Workshop on Spent Fuel Performance Margins

NEI/Industry Presentation

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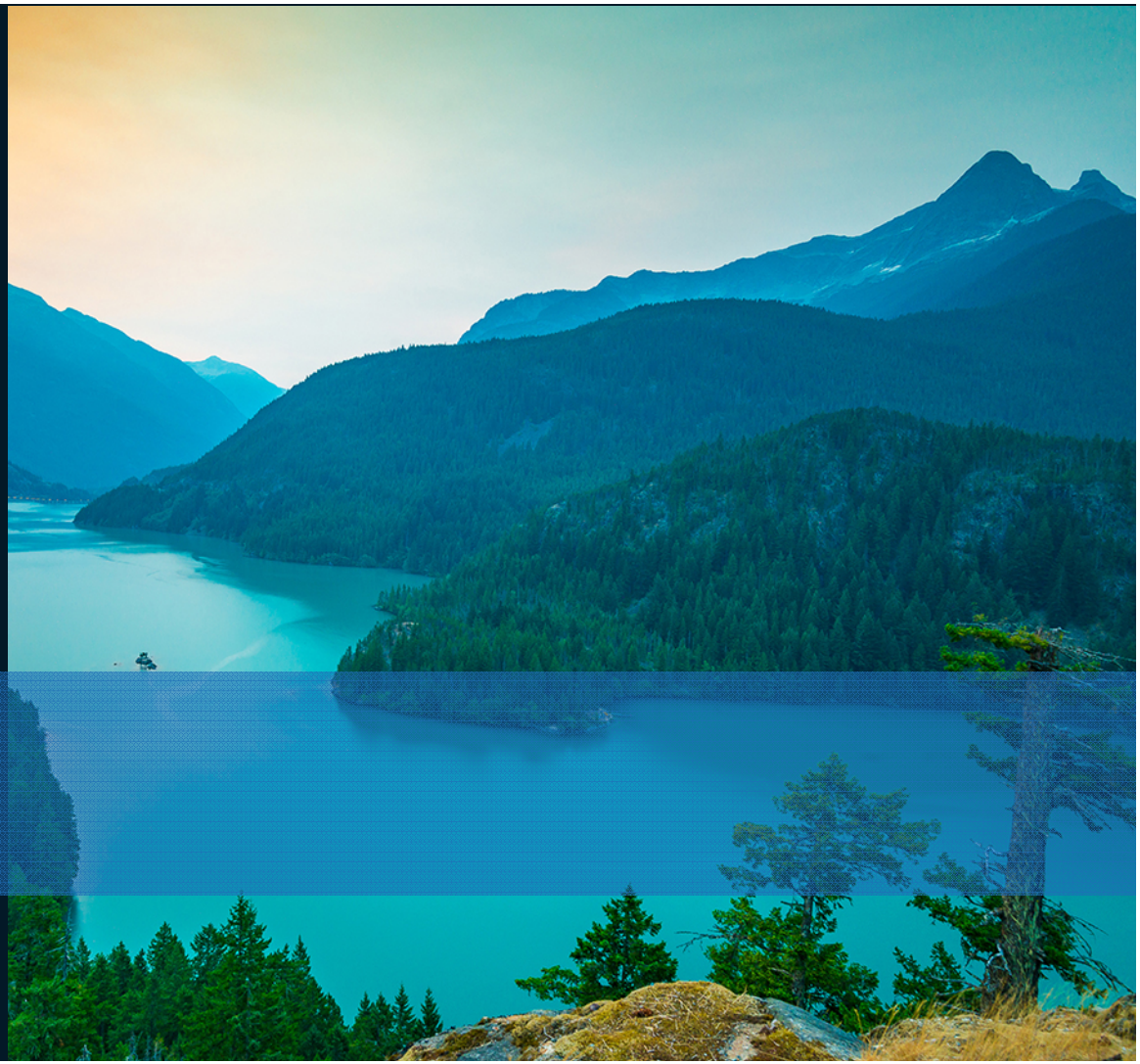
White Flint, MD

