



# BWXT Advanced Nuclear Reactor (BANR)

## Regulatory Update

BANR-LTR-23-0261

## Non-Proprietary Enclosure 2

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June 6, 2023



1. Fuel Development Progress
2. Review of Fuel Qualification Approach
3. Proposed Content of Fuel Qualification White Paper
4. PIRT Methodology
5. Integral Effects Testing and Separate Effects Testing (IET and SET)

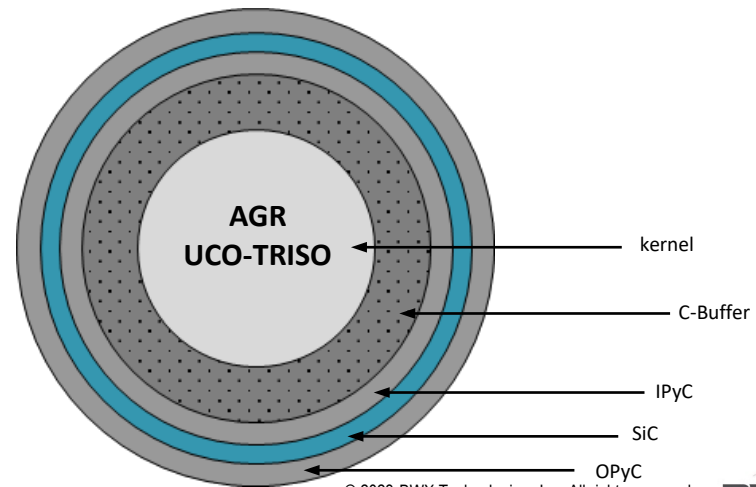
# 1 - Fuel Development Progress



## Particle Architecture Established

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	Metric	BANR TRISO	AGR TRISO	unit
	Kernel diameter	[[ [4] ]]	425 ± 10	micron
thickness	C-Buffer		100 ± 15	micron
	IPyC		40 ± 4	micron
	SiC		35 ± 3	micron
	OPyC		40 ± 4	micron
	Kernel/Particle volume ratio	0.1228	-	





## *UN Kernel Formation*

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## ***TRISO Coating Layer Development***

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## *Binder Jet Preforms*

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## ***Preliminary Design of Irradiation Test Train***

- Conceptual Design Completed in 2022
- Preliminary Design Review in June 2023
- Contents of test train

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- Irradiate fuel under a range of conditions, for example:

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## *Fuel Contents of Irradiation Test Train*

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## ***Irradiation Test Train Test Specimen Geometries***

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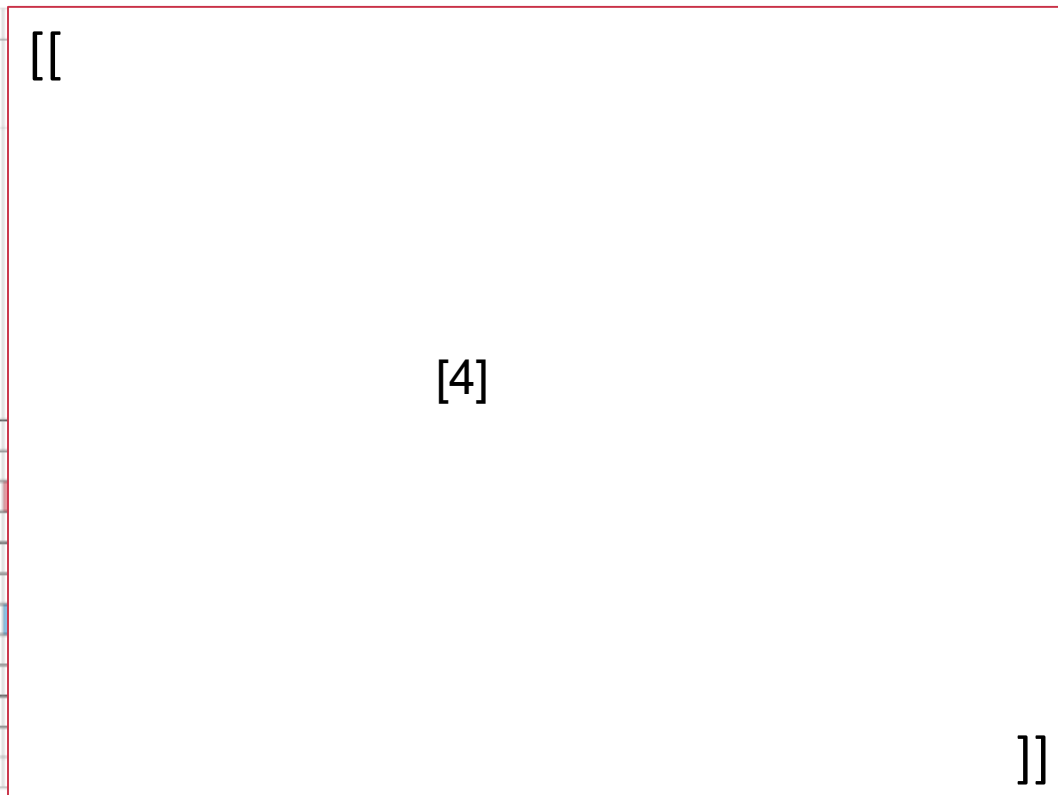
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## Refined Models of Full Scale BANR Fuel Elements (Example 1)

