NAC INTERNATIONAL

Observations on **Key Stor**age and **Transport** Technical **Issu**es

May 7-9, 2013

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MAGNASTOR

NEI Used Fuel Management Conference

St. Petersburg, FL

Topics

- **Background**
- **Key Technical Issues**
  - Criticality Calculations, Burnup Credit (BUC), Moderator Exclusion (ModEx) for Multipurpose Canister Systems (MCS)
  - Problem Statement
- **Path Towards Optimal Resolution**
- **Conclusions**
- **Questions/Discussion**

Background

YM in limbo: extended spent fuel storage/transport, CIS, and more regulation seem likely. Such outcomes are captured within the phrase "extended storage and transport (EST)".

In this regard, ISG 8 Rev 3 offers the latest and most complex "improvement" in criticality calculations to achieve BUC.

To offset complexity from EST, can we simplify regulations and system design and licensing for enhanced fuel capacities and more fuel types, while maintaining reasonable assurance of public health and safety? This leads to other questions:

Do Regulations Meet Purpose with Modern Packages?
Are Regulations Proportional to Risk?
Are Licensing Requirements Consistent?

Key Technical Issues

- **<u>Briefly</u> address criticality calculations, burnup credit (BUC), and moderator exclusion (ModEx) as key storage and transport technical issues.**
- **These deal with analyses of package criticality, and transport is the controlling regulation.**
- **We can express an approach to these issues in terms of a problem statement.**
- **And we can address some of the questions posed earlier to help guide our considerations.**

Problem Statement

Issues address package criticality in “as-designed” and normal, accident conditions of transport.

Problem: in the era of EST, can industry more efficaciously address the requirements of 10 CFR 71.55 (b), (c), (d), and (e), consistent with the reasonable assurance of public health and safety, considering the risk inherent in any failure to meet the requirements?

EPRI has done excellent work in evaluating these three areas and in proposing efforts that make design, licensing, and safety sense.

Criticality Calculations

- **Industry has adapted to NRC requirements for highly complex calculations involving events of very low credibility using advanced statistical validations to assure high confidence levels.**
- **ISG 8 R3 expands necessary criticality calculations as they relate to BUC. R3 is an improved approach to demonstrating BUC for dry storage, but the application to wet storage is causing some issues.**
- **EPRI provided input to the NRC in June 2012 on methods to assess fuel reactivity depletion bias, uncertainties; they appear to improve on R3's uncertainty in BUC calculations, expanding fuel coverage.**
- **EPRI* observes conservatisms in SRP/ISG-8 appropriate for HEU/Pu, but are excessive for spent fuel; NAC would agree.**

*EPRI, "Transportation of Commercial Spent Nuclear Fuel Regulatory Issues Resolution." Report Number 1016637, Project Manager A. Machiels, December 2010

Criticality Calculations
continued

- **First 10CFR71 issued in1958; many current requirements were formalized in a 1965 Part 71 proposed revision for packaging performance standards from the IAEA several years before; many were already in use in U.S. licensing after 1960.**
- **Interesting bases for regulations and compliance demonstration offered in proposed 1965 rule making:**
  - expressed intent in 1965 FedReg notice for analyses: “any analytical treatment which has a reasonable degree of certainty may be employed to predict the performance of a package;”
  - this language is consistent with EPRI’s* approach for using best estimate methodology, especially for BUC criticality calculations.

***Ibid**

Burnup Credit (BUC)

- **BUC has been permitted for reactor core reload analyses since forever and for limited application to storage/transport package licensing since the late 1990s. The methodology is well known.**
- **ISG 8 R3 is the latest effort at enhance BUC effects for higher capacities and more fuel coverage. EPRI's proposed approach seems better yet (see table below). But shipping high burnup fuel with BUC is still only possible on a case-by-case basis (due to clad data and "reconfiguration" issues – see ESCP issues).**

Comparison of Methods

Burnup (GWd/T)	Kopp Uncertainty (delta k)	ORNL (ISG8 Rev 3) Uncertainty (delta k)	EPRI Method Uncertainty and bias (delta k)
10	0.006	0.016	0.008
20	0.011	0.015	0.008
30	0.015	0.016	0.008
40	0.019	0.021	0.008
50	0.022	0.030	0.008
60	0.025	0.030	0.008

From "Recent Developments in the Depletion Reactivity Uncertainty," Dale Lancaster, INMM Spent Fuel Storage Seminar, January 2013.

Burnup Credit (BUC) continued

- **However, criticality calculations and BUC are just modest repairs or patches for damage inflicted by regulation, the imposition of moderator intrusion (ModInt) as an “as-designed” requirement.**
- **How did ModInt originate, why was it a concern, and how might we achieve ModEx to repair the damage, reducing focus on criticality calculations and BUC.**

Moderator Intrusion (ModInt)

- **ModInt formalized in Part 71through the 1965 proposed revision**
- **Bases for ModInt offered in FedReg for proposed 1965 rule making:**
  - current §71.55(b) “as designed” ModInt requirement included in regulations to prevent criticality from error, *“such as the omission of a gasket or complete tightening of the lid, which would allow water to enter the containment vessel.”*
  - regulation says that no matter how the containment is designed to exclude moderator, the design must be assumed to fail at all times; regulations are not package design specifications.
  - as a side note, packages for transporting HEU/Pu would generate more concern in those days from a criticality perspective and such a regulation is more easily defended from that perspective.