NUCLEAR ENERGY INSTITUTE



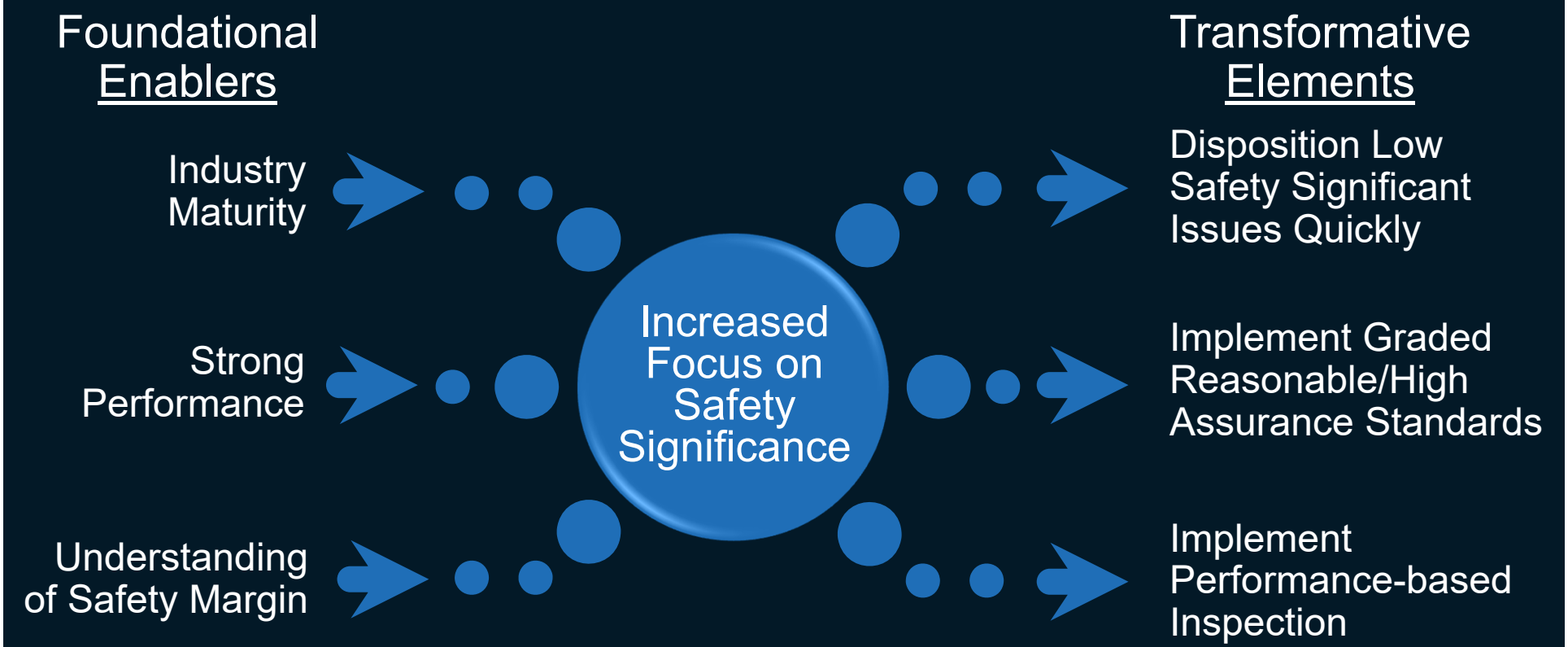
Spent Fuel Performance Margins: An Overview

ROD MCCULLUM, NEI

Why Understanding Margin is Important

- Memorandum from NMSS Director Mark Dapas to NMSS Staff 1/15/2019
  - *"Reviewers should consider the relative margin to any applicable regulatory limits pertaining to the item under review. If the licensee or applicant has reasonably demonstrated that there is significant margin from the regulatory limits, then a detailed review of the item may not be warranted beyond confirming the adequacy of the licensee's or applicant's models, codes, and/or approach, including any key parameters and assumptions, used to demonstrate that significant margin exists."*
  - *"Regulatory standards should already include the appropriate margin the Commission previously deemed necessary to provide for adequate protection. There is no requirement or expectation for additional margin beyond these regulatory standards, even if additional margin is reflected in any "acceptance criteria" contained within guidance documents."*

Understanding Enables Transformation



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Industry Category 1 Recommendations – Industry Action

Recommendation III-1: Licensees/CoC holders define and utilize more realistic source terms, supported by conservative modeling in the downstream calculations, in their applications to demonstrate the adequacy of dry storage system design.