Parameter	Units
Fuel element geometry type	-
Image	-
Active Core Radius	m
Active Core Height	m
Active Core L/D	-
Fuel Assembly Pitch (flat to flat)	m
# of Fuel Elements	#
Total Core Radius	m
Total Core Height (1.8*active height)	m
Coolant Channel Thickness	cm
Fuel Rind Thickness	cm
Fuel Meat Thickness	cm
Fuel Element Radius	cm
U mass (total)	kg



Cooling Channel

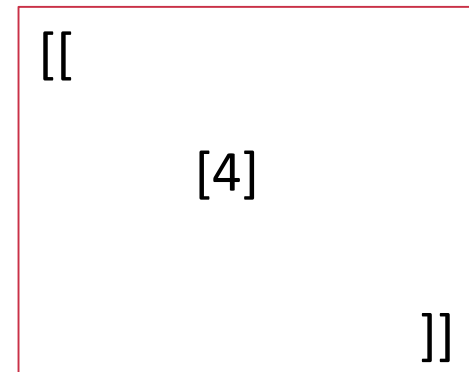
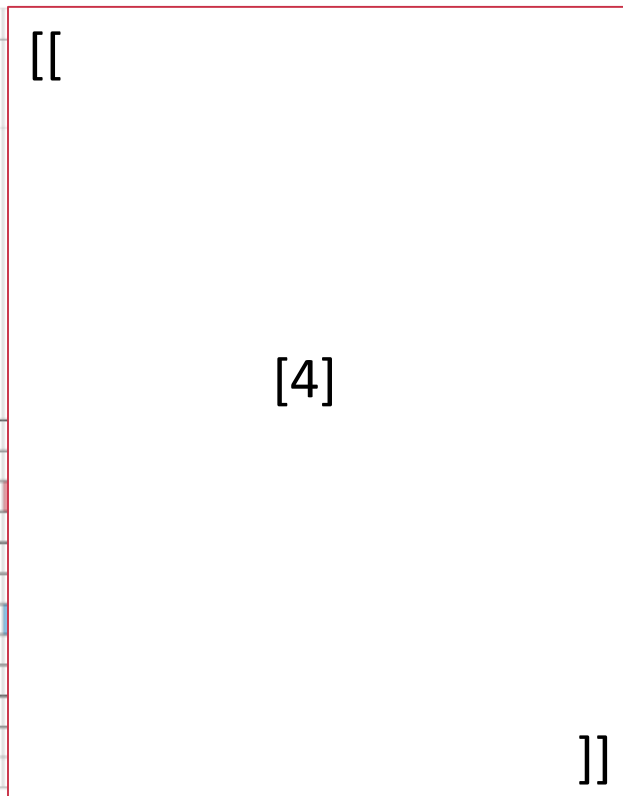
Core Moderator Block

