale
- 3.3.9 Fuel Assembly Handling
  - Criteria: The assembly design must withstand all normal axial loads from shipping and handling without permanent deformation
  - Analysis accounts for loads imposed on the fuel from shipping and handling
  - Shipping and handling loading conditions for NuScale should be less limiting than typical PWR fuel due to the lower fuel assembly mass
  - Allowable loads are expected to be similar to current AREVA PWR designs
  - The standard analysis method and limits therefore apply to NuScale

EMF-92-116PA Generic Restrictions

- SER approves EMF-92-116PA for PWR licensing applications up to {{ }}[2(a)-(d)] rod average burnup
  - this limit will be applied to the NuScale SMR fuel design
  - actual NuScale burnups based on fuel cycle design work are much lower than this limit (typical value is approximately 40 GWd/mtU)

Cited EMF-92-116PA sections are acceptable without limits for application to NuScale SMR

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EMF-92-116PA SMR Differences/Adjustments

- Only significant fuel design differences are the reduced fuel assembly length and mass, and the absence of a hold-down spring
  - both benefit the structural analyses
- NuScale operating environment within AREVA PWR experience
- One methodology adjustment

{{ }}2(a)

Minimal adjustments needed to apply EMF-92-116PA to NuScale SMR

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EMF-92-116PA SMR Summary and Conclusions

Conclusion: The following approved EMF-92-116PA mechanical design criteria and methodologies can be applied to the NuScale SMR fuel design

- Internal hydriding (3.2.1)
- Normal operation stress analysis in the fuel assembly structure (3.3.1)
- Fretting wear (3.3.3)
- Axial growth addressing both fuel rod and fuel assembly (3.3.6)
- Fuel lift analysis (3.3.8)
- Shipping and handling stress analysis (3.3.9)

BAW-10231PA Applicability to NuScale

Philippe Bellanger, AREVA

BAW-10231PA Overview

- BAW-10231PA, "COPERNIC Fuel Rod Design Computer Code," defines
  - the models and material properties needed to accurately predict the thermal and mechanical behavior of fuel rods under irradiated conditions
  - the methodology to analyze fuel rod criteria highly sensitive to irradiation history
    - rod internal pressure
    - clad corrosion
    - transient clad strain
    - fuel centerline temperature
    - clad creep collapse initialization
- COPERNIC is a modern fuel rod performance code that explicitly models the effects of burnup degradation on fuel thermal conductivity

BAW-10231PA Applications

- The COPERNIC code and its associated methods are currently used in US PWR licensing applications
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design
- NuScale fuel design is similar to AREVA 17x17 fuel design currently analyzed with COPERNIC
- NuScale SMR operating conditions are less severe (powers, temperatures) than that of the existing US PWR fleet

BAW-10231PA Applications

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}}2(a)-(d)

Current ranges of applicability bracket NuScale SMR design characteristics and operating conditions

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BAW-10231PA Pertinent Parameters

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}}2(a)-(d)

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BAW-10231PA Generic Restrictions

- Generic restrictions listed in the COPERNIC Safety Evaluation Report do not preclude application to NuScale SMR

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}}2(a)-(d)

- Safety Evaluation Report implies that the report is restricted to following designs
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design
- AREVA completed a detailed COPERNIC technical review and concluded it is applicable to the NuScale SMR

BAW-10231PA Thermal Models

- Thermal models predict the radial temperature distributions across the fuel, pellet-to-clad gap, clad, and clad oxide layer
  - fuel thermal conductivity {{ }}2(a)-(d)
  - gap conductance {{ }}2(a)-(d)
  - cladding thermal conductivity {{ }}2(a)-(d)
  - oxide thermal conductivity {{ }}2(a)-(d)
- COPERNIC models are currently applied over a range of {{ }}2(a)-(d) that bound the NuScale SMR operating conditions

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BAW-10231PA Fission Gas Release

- COPERNIC fission gas release model includes the effects of two phenomena
  - athermal release {{ }}2(a)-(d)
  - thermal release {{ }}2(a)-(d)
- COPERNIC models are currently applied over a range of {{ }}2(a)-(d) that cover the NuScale SMR operating conditions
- COPERNIC fission gas release database bounds NuScale's anticipated operating conditions