Recommendation III-2: In cases where conservative source term calculations demonstrate compliance with 72.104 and 72.106, licensees/CoC holders should not also apply a source term uncertainty (i.e. burnup uncertainty) in their applications.

Recommendation IV-3: Assess how thermal modeling is done and what can be simplified. Develop an industry consensus based thermal modeling methodology and document this as a best practices guide.

Recommendation VI-1: CoC holders should amend their CoCs to follow the precedent established through Regulatory Issue Resolution Protocol I-16-01 wherein a graded approach was developed to apply risk insights which resulted in a pilot amendment (#16) to Standardized NUHOMS® Certificate of Compliance No. 1004 for Spent Fuel Storage Casks (Docket 72-1004) that achieved a 90% reduction in the amount of information requiring NRC approval in the Fuel Qualification Table and reduced the overall size of the CoC by 33%. (Note: NRC would then have the action to review graded approach amendments as they are submitted.)

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Industry Category 2 Recommendations – NRC Action

Recommendation II-1: NRC should develop an Acceptance Review Grading process that would assign varying levels of review to an application, from the time it is initially received, based on risk insights.

Recommendation III-3: In cases where applicants have applied conservative source terms, conservative modeling, and source term uncertainty (i.e. burnup uncertainty) in their applications NRC should conduct a much less detailed review (i.e. simply check that sound methodologies have been applied instead of trying to independently repeat results).

Recommendation IV-2: In cases where applicants have applied the results of the PIRT described in Recommendation IV-1, NRC should revise its internal review guidance to limit the review toverification that the results of the PIRT have been appropriately applied instead of trying to independently repeat results.

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Category 3 Recommendations – Actions to be Defined (1 of 2)

Recommendation IV-1: As a first step to define the parameters on which thermal modeling should be focused, develop a Phenomena Identification and Ranking Table – PIRT – and use it to identify (a) the inputs, modeling approaches/techniques that have large impact on the results, and (b) those that don't and hence don't require scrutiny (i.e. a reasonable value can be assumed and not questioned). For this to be successful, industry and NRC, along with the scientific community, would have to engage in the PIRT process.

Recommendation IV-4: Work to provide a thermal modeling metric such as a peak cladding temperature limit (PCT) that is based on more scientific information. Currently in the US we are using 400° C as a "cliff edge" limit. Consider a higher ultimate limit structured with stepped lower limits (e.g., under 380° C, not a concern at all; 381° C-425° C, provide some additional rigor in PCT calculations and assumptions review; over425° C up to 450° C, high level of rigor in PCT calculations and assumptions review [or other values as may be agreed]). This is a Category 3 recommendation that will require significant engagement between industry and NRC and will likely result in the development of regulatory guidance.

Recommendation IV-5: Develop a graded approach for thermal modeling analyses considering the effects of multiple overlapping conservativisms to prevent gross ruptures and its relationship to providing reasonable assurance of adequate protection of public health and safety of spent fuel integrity during short term operations and/or storage. This a Category 3 recommendation that will require significant engagement between industry and NRC and will likely result in the development of regulatory guidance.

Recommendation V-1: Revise the guidance in Section 6.4 of NUREG-1536 to 1) request typical/realistic/representative instead of bounding dose rates, consistent with the reduced safety significance of the presented results and to 2) remove or appropriately modify the discussion that implies that the dose and dose rates provided in the FSAR demonstrate that the design is sufficient to meet the regulatory dose requirements

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Category 3 Recommendations – Actions to be Defined (2 of 2)

Recommendation V-2: Revise the guidance in Chapter 6 of the proposed NUREG-2215 with respect to details of modeling of the dose rate evaluations to consider the experiences from the many loaded dry storage systems.