Fuel Matrix



## Refined Models of Full Scale BANR Fuel Elements (Example 2)

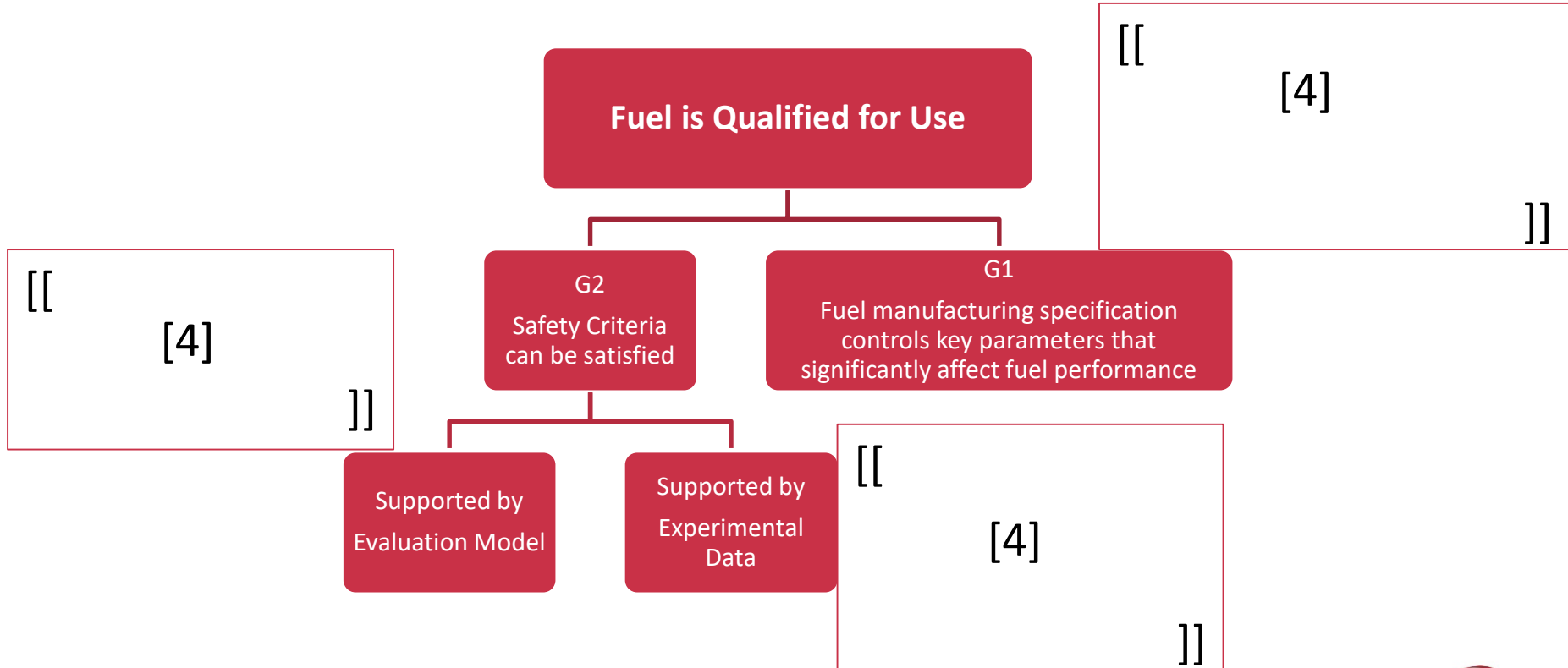
Parameter	Units
Fuel element geometry type	-
Image	-
Active Core Radius	m
Active Core Height	m
Active Core L/D	-
Fuel Assembly Pitch (flat to flat)	m
# of Fuel Elements	#
Total Core Radius	m
Total Core Height (1.8*active height)	m
Coolant Channel Thickness	cm
Fuel Rind Thickness	cm
Fuel Meat Thickness	cm
Fuel Element Radius	cm
U mass (total)	kg