BAW-10231PA Mechanical Models

- Pellet mechanical models predict the fuel pellet deformations caused by
  - fragmentation and fragment relocation
  - fuel densification
  - fuel swelling (solid and gaseous)
  - fuel thermal expansion
- These models are a function of {{ }}$^{2(a)-(d)}$
- COPERNIC models are currently applied over a range of {{ }}$^{2(a)-(d)}$ that cover the NuScale SMR operating conditions
- COPERNIC validation database covers NuScale's anticipated operating conditions

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BAW-10231PA Mechanical Models

- Clad mechanical models predict the cladding deformation caused by
  - clad creep (thermal and irradiation components)
  - clad axial growth
  - clad thermal expansion
- These models are a function of {{ }}2(a)-(d)
- COPERNIC models are currently applied over a range of {{ }}2(a)-(d) that cover the NuScale SMR operating conditions
- COPERNIC validation database covers NuScale's anticipated operating conditions

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BAW-10231PA Clad Corrosion

- Corrosion model predicts the oxide layer growth rate
- Model is a function of

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}}2(a)-(d)

- COPERNIC models are currently applied over a range of {{ }}2(a)-(d) that cover the NuScale SMR operating conditions
- COPERNIC corrosion calibration and validation database covers the NuScale SMR's anticipated ranges for {{ }}2(a)-(d)

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BAW-10231PA Methodology

- The methodology described in BAW-10231PA is applicable to NuScale
- Analysis input specific to the NuScale SMR design will be used

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}}2(a)-(d)

BAW-10231PA SMR Differences

- Coolant natural circulation flow is a key difference between NuScale SMR and conventional PWRs
  - coolant-to-clad heat transfer correlations are typically a function of flow regime and NuScale SMR Reynolds number is 15-20% that of conventional PWRs due to its natural circulation

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}}2(a)-(c)

- NuScale SMR system pressure is 1850 psia vs. 2000-2280 psia in conventional PWRs
  - rod internal pressures will be limited to system pressure (instead of the approved {{ }} 2(a)-(c) design limit)
  - low powers and low burnups allow for this conservative approach

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BAW-10231PA Summary

Conclusion: The approved BAW-10231PA models and methodology can be applied to the NuScale SMR fuel design for the following applications

- rod internal pressure analyses
- fuel centerline temperature analyses
- transient clad strain analyses
- creep collapse initialization analyses
- clad corrosion analyses

BAW-10084PA Applicability to NuScale

Philippe Bellanger, AREVA

BAW-10084PA Overview

- BAW-10084PA, "Program to Determine In-Reactor Performance of BWFC Fuel Cladding"
  - documents the creep collapse methodology to ensure that AREVA fuel rods do not collapse during their design lifetimes
  - describes and validates the ovalization creep rate correlations
  - lists and justifies the creep collapse design limits
- BAW-10227PA extends the application of the creep collapse methodology to {{ }}2(a)-(c)
  - BAW-10084PA was approved prior to the introduction of {{ }}2(a)-(c)
- BAW-10231PA supersedes the creep collapse initialization portion of the original methodology
  - BAW-10084PA was approved prior to the approval of the COPERNIC code

BAW-10084PA Applications

- The CROV code and its associated method are currently used in US PWR licensing applications
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design
- NuScale fuel design is similar to AREVA 17x17 fuel design currently analyzed with COPERNIC
- NuScale SMR operating conditions {{ }}[2(a)-(c)] are less severe than or equivalent to that of existing US PWR fleet

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BAW-10084PA Pertinent Parameters

- Creep ovalization rates and collapse criteria limits are most affected by

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}}2(a)-(c)

- NuScale SMR key parameters are within the operating experience of the PWRs currently licensed with BAW-10084PA

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BAW-10084PA Generic Restrictions

- BAW-10084PA is applicable to AREVA's fuel designs but restricted to {{ }}2(a)-(c)
  - BAW-10227PA extended the application of the CROV code to fuel designs with {{ }}2(a)-(c)
- Creep correlation was approved for {{ }}2(a)-(c)
  - NuScale SMR features lower core powers and coolant temperatures than conventional PWRs
  - fuel irradiated in NuScale SMRs will experience lower {{ }}2(a)-(c)

