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Thoughts and Insights Panel

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MAGNASTOR

Thoughts and Observations on Progressing Towards Regulatory and Licensing Proportionality

Reasonably Assured, Adequate Protection of Public Health and Safety Through Risk-Informed, Spent Fuel Transport And Storage Regulation

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Discussion Points

- **Introduction**
- **Background**
  - Regulation Ancient History
- **Thoughts**
  - NRC Mission and Implementation Thereof
  - So, How's That Working Out for Us?
  - Regulatory and Licensing Proportionality
- **Observations (Insights?)**
  - Some Issues Requiring Insight and Reasonability
- **Final Thoughts**

Introduction

- This is only an expression of one viewpoint, mine, of where the design and licensing trend line **<u>should</u>** be going
- It is my philosophical, aspirational view of where the design and licensing process needs to go to assure public health and safety, to facilitate long term spent fuel storage and transport, and to support public needs
- This is not yet a vision. But I hope it's not an hallucination

Vision without execution is hallucination.
– Thomas A. Edison

Background

- Part 71 requirements developed in 1950s and early 1960s – required nuclear packages to withstand "maximum credible accident"
- There were no computers, no real computational analysis tools, few data bases, little experience, little understanding of comparative nuclear transport risk, and nuclear criticality was the big bogeyman
- Part 71 performance standards have withstood the test of time
- ***Yet, even now, nuclear packages remain the only global class of HazMat packages required to withstand the "maximum credible accident," despite the transport of FAR more hazardous materials***
- Part 72 requirements are newer, more flexible, but are in the same vein
- Old regulations prove difficult for new contents, conditions, or situations
- Regulations reflected their times, and still do. But the licensing process can be a change agent as we gain knowledge and experience to address new situations

Thoughts

- Regulations are old, like so much else, yet proven to result in safety
- “Regulatory interpretations,” the licensing process, may be an issue
- How is implementation of these regulations fairing - the licensing process - and are there possible improvements
- Several issues come to mind whose reasonable resolution will improve licensing, preserve public safety, facilitate safe transport and storage, and not add to the public misperception of all things nuclear
- Of course, the heart of designing and regulating spent fuel storage and transport is assuring public health and safety
- In this regard, there has been insightful guidance on the topic in the past. As an example . . .

NRC Mission And Reasonable Assurance

NRC Mission Statement : ***"…regulate …to ensure adequate protection of public health and safety …"***

"The NRC's and licensees' activities are conducted within the broad context of protection of public health and safety but bounded by the more manageable goal of assurance of adequate protection of public health and safety. . . . . <u>Technology and regulation are not stagnant; they should improve with time.</u> *<u>Therefore, assurance should be based on increasingly quantifiable evidence of the safety status.</u>* And . . . should. . . provide. . .

<u>Reasonable</u> Assurance of Adequate Protection of Public Health and Safety."

"Furthermore, the courts have long accepted the Commission's definition of its statutory mandate to 'provide adequate protection of public health and safety' as requiring not a risk-free environment, but a 'reasonable assurance'. . ."