- Cooling Channel
- Core Moderator Block
- Fuel Matrix

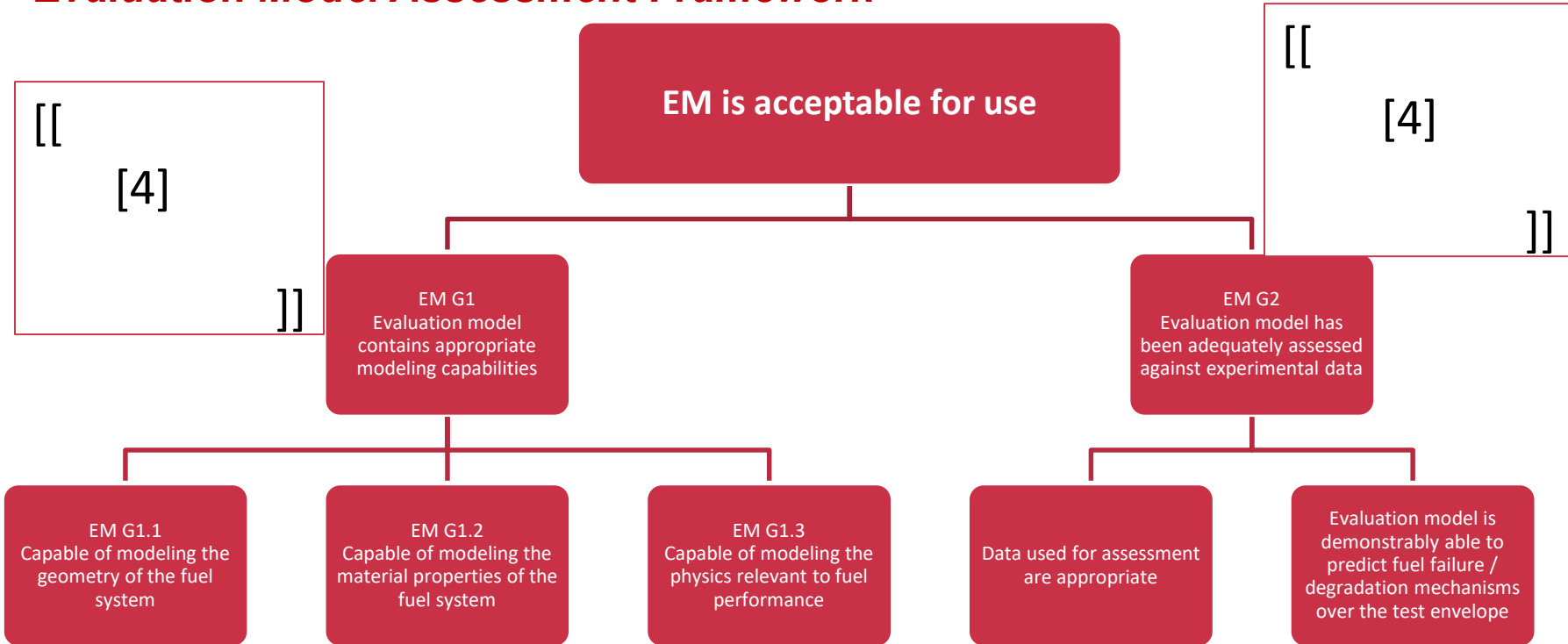


### Fuel Qualification Assessment Framework





### Evaluation Model Assessment Framework





### ***The BANR fuel qualification white paper will include testing plans***

- Implementing aspects of Accelerated Fuel Qualification (AFQ)
  - “Design, Build, Test” → culture and pathway
- Integration of modeling and simulation with experimental work
- Integration of SET and IET → more data, better data, less time and cost
- Examples of envisioned SET and IET activities



## ***Fuel Qualification White Paper will provide framework for Fuel Qualification Topical Report***

- TRISO particle discussion

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- PIRT for Fuel Qualification

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- Fuel design criteria

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## ***Fuel Qualification White Paper will provide framework for Fuel Qualification Topical Report***

- Fuel performance modeling
  - Defined analytical approach

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- Fuel fabrication specifications

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- Test plans

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- Fuel Performance

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### Scope

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- Outputs support risk-informed and performance-based integral fuel performance criteria specific to evaluation criteria for scenarios of interest.
  - Primary properties
  - Phenomena (processes, characteristics, factors, and phenomena)
  - Methods (QC methods of analysis, controls and tests performed)
  - Utilizes a EMDAP to define the level of “graded approach” required for a modified fuel/fuel form



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## *Approach*

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## *Methodology*

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## *Methodology (continued)*

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## *Example 1*

### MODIFIED OR NEW PHENOMENA OR METHOD

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## ***Example 2***

### MODIFIED OR NEW PHENOMENA OR METHOD

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### ***IET and SET will play separate and integrated roles in fuel qualification***

- Integral effects testing (IET) demonstrates and validates performance of BWXT fuel in conditions representative of normal operations and accidents
  - Example: Efforts already underway for irradiation testing of relevant fuel in ATR
- Separate effects testing (SET) allows us to understand specific aspects of the fuel or matrix material in controlled conditions, enabling design changes as well as improvement and validation of Evaluation Models

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### ***BWXT BANR-1 ATR Irradiation Test Objectives and Example***