BAW-10084PA SMR Differences

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}}2(a)-(c)

BAW-10084PA Summary

<u>Conclusion:</u> The approved BAW-10084PA models and methodology can be applied to the NuScale SMR fuel design

- minor adjustment to the method {{ }}2(a) will be described and justified in NuScale's Codes and Methods Applicability Topical Report
- creep collapse initialization data will be generated per the approved method described in BAW-10231PA

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BAW-10227PA Applicability to NuScale

Philippe Bellanger, AREVA

BAW-10227PA Overview

- BAW-10227PA, “Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel,” summarizes
  - the analysis methodology used for AREVA M5® fuel rod cladding
  - the M5® fuel rod design limits and their justification
- Chapter 2 of BAW-10227PA addresses M5® structural components
  - NuScale assembly structural components are made of Zircaloy-4 and therefore this chapter is not relevant to the NuScale design
- Chapter 4 and Appendices C, D, F, and G relate to AREVA accident criteria and evaluation methodology
  - NuScale will submit a separate methodology for NRC review and therefore these sections of BAW-10227PA are not relevant to the NuScale SMR

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BAW-10227PA Overview

- The methodology relative to some fuel rod design criteria was later superseded by BAW-10231PA
  - rod internal pressure
  - clad corrosion
  - transient clad strain
  - fuel centerline temperature
  - clad creep collapse initialization
- BAW-10227PA chapters relevant to the NuScale SMR are limited to

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}}2(a)

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BAW-10227PA Applications

- BAW-10227PA has been used to license various US PWR fuel types
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design
- NuScale fuel rod design has identical radial dimensions as other AREVA 17x17 fuel design
- NuScale SMR operating conditions are less severe (temperatures, pressures) than that of the existing US PWR fleet

BAW-10227PA Pertinent Parameters

- Fuel rod mechanical analyses (clad stress, buckling, and fatigue) are most influenced by one or more of the following parameters

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}}2(a)-(c)

- Key parameters for the NuScale fuel rod mechanical analyses are within the range of existing applications of BAW-10227PA

BAW-10227PA Generic Restrictions

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}}2(a)-(c)

BAW-10227PA SMR Differences

- No difference in fuel rod radial dimensions
- Differences in operating environment
  - NuScale SMR operating conditions are less severe (temperatures, pressures) than that of the existing US PWR fleet
- No methodology adjustment necessary

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BAW-10227PA Summary

<u>Conclusion:</u> The approved BAW-10227PA methodology can be applied to the NuScale SMR fuel design for the following applications

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}}2(a)-(c)

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XN-75-32(P)(A) Applicability to NuScale

Richard Harne, AREVA

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XN-75-32(P)(A) Suppl. 1- 4 Overview

- XN-75-32(P)(A) Supplements 1- 4 defines the NRC approved procedure for evaluating fuel rod bowing
  - fuel rod bowing is the deviation from straightness of fuel rods in the fuel assembly
  - fuel rod bowing is primarily influenced by
    - slip load of the intermediate grids and upper end spacer grid
    - span length between spacer grids
    - coolant cross flow forces
    - core operating conditions
  - primary concerns
    - reduction in rod-to-rod water gap resulting in decrease in critical heat flux (CHF) margin
    - increase in rod-to-rod water gap resulting in increase in local power peak

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XN-75-32(P)(A) Suppl. 1- 4 Applications

- The procedure for evaluating fuel rod bowing presented in XN-75-32(P)(A) Supplements 1- 4 has been used to license most HTP PWR fuel designs in the US
  - W-type 17x17 and 15x15 fuel
  - CE-type 14x14, 16x16, and 15x15 fuel

- The NuScale fuel design is very similar to the HTP 17x17 fuel design in operating plants in the axial region of the fuel rods with the exception of
  - the fuel assembly length
  - relative guide tube dashpot height

XN-75-32(P)(A) Suppl.1- 4 Pertinent Parameters

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}}2(a)-(d)