Recommendation VI-2: Align approaches in fuel qualification information for dry cask storage systems CoC (Tech Specs) with current practices in operating reactors (fuel qualification is not in the TS). This is a Category 3 recommendation as Industry and NRC will need to engage in a dialogue to determine the best way to accomplish this.

Recommendation VII-1: Align approaches in criticality safety analyses for dry cask storage systems with current practices in spent fuel pools (full fission product burnup credit, 100% credit for neutron absorber capability). Industry and NRC will need to engage in a dialogue to determine the best way to accomplish this.

Recommendation VII-2: Develop a more realistic approach to the modeling of fuel reconfiguration scenarios in criticality analysis. Industry and NRC will need to engage in a dialogue to determine the best way to accomplish this.

Recommendation VII-3: Develop a safety-focused definition of the term “gross rupture” through a graded or risk-informed approach within the current context to reasonable assurance to adequate protection of the public health and safety as required by 10 CFR Part 72.122h. This definition should be clear and have a well-established basis so that it does not evolve over time. This is a Category 3 recommendation as Industry and NRC will need to engage in a dialogue to determine the best way to accomplish this.

April 23rd Public Meeting: Action Items Status Update

BOB QUINN, WESTINGHOUSE

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April 23, 2019 Public Meeting Action Items Status Update

Industry Action Items	Status
Identify priority Phenomena Identification and Ranking Table (PIRTs) in the White Paper	WP identifies a PIRT be performed related to decay heat (Rec IV-1).
Provide cost/benefit information in the White Paper (with specific examples)	High level cost-benefit described at REG CON. Specific examples to be described in this meeting.
Identify, in the White Paper, opportunities to generically address issues that are currently dealt with in individual licensing actions	Entire theme of WP is to address issues generically. Good example is Rec IV-3.
Identify areas where defining margin would require extensive effort to collect information and eliminate these areas from consideration	WP used this as guiding principle; no recommendations of this nature are included.

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April 23, 2019 Public Meeting Action Items Status Update (continued)

Industry Action Items	Status
Clearly explain in the White Paper the distinction between, and benefits of, changing a limit, and changing how compliance with the limit is approached	Recommendations speak explicitly to either limit (Rec. IV-4) or to ways to demonstrate compliance (all others)
Inform NRC on industry's position about the need for additional Boiling Water Reactor (BWR) burnup credit	Discussed in the WP, but no recommendation at this time.
Include in White Paper analyses of costs of future canister repair efforts to inform confinement margin discussion	Confinement margin not included in WP.

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Phenomenon Identification and Ranking Tables

- This presentation will be provided in a separate presentation by EPRI.

Cost-Benefit Examples

STEFAN ANTON, HOLTEC

Compliance with Site Boundary Regulatory Dose Limit

- Site Specific Demonstration - Approach
  - Select or determine the fuel that is desired to be loaded
  - Establish site specific characteristics of the ISFSI
    - Cask type, basket loadings, cask arrangement, distance to dose locations
  - Perform dose calculations for the ISFSI, iterate as needed to meet limits
    - **This uses the *methods* documented in the FSAR**
  - Establish surface dose rates limits for each cask, corresponding to ISFSI condition
  - After loading of each cask, measure surface dose rates and compare with limits
  - Driver is the 10CFR72.104 annual dose limit of 25 mrem

FSAR Dose and Dose Rate calculations

- FSAR Dose and Dose Rate calculations
  - Select (bounding) fuel, cask type and cask loading
  - **Establish dose and dose rate calculation methodology**
  - Calculate surface and 1 m dose rates
    - These are not related in any way to the site-specific dose rates to show compliance, since they are not based on the site specific ISFSI characteristics
  - Calculate site boundary dose for some cask arrays examples and dose locations
    - These are not related in any way to the site-specific dose rates to show compliance, since they are not based on the site specific ISFSI characteristics
  - Driver are some wording in the regulatory guidance document, namely NUREG-1536 (now NUREG-2215)