- Collect continuous fission gas measurements released from the fuel
- Irradiate fuel under a range of conditions, specifically:

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- Fuel specimens:

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### ***Post Irradiation Examination (PIE) Provides Fuel Performance and Characterization Data to Support Fuel Qualification***

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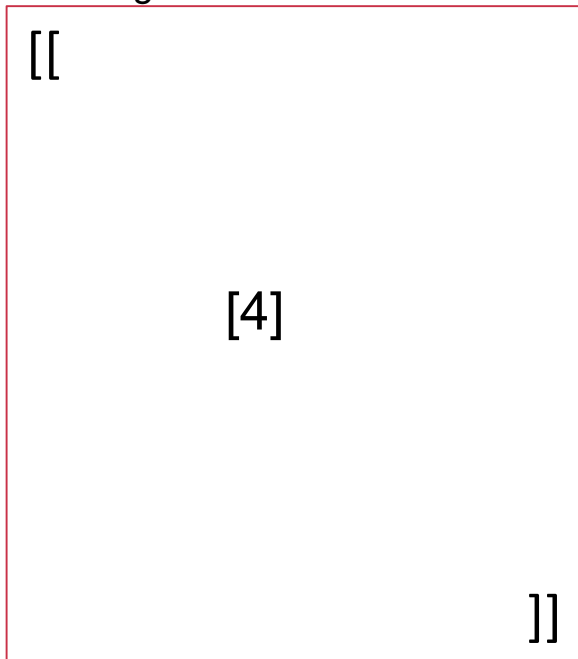
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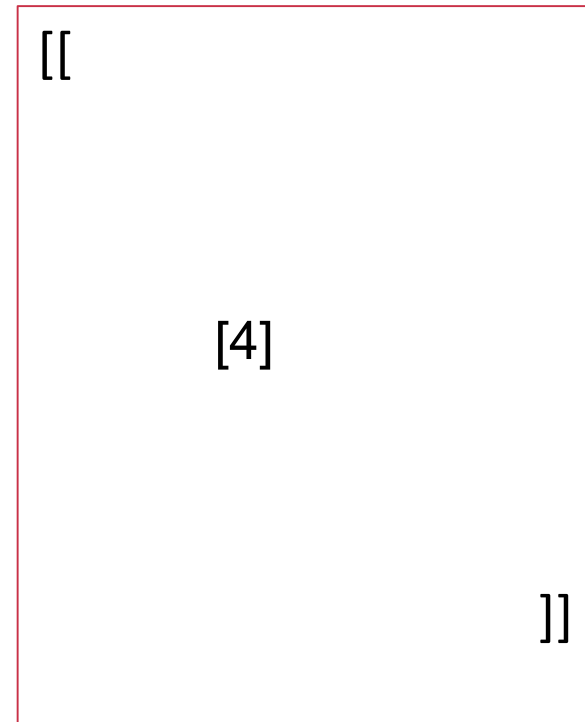
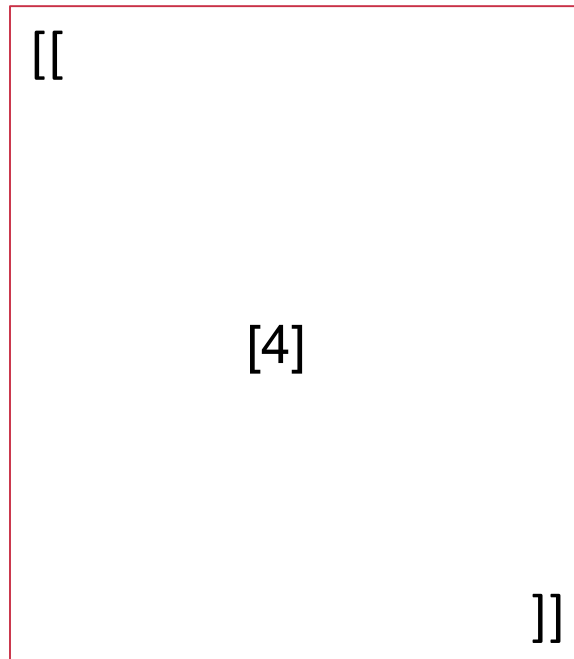


## **Examples of Characterization Planned for BANR Test Specimens**

○ Surrogate-TRISO/CVI-SiC



○ natUN-TRISO/CVI-SiC



# Questions and Open Discussion