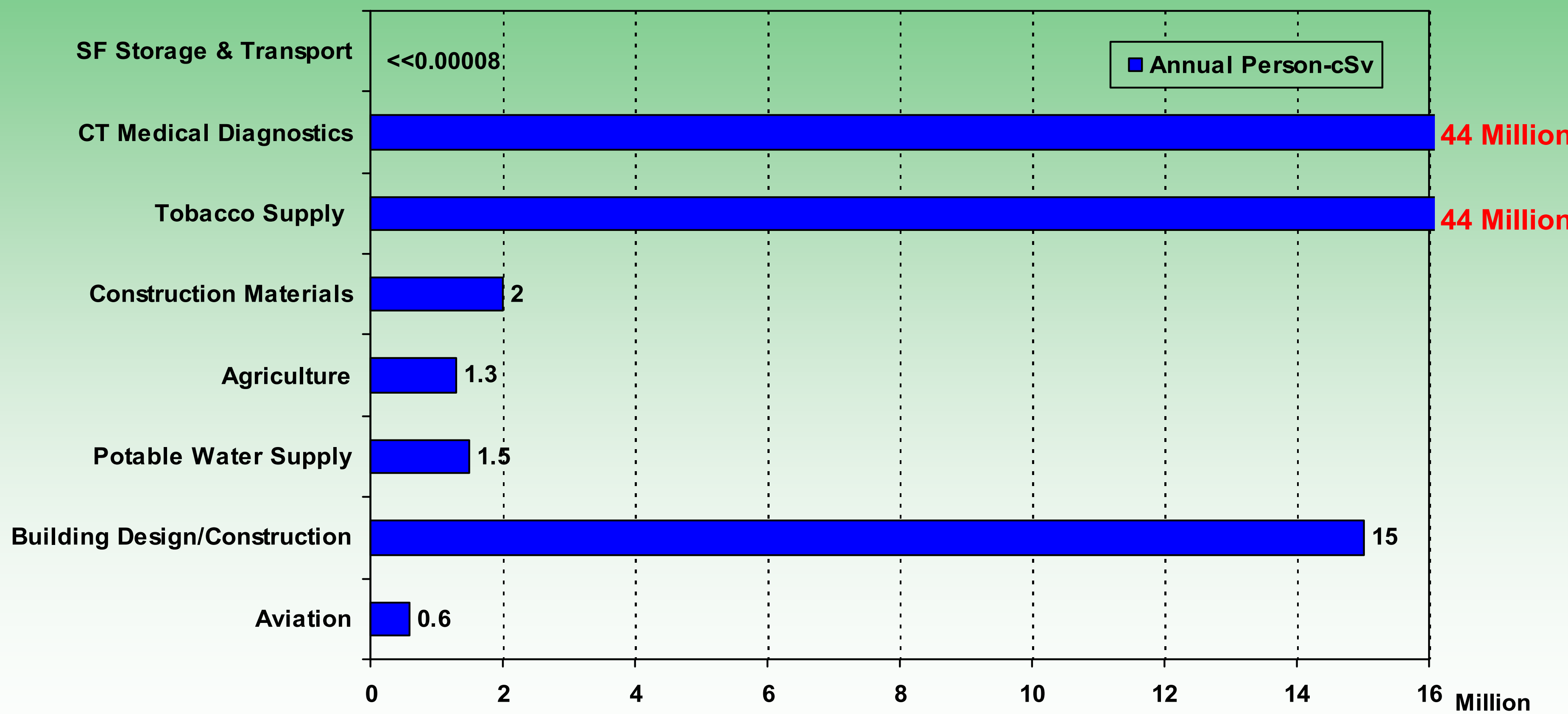
Dr. Nils Diaz, NRC Chairman,
Regulatory Information Conference, March 28, 2000

So, How's That Working Out for Us?

- How are the industry and regulator doing in providing adequate assurance of public health and safety with respect to the key consideration, **radiological impact** on, and **radiological risk** to, the public
- NAS has found dry spent fuel storage and transport to be safe. But just how safe is our industry, radiologically, and comparatively speaking
- Many non-nuclear industries routinely contribute large radiation doses to the U.S. public as a result of their products and conduct of business
- Seven such industries are Medical Diagnostics, Tobacco Supply, Building Design/Construction, Potable Water Supply, Aviation, Agriculture, and Construction Materials; their population doses are unregulated, uncontrolled, unmonitored, unreported, and undisputed (since they are not undocumented)
- These 7 industries, and the others like them, are seen as radiologically "safe", by definition: society accepts them, there is no public outcry, no one seeks regulation, and the states frankly don't care much about such small threats
- Here's how we stack up against this group

Comparative Annual Collective Dose*

NAS says compare technology risks of like causes and similar outcomes, and “The mean collective dose risk is most useful as a comparative tool.”



Comparative annual CEDE to U. S. populations above background from seven non-nuclear industries and from commercial spent fuel storage and transport.

*Pennington, C.W., 2007. Exposing America: comparative assessments of ionizing radiation doses to U.S. populations from nuclear and non-nuclear industries. *Progress in Nuclear Energy*. 49 No. 6: p.473-485
*Pennington, C.W., 2010. A demonstration of the comparative radiological safety of commercial nuclear power generation in the USA. *Int. J. Nuclear Governance, Economy and Ecology*, Vol. 3, No. 1, pp.59–103

