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UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Impacts of HBU, IE and ATF on Radiological Source Terms

3rd Joint EPRI-INL Higher Burnup Workshop

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Types of Radiological Source Terms

- Radiological source terms for postulated accidents:

  1) MHA-LOCA, which is based on a generic, deterministic, core-average, fuel melt source term

  2) Non-LOCA DBA, which are based on site-specific, mechanistic, peak fuel rod, source terms

- Both may be sensitive to high burnup (HBU), increased ^{235}U enrichment (IE), and accident tolerant fuels (ATF)

Impacts on Radiological Inputs and Assumptions

Radiological Inputs / Assumptions	Extended BU 62-68	HBU 68-75	Increased ^{235}U Enrichment	Doped UO_2 Fuel	Coated Zirconium Cladding	FeCrAl Cladding
Core Average Radionuclide Inventories						
Core Average Decay Heat						
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form						
Steady-State Radionuclide Release Fractions (Pellet→ Rod Plenum)						
Fuel Rod Damage (Number of Failed Fuel Rods)						
Transient Radionuclide Release Fractions						
Fuel Rod Power Peaking Factors (FdH)						

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Radiological Inputs / Assumptions	Extended BU 62-68	HBU 68-75	Increased ^{235}U Enrichment	Doped UO_2 Fuel	Coated Zirconium Cladding	FeCrAl Cladding
Core Average Radionuclide Inventories	✓					
Core Average Decay Heat	✓					
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form	✓					
Steady-State Radionuclide Release Fractions (Pellet→ Rod Plenum)	✓					
Fuel Rod Damage (Number of Failed Fuel Rods)	- -					
Transient Radionuclide Release Fractions	✓					
Fuel Rod Power Peaking Factors (FdH)	- -					

Impacts on Radiological Inputs and Assumptions

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Core Average Radionuclide Inventories	✓	✓	✓			
Core Average Decay Heat	✓	✓	✓			
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form	✓	✓	✓			
Steady-State Radionuclide Release Fractions (Pellet→ Rod Plenum)	✓	✓	✓			
Fuel Rod Damage (Number of Failed Fuel Rods)	- -	✓	✓			
Transient Radionuclide Release Fractions	✓	✓	✓			
Fuel Rod Power Peaking Factors (FdH)	- -	✓	✓			

Impacts on Radiological Inputs and Assumptions

Radiological Inputs / Assumptions	Extended BU 62-68	HBU 68-75	Increased ^{235}U Enrichment	Doped UO_2 Fuel	Coated Zirconium Cladding	FeCrAl Cladding
Core Average Radionuclide Inventories	✓	✓	✓	- -		
Core Average Decay Heat	✓	✓	✓	- -		
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form	✓	✓	✓	- -		
Steady-State Radionuclide Release Fractions (Pellet→ Rod Plenum)	✓	✓	✓	Proprietary		
Fuel Rod Damage (Number of Failed Fuel Rods)	- -	✓	✓	Proprietary		
Transient Radionuclide Release Fractions	✓	✓	✓	Proprietary		
Fuel Rod Power Peaking Factors (FdH)	- -	✓	✓	- -		

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Core Average Radionuclide Inventories	✓	✓	✓	- -	- -	
Core Average Decay Heat	✓	✓	✓	- -	- -	
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form	✓	✓	✓	- -	- -	
Steady-State Radionuclide Release Fractions (Pellet→ Rod Plenum)	✓	✓	✓	Proprietary	- -	
Fuel Rod Damage (Number of Failed Fuel Rods)	- -	✓	✓	Proprietary	?	
Transient Radionuclide Release Fractions	✓	✓	✓	Proprietary	- -	
Fuel Rod Power Peaking Factors (FdH)	- -	✓	✓	- -	- -	

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Core Average Radionuclide Inventories	✓	✓	✓	- -	- -	?
Core Average Decay Heat	✓	✓	✓	- -	- -	?
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form	✓	✓	✓	- -	- -	?
Steady-State Radionuclide Release Fractions (Pellet → Rod Plenum)	✓	✓	✓	Proprietary	- -	?
Fuel Rod Damage (Number of Failed Fuel Rods)	- -	✓	✓	Proprietary	?	?
Transient Radionuclide Release Fractions	✓	✓	✓	Proprietary	- -	?
Fuel Rod Power Peaking Factors (FdH)	- -	✓	✓	- -	- -	?

