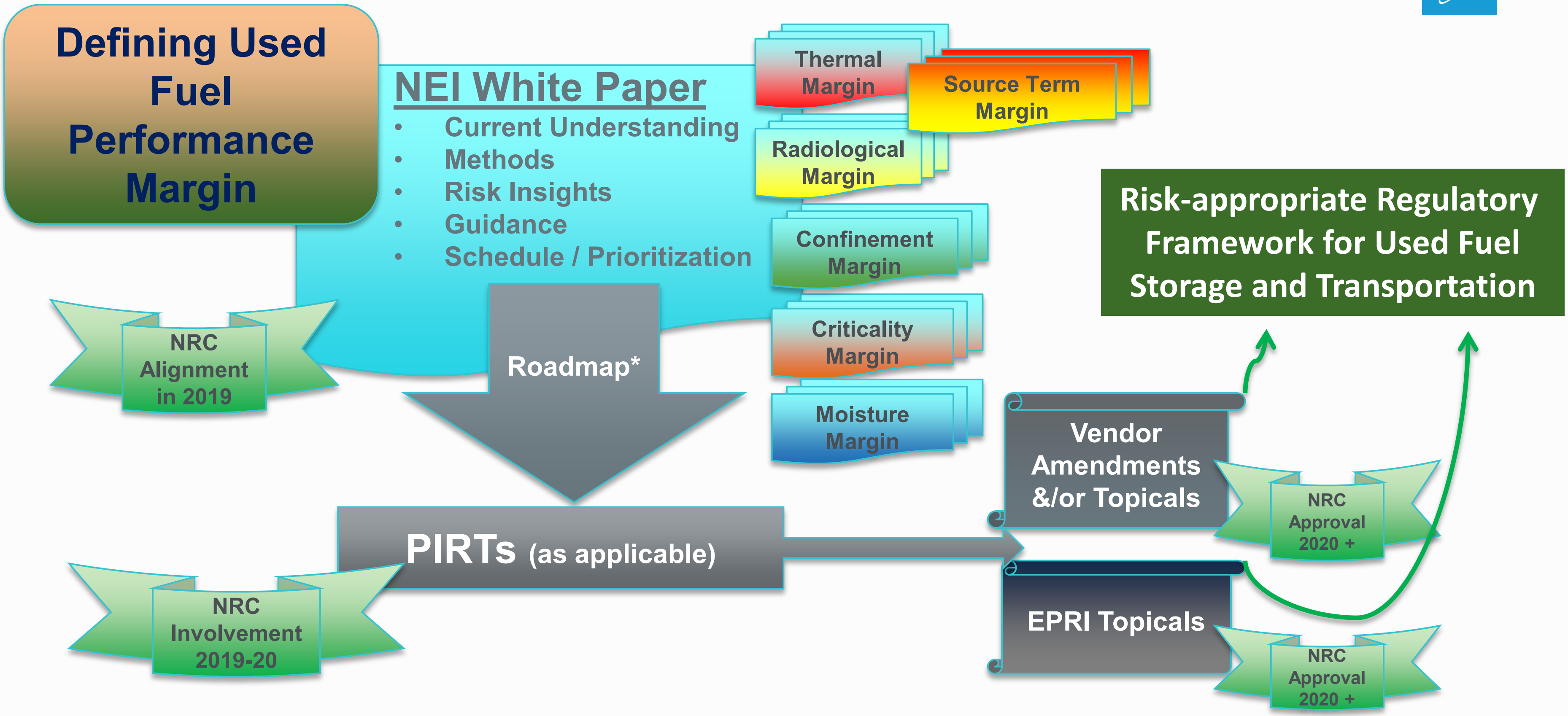
Defining Used Fuel Performance Margins

April 23, 2019

NUCLEAR ENERGY INSTITUTE

White Paper Concept



*Not all elements of the roadmap will be addressed in the same manner or at the same pace

White Paper Overview

High Level TOC

Introduction (1 of 2)

Background: brief overview of the history that has led us to a highly conservative regime

- Initial DFS was going to be for <20 years so easy to be conservative ("it's only temporary")
- Some "limits" were based on very conservative values ("we know it's not a problem")
- Increasingly more information and detail being requested by NRC staff reviewers
- Result is overly conservative designs, and ever increasing costs for application preparation and NRC review fees
- Also results in unnecessary requirements and restrictions on licensees

Introduction (2 of 2)

Objective: improve safety by focusing efforts on the most safety significant parameters, phenomenon, etc. thereby improving regulatory efficiency

- develop more accurate analytical models and analysis approaches, as well as more realistic, scientifically based limits, for source terms and thermal, radiological, criticality, and confinement safety analyses.
- accomplished through understanding and identifying the existing margin between real conditions and actual safety limits and criteria, and then applying that knowledge in a risk informed manner
- Meet the regulatory requirement to *provide reasonable assurance of adequate protection of public health and safety*

Summary of Performance Margins and Current Methods Margins

- Source term development conservatisms vs. real conditions
- Modeling approaches that lead to conservative results
- Allowable values (limits) that include significant conservatisms to real, scientifically based limits or thresholds

Risk Insights

- Use risk insights to inform the process
- Identify those areas that are more significant vs. those that are less significant to safety
  - Focus our efforts and resources on the more significant issues
  - Less focus on those that have little safety significance
  - PIRT(s) may be utilized, as applicable, to identify the inputs and modeling approaches/techniques that have large impact on the results,

- More or less focus does not mean less safety, it means enhanced safety because we are focusing on the right things

Source Terms

Review the conservatisms in how source terms are generated

- Inputs to source term codes
- How much accuracy in the fuel data (burnup, enrichment detail, power history) is adequate without being too conservative
- Realistic vs. bounding