Moderator Intrusion (ModInt)
continued

- **All licensed MCS systems meet §71.55(c) *["…package incorporates special design features that ensure that no single packaging error would permit leakage, and if appropriate measures are taken before each shipment to ensure that the containment system does not leak."*]**
  - the double containment system of MCS during transport
  - redundant closure of the MCS canister
  - weld inspections on canister and both closures
  - leakage testing of canister
  - QA of canister loading and closure
  - QA of transport cask seal installation
  - bolting of transport cask lid and inspections of torque values
  - leakage testing of transport cask [also tests canister again]
  - QA of transport cask loading and closure
  - QA of transport cask records prior to release for transport
- **An accident condition is required for ModInt for current spent fuel packages, even with single error; EPRI shows no single misloading could credibly produce a criticality event, even with ModInt.**

Path Towards Optimal Resolution: ModInt to ModEx

- **So it seems to make great sense for industry to move towards ModEx through NRC staff action or using a petition for rulemaking (PRM).**
- **Why has ModEx not moved forward? SECY-07-185 "Moderator Exclusion in Transport Packages," Dec18, 2007, stalled NRC staff, but now with YM and EST, ModEx may be considered more timely today, 5+ years later. Still, a PRM may be necessary for action.**
- **History shows that a PRM has strong bases for approval. NRC has two relatively recent rulemaking experiences in resolving similar matters to achieve improvements:**
  - Rulemakings on § 71.63(b), double containment of Pu:
    - June 1998, DOE PRM-71-11;
    - January 2004, IEC, Inc. PRM-71-12

ModInt to ModEx continued

- **NRC bases for changing 71.63(b) double containment regulations:**
  - June 1998: the benefits of the proposed rule: reducing occupational dose; reducing the dose to the public; decreasing loading/unloading time; and reducing the cost of the containment system."
  - June 1998: Because of material properties of HLW, the sealed canisters, and the approved QA programs, canisters of vitrified HLW packaged in accordance with 10 CFR Part 71 are highly unlikely to result in releases of dispersible or respirable forms of plutonium… for normal transportation, the vitrified HLW canisters meet the intent of the § 71.63(b) without need for double containment.
  - January 2004: …the NRC believes Type B package standards, evaluated against 40 years of use and millions of safe shipments of Type B packages, provide reasonable assurance that public health and safety and the environment would be adequately protected. The NRC believes that, in this case, the reasonable assurance standard provides an adequate basis for the public's confidence.
  - January 2004: The NRC expects cost and dose savings would accrue from the removal of §71.63(b).

The same rulemaking bases would apply for §71.55(b) and §71.55(e).

A Role for Risk-Informed Regulation?

- **Are the regulations proportional to risk, and are licensing requirements consistent with regulations and their intent?**
- **EPRI* and industry have evaluated ModEx; some observations:**
  - the “double containment” offered by MCS virtually obviates need for §71.55(b) assurance
  - EPRI* has shown §71.55(e) (accident conditions) is incredible and unnecessary in regulation
  - EPRI* shows potential for transport criticality per shipment is ~1E-16, but this is conservative, since up to 3 fresh assemblies must be loaded in the center for criticality (and BUC < ISG 8 R3).
- **The probability is far lower than any credible event in regulatory practice. What about the threat of criticality?**
- **Using actual criticality events with metal/oxide HEU fuel and Oklo reactor uraninite (UO2) fuel as bounds, protracted criticality could produce between 1E+16 and 4E+17 fissions, 0.2 - 3.7 kWh of heat, and maybe up to 5 -10 mCi of new fission products. Cask thermal and shielding performance would not be seriously challenged.**
- **Public health and safety are unaffected by such a risk.**

***Ibid**

Conclusion

- **Criticality calcs, BUC make transport design/licensing more complex, less efficient than warranted by good regulation and criticality risk.**
- **The crux of the regulatory matter on ModInt seems to be:**
  1. ModInt supersedes package design, imposes design failure
  2. ModInt required for hypothetical accident conditions
  3. Subcriticality is the acceptance criterion – but how much?
- **Solving 2 may not solve 1, which causes the capacity problem; 3 can impose large conservatisms; and none of this is risk-informed.**
- **ModInt design requirement for LEU spent fuel packages does not make technical/ safety sense; bases of current §71.55(b) requirements not applicable to MCS; ModInt for accident conditions is less than improbable; regulations need revision, especially for MCS.**
- **A rulemaking to revise §71.55 is appropriate; because of the time required, further ISG may help applicants until the PRM is ruled on.**

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Questions?

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