XN-75-32(P)(A) Suppl.1- 4 Pertinent Parameters

Parameter	NuScale SMR Value	17x17 PWR Value
Rated Thermal Power (MWt)	160	3455
Average Coolant Velocity (ft/s)	3.1	16
System Pressure (psia)	1850	2280
Core Tave (F)	547	584
Linear Heat Rate (kW/m)	8.2	18.0
Typical Cycle Length (years)	2	1.5
RCS Inlet Temperature (F)	503	547
Fuel Assemblies in Core	37	193
RCS Reynolds Number	76,000	468,000

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XN-75-32(P)(A) Suppl. 1- 4 Applications

Gap closure model

- the NuScale design is within current experience for fuel rod bending stiffness and core operating parameters, and is less limiting for end grid slip loads and spacer grid span lengths
- the NuScale design is expected to have a relatively high resistance to fuel rod bow in comparison with AREVA non-HTP 17x17 PWR fuel

- CHF-based penalties
  - based on magnitude of gap closure and reduction of CHF

{{ }}2(a)-(c)

- LHGR penalties
  - NuScale fuel design is within current experience for fuel-to-moderator ratio

Topical report CHF-based penalty procedure and power peaking augmentation are applicable to the NuScale SMR fuel design

XN-75-32(P)(A) Suppl. 1- 4 Generic Restrictions

- SER restriction: Acceptability is limited to fuel designs, exposures, and conditions stated in topical report supplements and supporting documentation
  - justification of the applicability of the report to HTP fuel has been established in

    ANF-89-060(P)(A) Supplement 1, "Generic Mechanical Design Report, High Thermal Performance Spacer and Intermediate Flow Mixer", February 1991
- SER restriction: Not applicable to fuel designs that exhibit a greater propensity for bowing than that given in data from which models were reviewed

<u>Conclusion:</u> XN-75-32(P)(A) Supplements 1- 4 is applicable to NuScale SMR

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XN-75-32(P)(A) Suppl. 1- 4 Differences/Adjustments

- No significant fuel design differences
  - expected lower propensity for fuel rod bowing

- No significant operating environment differences

- No methodology adjustment needed

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XN-75-32(P)(A) Suppl. 1- 4 Summary and Conclusions

The XN-75-32(P)(A) Supplements 1- 4 “Computational Procedure for Evaluating Fuel Rod Bowing” can be applied to the NuScale SMR fuel design with no methodology adjustment

BAW-10133PA Applicability to NuScale

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BAW-10133PA Overview

- "BAW-10133PA" refers to BAW-10133PA, Rev. 1 including Addenda 1 and 2
- The topical report defines
  - the method to construct horizontal and vertical accident models
  - the method to calculate the component loads from horizontal and vertical accident loadings
  - acceptance criteria for grid and non-grid components

BAW-10133PA Approved Applications

- SER for BAW-10133PA notes approval for "Mark-C fuel design and similar designs"
- Methodology was modified in Addendum 1 and stated that "the application of this method is for generic use"
- Sample problems demonstrate applicability to two 17x17 designs (Mark-C and fuel for Westinghouse reactors)
- The method has been applied to numerous designs
  - Westinghouse 15x15 and 17x17
  - B&W 15x15 and 17x17
  - CE 14x14 and 16x16
- Application to other designs has been extended through reference in License Amendment Requests

BAW-10133PA Pertinent Parameters

- Design specificity is introduced in the characterization of fuel through testing
- Plant specificity is introduced in the geometry of the model boundary conditions and inputs
- Key parameters
  - horizontal models
    - fuel assembly frequencies and damping
    - spacer grid stiffness and strength
  - vertical models
    - axial stiffness
    - bottom nozzle impact properties

BAW-10133PA Generic Restrictions

- No restrictions are imposed in the Safety Evaluation Report

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BAW-10133PA SMR Differences/Adjustments

