



## Some Thoughts On and Considerations About Moderator Exclusion



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# Topics

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- Some Background . . .
- Some Considerations . . .
- Summarizing Lessons from History . . .
- Some Recommendations . . .
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# Some Thoughts . . .

- Moderator exclusion (modex), like burnup credit (BUC), of heightened interest within industry and NRC for almost 15 years
- Higher capacity systems mean safer storage and transport, and modex and BUC contribute to that safety enhancement, especially with market trends towards higher enrichment and burnup fuel
- Occasional sharp tongues and sharp elbows have been displayed on both these issues over the last 15 years or so
- Personal observation: industry and NRC should cooperate, collaborate, and coordinate collectively on regulatory or licensing “fixes” on these matters **NOW**: we have shared interests that seem obvious to enhance safety, licensing practice, and operational efficiency
- The crux of the regulatory matter on modex seems to be:
  1. moderator intrusion is an assumption for the package design
  2. moderator intrusion required for hypothetical accident conditions
  3. subcriticality is the acceptance criterion – but how much?
- Solving 2 does not solve 1, which causes the capacity problem, and 3 can impose large conservatism; also, none are risk-informed
- What follows is a general approach to address modex: historical content, similar issue resolution, bases, and broad recommendations

# Some Background\* . . .

- 10CFR71 first issued in 1958; moderator intrusion formalized in Part 71 for comment in late 1965 as part of new packaging performance standards; issued by the IAEA several years before and many were in use in U.S. licensing practice since 1961
- Interesting bases for regulations and compliance demonstration offered in proposed 1965 rule making:
  - current §71.55(b) contents included 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.”
  - as a side note, packages for transporting spent fuel for reprocessing in those days were all wet packages – §71.55(b) criticality analyses were necessary for those anyway
  - expressed intent for analyses: “any analytical treatment which has a reasonable degree of certainty may be employed to predict the performance of a package”
- EPRI has done extensive research on and assessment of these matters of modex and BUC

\*Hafner, RS; Development of U.S. Regulations for the Transportation of Radioactive Materials – A Look Back Over the Past 40 Years; Chapter 52, Companion Guide to the ASME Boiler & Pressure Vessel Code; LLNL, UCRL-BOOK-215042, September 6, 2005

# Some Considerations . . .

- NRC and industry also have 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; and January 2004, IEC, Inc. PRM-71-12
- NRC bases for changing 71.63(b) double containment regulations:
  - June 1998: “*Therefore, the proposed rule would have the following benefits: (1) Reducing the occupational dose associated with loading, unloading, decontaminating, and handling the shipping casks; (2) reducing the dose to the public during normal transport by decreasing the total number of shipments; (3) decreasing total loading and unloading time (and resultant expense); and (4) reducing the cost of the containment system.*”
  - June 1998: “*Because of the material properties of the vitrified HLW, the sealed canisters, and the approved quality assurance programs as described in the petition, 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 under normal transportation conditions, as identified under 10 CFR Part 71. Therefore, for normal transportation, the vitrified HLW canisters meet the intent of the § 71.63(b) requirement without the need for double containment.*”

# Some Considerations . . . (continued)

- January 2004: *"...the NRC continues to believe that the Type B package standards, when evaluated against 40 years of use worldwide, and millions of safe shipments of Type B packages, together provide reasonable assurance that public health and safety and the environment would be adequately protected during the transportation of radioactive material. The NRC believes that, in this case, the reasonable assurance standard, provided by the Type B package requirements, provides an adequate basis for the public's confidence in the NRC's actions."*
- January 2004: *"The NRC expects that cost and dose savings would accrue from the removal of §71.63(b)."*
- The same rulemaking bases apply now for §71.55(b) and §71.55(e)
- Further, EPRI\* and industry have provided many evaluations of the modex issue; some observations are relevant here:
  - the "double containment" offered by multipurpose canister systems (MCS) virtually obviates need for §71.55(b) assurance
  - criticality conservatisms in SRP/ISG-8 for licensing may be applicable to HEU and HEPu, but are excessive for spent fuel
  - EPRI\* has shown §71.55(e) (accident conditions) is basically incredible and not necessary in regulation (but ISG-19 is also a partial solution)

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

# Some Considerations . . . (continued)

- Every MCS system that is licensed already meets the expressed regulatory intent of §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.* ]
  - double containment system of MCS
  - redundant closure of the canister
  - weld inspections on canister and both closures
  - leakage testing on 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
- Additionally, with modern packages, an accident condition would be required to permit moderator intrusion into an as-loaded spent fuel package, even with a single error
- Plus, EPRI has shown no single mis-loading of fuel could credibly produce a criticality event, even with moderator intrusion

# Summarizing Lessons from History . . .

- The regulatory intent of §71.55(b): to prevent criticality from transport preparation error, such as gasket or bolt tightening issues
- The regulatory remedy of §71.55(b) and (c): criticality analysis with moderator intrusion, or, for exception to such analysis, protections against single error permitting leakage and appropriate measures before transport to assure no leakage
- Methods for criticality analyses: “any analytical treatment which has a reasonable degree of certainty may be employed to predict the performance of a package”
- Some bases of successful petition for rulemaking (PRM) to eliminate a requirement:
  - provision no longer necessary or no improvement in safety
  - provision is now out of date (e.g., Pu nitrate shipments)
  - robustness of package standards based on 40 years of safety
  - methods/processes now exist to obviate the concern
  - provision diminishes the total safety of the resulting package
- With these history lessons, there seems to be a path forward for a PRM on modex to enhance safety by achieving higher capacities for transport, not lower

# Some Recommendations . . .

- For expeditious action with greatest efficacy, use two-pronged plan
  - rulemaking to revise regulations
  - staff guidance for interim acceptance criteria for §71.55 compliance
- Rulemaking on §71.55(b), §71.55(c) and §71.55(e):
  - decide who petitions for rulemaking and formulate a detailed petition to submit ASAP
  - for §71.55(b), follow previously outlined approach
  - for §71.55(e) (accident conditions), follow EPRI Report 1016637
- Interim staff guidance: possible contents
  - review designs (metal casks and MCS) for appropriate approaches and show risk-informed approach to guidance
  - show design and loading features that obviate credible criticality concerns
  - stipulate §71.55(b) compliance approach: in spirit of historical analysis guidance, suggest a  $k_{\text{eff}} \leq 0.9975$  for conservative SRP/ISG-8 criticality calculations or  $k_{\text{eff}} \leq 0.98$  with pre-SRP/ISG-8 requirements (precedent exists for reducing the administrative margin for criticality)
  - for §71.55(e), use ISG-19 for MCS
- Based upon review of BUC issues, perhaps include acceptability of BUC with actinides and limited fission products

# Conclusions

- Moderator intrusion as a fundamental assumption about fissile packages does not make technical or safety sense for spent fuel, in light of modern package design and increases in the initial enrichments of modern fuel cycles
- History shows that bases of current §71.55(b) regulatory requirements and such older concerns are no longer applicable to modern spent fuel packages
- Moderator intrusion under accident conditions is beyond improbable and the regulations should be revised for a more rational treatment, especially for MCS technology
- A rulemaking to revise §71.55 is appropriate, but, because of the extraordinary time required, interim staff guidance is necessary for applicants as to what is acceptable to meet current regulatory requirements until the PRM is ruled on

# The Importance of Remembering the Past

*Those who cannot remember the past  
are condemned to repeat it.*

-- George Santayana, Spanish-American Philosopher  
(1863-1952)

***Let's not repeat the past, but learn from it***

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