FSAR/CoC Effort; Summary

- The effort to maintain and establish FSAR content and CoC requirements with respect to doses and dose rates is significant
  - This effort has increased significantly in the last few years with the introduction, or re-introduction of CoC requirements which are based on the FSAR dose calculations (FQTs)
  - Holtec has spent on the order of 1000 hours developing and implementing those.
  - However, that number pales in comparison to the overall impact, namely
    - Review of FSAR and CoC by NRC
    - Implementation of processes by EVERY user to ensure these requirements are met
    - Ongoing consideration, essentially in perpetuity, in future licensing actions such as 72.48s, LARs, site specific evaluations, and corresponding NRC review or inspections.
- After 3000+ systems loaded with 130,000+ assemblies at 70+ sites in the US, users base their dose and dose rate perspectives on the industry experience, not on FSAR content
- In Summary
  - FSAR doses and corresponding CoC requirements have no link to safety (i.e. regulatory dose limits), are not of any informational value to users, but require significant effort by all parties involved
  - Basis for this FSAR/CoC approach are some wordings in the regulatory guidance documents, presumably going back to a time where no relevant operational experience with ISFSIs existed
  - The guidance should be revised

Cost-Benefit Examples

GEORGE CARVER, NAC

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Cost-Benefit Overview

NAC-STC High-Burnup Fuel Amendment

- Excessive analytical level of detail (academic exercise) required for a licensed system resulting in no impact to the safety of the design
- NAC initially provided thermal analysis, based on the existing NRC approved thermal methods/models for the NAC-STC to support reasonable assurance the cask would perform as required
  - No basket design changes
  - Change in individual fuel thermal loads and loading pattern
- NRC's thermal reviewers "suggested" that NAC needed to develop and qualify new, best estimate models for assessing HBU fuel performance, and included directions to use NUREG-2152 (authored by the thermal reviewers) for the development and qualification of thermal models

NAC-STC High-Burnup Fuel Amendment (Cont'd)

- NAC was had no choice but to develop 3 brand new discrete thermal models (utilizing 900K, 3000K, 7200 elements including mesh refinement in axial direction) to support a methodical discretization allowing development of a Grid Convergence Index (GCI)

Model ID	Number of Hexahedral Elements	PCT (ºF)	ΔT (ºF)
Model No. 1	7,168,000	633	151
Model No. 2	3,024,000	632	151
Model No. 3	896,000	629	151
Base Model	95,672	638	153

- Performance of this work required over 2000 additional man-hours, demonstrated no significant change in PCT and resulted in no changes to the design or loading configuration(s)
- Proximity (~25F) of our calculated PCT, with no credit given for conservatisms in the model, to the PCT limit was used as the basis for requiring the GCI be performed

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Cost-Benefit Overview

Generic Issue with License Submittals

- Excessive analytical level of detail (academic exercise) required for a licensed system resulting in no impact to the safety of the design
- NAC provide “license” drawings which are meant to provide the reviewer with enough information to perform a safety review
- In criticality analysis, the current review includes the effects of tolerances
- As such, it requires the license drawings require tolerances which results in:
  - Additional complexity to the drawings
  - Larger, more conservative values to bound actual manufacturing
- In an instance where manufacturing violates these conservative values, there is the potential that an amendment would be required
- This drives both cost (internal and NRC) and time for implementation, since an amendment can take 9 months to 2 years

Cost-Benefit Examples

TN-ORANO

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Cost-Benefit Overview

- Significant time and computational resources are being engaged in developing mesh sensitivity studies
  - CoC 1042
  - CoC 1029
  - TN-32 HBU
- Temperature difference between meshes

Grid ID	No. of Elements	Temperature (°F)
N0	876,515	712
N1	1,925,705	712
N2	4,196,112	711
N3	9,218,858	709

TN-Orano – Thermal Performance Margin

- Conservative inputs for Grid Convergence Index (GCI) evaluation results in large uncertainties without any credit for conservatisms already built into the thermal models

TN-32BHBU	Design Basis from SAR (°F)	Measured (°F)
PCT	605	445

- Recommendations IV-2, IV-3 and IV-5 would result in better quality and simplified model
- Savings of ~1000 hrs for both TN and NRC for every licensing action

TN-Orano – Shielding Performance Margin

- Dose rate calculation current process
  - Determine bounding source term
  - Burnup and enrichment uncertainties
  - Conservative models
- Results