Impacts on Radiological Inputs and Assumptions

Radiological Inputs / Assumptions	Extended BU 62-68	HBU 68-75	Increased ^{235}U Enrichment	Doped UO_2 Fuel	Coated Zirconium Cladding	FeCrAl Cladding
Core Average Radionuclide Inventories	✓	✓	✓	- -	- -	?
Core Average Decay Heat	✓	✓	✓	- -	- -	?
Core Average MHA-LOCA Release Fractions, Timing, Chemical Form	✓	✓	✓	- -	- -	?
Steady-State Radionuclide Release Fractions (Pellet→ Rod Plenum)	✓	✓	✓	Proprietary	- -	?
Fuel Rod Damage (Number of Failed Fuel Rods)	- -	✓	✓	Proprietary	?	?
Transient Radionuclide Release Fractions	✓	✓	✓	Proprietary	- -	?
Fuel Rod Power Peaking Factors (FdH)	- -	✓	✓	- -	- -	?

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License Amendment Requests

- Licensees should evaluate their plant's license bases associated with radiological consequence assessments to determine potential impacts of HBU, IE, and ATF
  - Existing source terms likely limited to 62 GWd/MTU rod average and existing fuel designs

- Licensees will likely need to submit a LAR to address impacts on radiological consequence assessments
  - Changes to radiological source terms not allowed under 10 CFR 50.59 provisions*

* 10 CFR 50.67 Statement of Considerations states that changes to the fraction of the fission product inventory of the radionuclides released from the reactor fuel, their chemical and physical form, or the timing of their releases should not be implemented under 10 CFR 50.59..

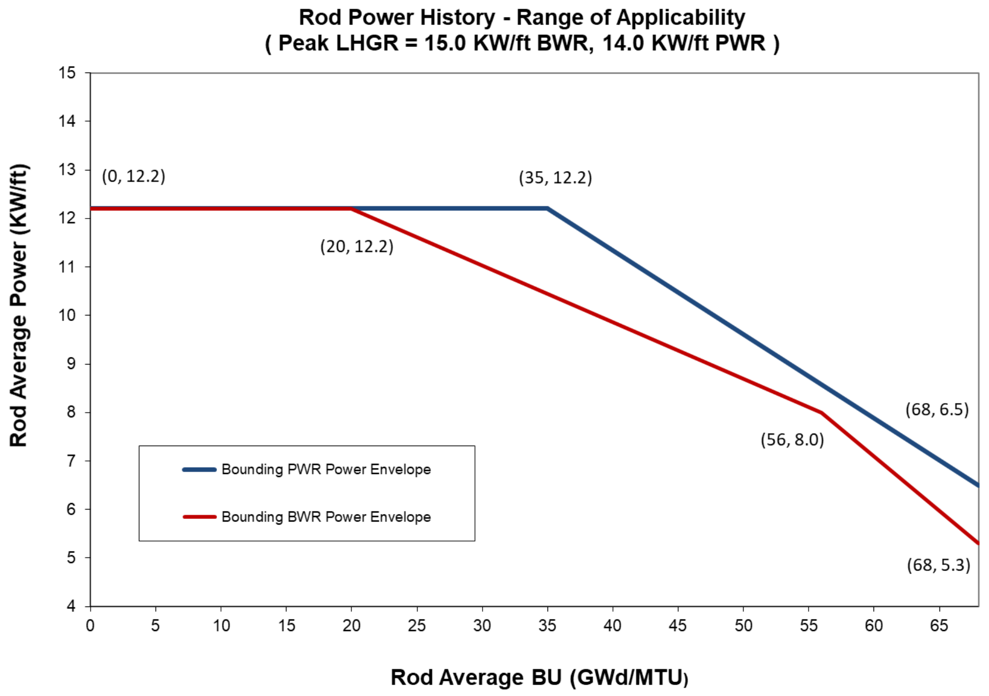
Regulatory Guidance

- DG-1389 provides updated guidance for calculating AST radiological consequences
  - Future revision to RG 1.183

- Applicability expanded to support near-term industry objectives
  - MHA-LOCA source term applicable up to 68 GWd/MTU rod average burnup, 8.0 wt% ^{235}U, Chromia-doped UO_2 fuel, and coated zirconium cladding
  - Deterministic, core-average melt source term less sensitive to rod design and power history
  - Revised source terms to support HBU (beyond 68) under development

Regulatory Guidance

- Non-LOCA DBA source term applicable up to 68 GWd/MTU rod average burnup for expanded operating domain
- Mechanistic, peak rod source term sensitive to rod design and power history
- Too many degrees of freedom in design and operations
- Vendor proprietary fuel properties
- **Acceptable analytical method for calculating plant-specific release fractions provided in updated guidance**



QUESTIONS?