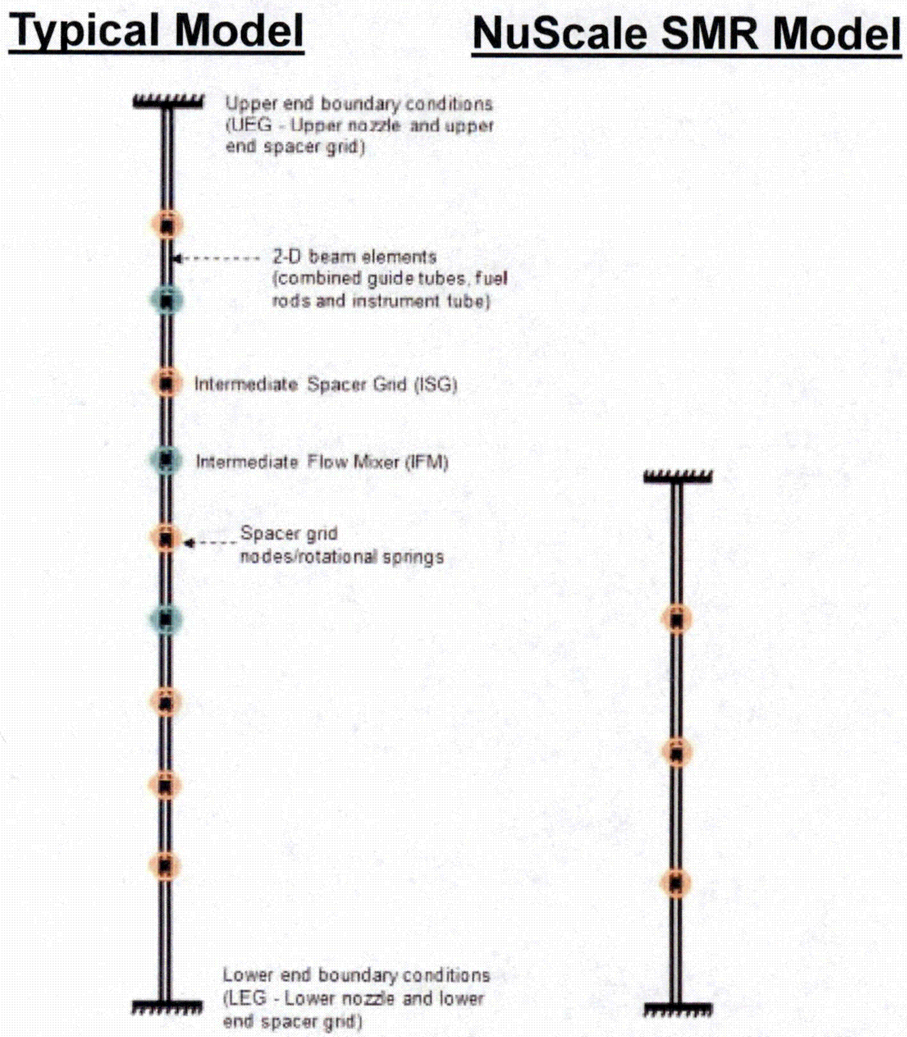
- Definition of assembly damping values
  - lower flow conditions and shorter assemblies challenge the established value in BAW-10133PA, Rev. 1, Addendum 2
  - a new value will be established and justified based on

{{

}}2(a)-(d)

BAW-10133PA SMR Differences/Adjustments

- Limited number of nodes and assembly frequencies in the horizontal fuel model
  - per BAW-10133PA, rotational nodes are added at intermediate spacer locations
  - for the NuScale design, only three nodes are present
  - initial modeling and testing indicate this is sufficient



BAW-10133PA SMR Differences/Adjustments

- A single assembly model will be used to evaluate the vertical response of NuScale SMR fuel for seismic and LOCA
  - BAW-10133PA defines different vertical models for seismic/LOCA
    - seismic: single assembly model
      - » appropriate since fuel excitation is caused only by motion of core plates
    - LOCA: core bounce model
      - » models response of reactor internals and fuel to oscillatory hydraulic forces
      - » single assembly model is an element in the core bounce model
  - Due to the nature of the NuScale SMR design, no significant hydraulic forces act on the fuel during a LOCA
  - With vertical excitation only coming from core plates, a single assembly model is appropriate for both seismic and LOCA

BAW-10133PA Summary

- The methodology of BAW-10133PA is applicable to the NuScale SMR design
- The most significant methodology adjustment is to adapt the damping to the NuScale application

Summary

- Licensing strategy change
- Progress update
- Applicability of AREVA methods

Next Steps

- NRC feedback
- Submit Codes and Methods Applicability Topical Report

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