	Calculated	Measured
Operational Exposure	2,081 mrem	650 mrem
Fence Dose Rate	4 mrem/hr	0.2 mrem/hr

TN-Orano – Shielding Performance Margin

- Recommendations III-1 to III-3
  - Reduce conservatism in analysis
  - Realistic results
  - Reduction in number of analysis
- Savings of ~1000 hrs for both TN and NRC for every licensing action

Licensee's Perspective

ZITA MARTIN, TVA

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Cost-Benefit Overview: A Licensee's Perspective

Utilities allow 1-1.5 years to transition Amendments. Impacts of delays are:

- Potential cancellation of campaign resulting in:
  - Loss of Prudent Operating Reserve (POR)
    - Potential outage delays (additional / slower fuel movements)
    - Increased SFP heat load (Decrease TTB / Delay in Off-load)
  - Loss of Full Core Reserve (FCR)
    - Potential outage delays (additional / slower fuel movements)
    - Inability to perform certain outage maintenance activities
    - Increased SFP heat load (Decrease TTB / Delay in Off-load)

Recovery from cancellation takes years due to lack of Refuel Floor time. This affects multiple outages.

Cost-Benefit Overview: A Licensee's Perspective

- Timeline for Activities on Refuel Floor (RFF) using floor and crane (2 units per site)

Activity (Assuming 2 Units / site)	Time on RFF (wks)
Outages (4 wks / unit)	8
Outage Mobilization/Demobilization (4 wks / unit)	8
New Fuel Receipt (4 wks / unit)	8
Dry Cask Loading (3-4 casks/unit - 1 wk / cask)	6 - 8
Dry Cask Mobilization/Demobilization (2 wks)	2
Crane PMs (Overhead / Fuel Bridge)	1
Fuel Moves for B5b (heat dispersal)	3
Building PMs	2
SNM Inventory /	1
SFP Cleanout - BWRs (12) / Fuel Inspections (4)	16
Maintenance/Repairs (?) / Modifications (?)	?
Total	41 / 16

Cost-Benefit Overview: A Licensee's Perspective

- Compressed schedule for implementation, resulting in stress to perform required activities per 10 CFR 72.212(b)(5):
  - Ensure cask systems are certified to new Amendment (Receipt of system 5-6 months prior to campaign, manufacturing begins 2 years prior to receipt)
  - Review documents (CoC, FSAR, NRC SE) for changes in design, process, limits, requirements, methods (multi-discipline review)
  - Identify impacts of changes to site Calculations, Processes (including new equipment required), Procedures, 72.212 Report, Fuel Selection Requirements
  - Revise documents as appropriate
    - Calculations - as a minimum revise to indicate calc bounds new Amendment (vendor resources to perform – site resources to review/approve)
    - Processes (new equipment purchase, receive, calibrate, vendor manual, drawings, etc)
    - Procedures - as a minimum revise to reference new Amendment
    - 72.212 Report – Approval required at upper management level

Cost-Benefit Overview: A Licensee's Perspective

- Compressed schedule for implementation, resulting in stress to perform required activities per 10 CFR 72.212(b)(5): (cont'd)
  - Training
    - Impacted site organizations (loading crews as a minimum)
    - Fuel Selection personnel (needs to occur before fuel selection)
  - Implementation
    - Fuel move sheets generated and verified
    - Fuel moves, as necessary

Utilization of the Regulatory Issue Resolution Protocol (RIRP)

MARK RICHTER, NEI

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Utilization of the Regulatory Issue Resolution Protocol (RIRP)

- NEI 10-03 Used Fuel Transportation Issue Resolution Protocol
  - Defines structured process-serves as “mini” project plan
  - Facilitates status tracking and reporting
  - Identifies action owners, responsibilities and accountability
  - History of successful application
    - RIRP I-10-01 “Dry Spent Fuel Storage Canister Chloride Induced Stress Corrosion Cracking”
    - RIRP I-16-01 “Improving the efficiency of the regulatory framework for dry storage of used nuclear fuel”
- RIRP closure exemplifies strong collaborative effort between NRC, EPRI and industry