Thermal: Modeling

1st step: Focus the effort

- Identify the inputs, modeling approaches/techniques that have large impact on the results,
- Use results to identify areas that don’t have a large impact and hence don’t require scrutiny (i.e. a reasonable value can be assumed)

Identify areas for modeling simplification

- Develop a consensus-based modeling approach
- Consider a best practices guide

Thermal: Acceptance Criteria for PCT

Work to develop a peak cladding temperature (PCT) limit that is based on more scientific information

- Currently in the US we are treating 400ºC as a “knife edge” limit
- This is not the case; for example it is reported in Europe a limit of 450ºC has been used

Radiological (1 of 3)

Modeling and Computation

- 1st step: define the parameters on which the effort should be focused
  - Identify the inputs, modeling approaches/techniques that have large impact on the results,
  - Use results to identify areas that don't have a large impact and hence don't require scrutiny (i.e. a reasonable value can be assumed)
- Identify areas for modeling simplification
  - Develop a consensus-based modeling approach
  - Consider a best practices guide including reporting of results

Radiological (2 of 3)

Acceptance Criteria for Fuel Qualification

- Work to develop Criteria for Fuel Qualification for radiological shielding
    - Currently in the US, Fuel Qualification for shielding is complex and requires demonstration by calculation
    - Dose Rate measurements / benchmarks can be employed to inform criteria.

Radiological (3 of 3)

Criteria for Dose Rate Measurements / Compliance

- Develop Critical Parameters for Dose Rates
  - Average dose rates adequate for Off-Site Dose compliance
  - Maximum dose rate / locations identified adequately and controlled (shielding) during operational evolutions

Criticality Control (1 of 3)

Analysis Methods

- PWR/BWR - Having to assume worst case geometric location of materials in conjunction with worst case tolerances on all components. In particular on tolerancing of components a statistical treatment is justified and should be permissible.
- BWR - Fresh fuel is evaluated. Guidance should be available for BWR burnup credit. While NUREGs have been issued on this subject they contain a significant caution in that the quantity of information is limited and that further work is needed. This does not provide a clear path to a successful licensing effort

Criticality Control (2 of 3)

Safety/Administrative Margin

- A 5% margin required is excessive when all normal/off-normal/accident worst case conditions have already been considered, including code uncertainty and bias.

Transport

- Moderator in the TSC under normal conditions. NRC interpretation of 71.55(b) unless exception is taking under 71.55(c). Packages are constructed and designed to not allow significant leakage (dispersal requirements under 71.51 limit the amount of material).

Criticality Control (3 of 3)

Damaged Fuel

- In the context of both storage and transportation system the assumption of “floating” fuel and optimum size/spacing introduces a significant conservatism. EPRI analysis have shown that a more “realistic” impact of fuel configuration as a result of damage is small.

Materials

- The 75% or 90% credit on neutron absorber panels seems excessive given current fabrication controls and testing methods.

Confinement (1 of 2)

Understand design margin basis, material susceptibility, and aging management concerns

- Implement aging management programs that include inspections and repair/mitigation processes that preserve/restore margin
- Analytical assessment informs aging management programs to preserve confinement integrity
- Recognize time to address any identified degradation

Understand potential operational challenges to confinement integrity

- Analytical assessment informs reasonable limits to prevent loss of integrity

Confinement (2 of 2)

NRC has already made progress in the area of containment thru issuance of several ISG's:

- ISG-5, ISG-15 (supersedes ISG-4), ISG-18, ISG-19
- Specifically, the removal of helium leak testing of the closure welds (ISG-18) provided significant dose reductions during loading
- Also, interim pathway for licensing moderator exclusion in ISG-19

Moisture

- Current limit (0.43 gram mole in NUREG-1536) derived from a test geared to understand how dry a cask could get
- PNL-6365 drying report
  - 3 of 4 tests loaded the cask with dry fuel (not from a SFP)
  - Wet-loaded canister took at least 5 attempts and 1.5-3 days to dry
- How dry do we need to be to avoid any issues?
- CNWRA report states
  - 5-55 moles (0.1-1.0 L) of water are insufficient to be a corrosion concern
  - 17.4 moles of water may be sufficient to reach flammability criteria (after >72 years of radiolysis)

HBU Demo cask measured 5.4 moles (maximum) of water after the drying process, or <0.1 liters of water

Applications (1 of 2)

Better understanding of source term margin

- Minimize impact on spent fuel management
  - Avoids unnecessarily delaying loading due to site dose budget
- More effective ALARA planning
  - Use it where it's needed
- Improve off-site dose calculations
  - Reduce need for unnecessary loading restrictions
  - Reduce frequency of 72.212 updates for off-site dose
- More efficient use of resources for thermal licensing calculations
  - Applicant and regulator have more emphasis on safety by focusing on more impactful areas

Applications (2 of 2)

Better understanding of criticality margin

- Reduce B-10 requirements
  - Simplifies validation testing
  - Significant cost reduction

- Eliminate need to cycle SFP boron concentration
  - Current higher boron concentrations required for cask loading that needs to be diluted back down for plant operation

Schedule

Action Plan: NEI White Paper

	2019											2020
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Define	Industry Focus Group sets expectations for White Paper											
Align		RIC session on topic	Public Meeting	NEI Used Fuel Mgmt Conf			Public Meeting			NRC Reg Con	Course Correct if Needed	
			Industry Ltr on Approach	NRC Responds to Approach			Submit Draft White Paper					
Develop			Draft White Paper					Review White Paper				
Close											Finalize White Paper	NMSS Bus. Line Comm. Brief

Vision

Relationship Between Performance and Transformation

Foundational Enablers

Transformative Elements

Conclusion

Industry looks forward to NRC's feedback and continued dialogue in this effort to enhance used fuel safety by focusing resources on safety significant areas