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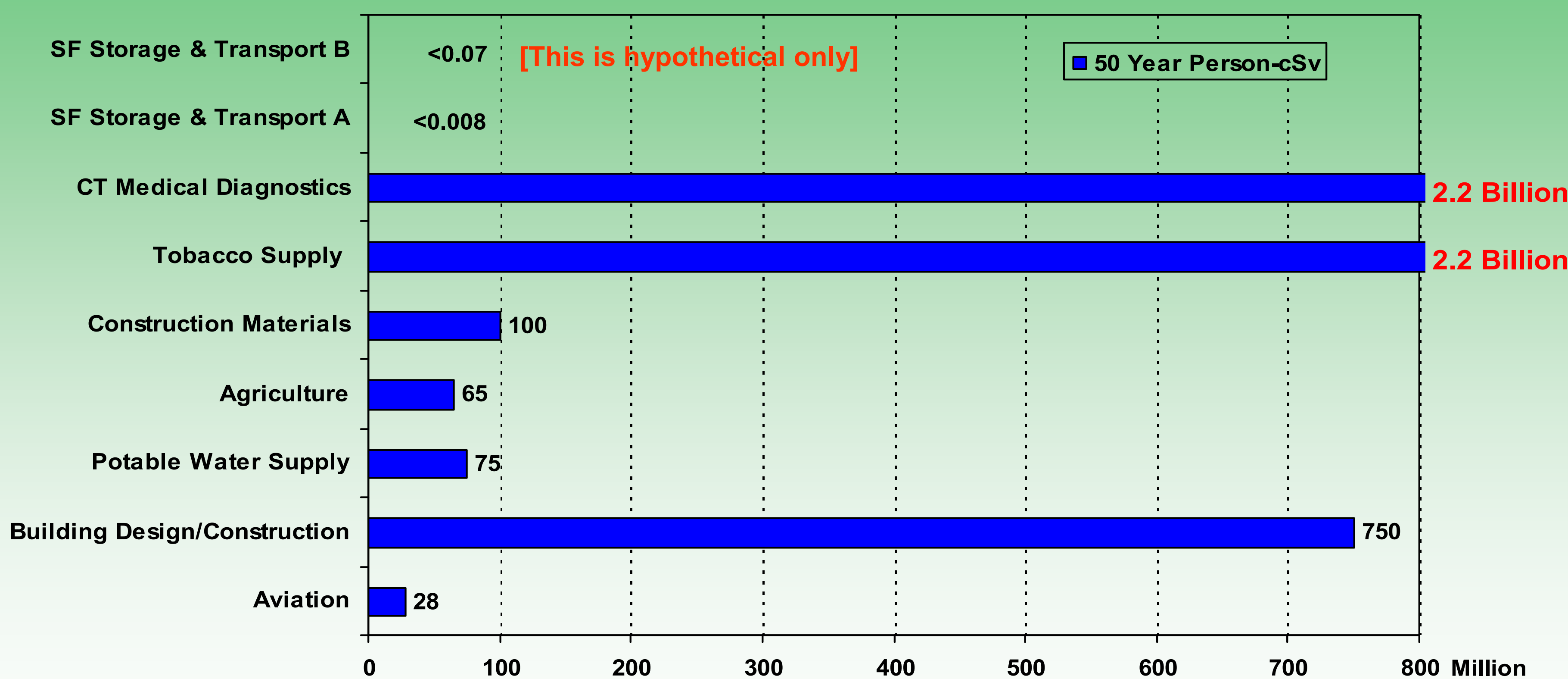
Comparative 50-Year Collective Dose*

*See footnotes on previous slide.



Comparative CEDE to U. S. populations above background from seven non-nuclear industries and from commercial spent fuel storage and transport

Safety not only has to be achieved but also must be seen to be achieved. – Roy Gibson, UK AEA, 1961

How It Has Worked Out

- Spent fuel storage and transport are, comparatively, the radiologically safest industry of all those that have any radiological impact on the public - by orders of magnitude. I'm sure we all want it to stay that way, too
- AND, should the worst ever occur with a transport or storage system, the hypothetical radiological risk for credible events is still in the infinitesimal range, with worst case peak doses to the public realistically in the sub-rem range
- The Part 71 regulations, though ancient, have driven packaging design, including that for storage, to assure adequate public health and safety
  - Hypothetical accident conditions have proven durable and defensible for almost 50 years, and the result is *"assurance . . . based on increasingly quantifiable evidence of the safety status."*
- The industry and the regulator have done their jobs, but issues arise as we must accommodate new situations. Fortunately, as Chairman Diaz said, *"Technology and regulation are not stagnant; they should improve with time."*
- Perhaps it is time for a regulatory or licensing approach change

Safe is as safe does. – Forrest Gump (?)

Regulatory and Licensing Proportionality

This provides a sense of what I term regulatory or licensing proportionality, a proportional response of design and licensing to the risk-informed hazard

> Radiation is radiation yet radioactive risks are often treated quite differently depending on the source. The risks from radiation need to be scrutinized and given equal treatment under the law [regulation]. . . . it is not beneficial and I disapprove of the arbitrary imposition of a zero factor to narrowly selected radiological risks with no importance to public health and safety. I oppose it not only because it is contrary to the law governing the NRC, but because it hampers debate and gets in the way of good regulation.
>
> **Dr. Nils Diaz, NRC Chairman,**
> **Regulatory Information Conference, March 28, 2000**

Observations (Insights?– Well, My Sights)

- Issues over last decade seem intractable to resolutions that improve packaging design with safe and more efficient transport/storage. A few include:
  - Burnup effect on reactivity; moderator exclusion; high burnup fuel; requirements on fuel conditions, post-accident, as well as "ready retrieval," and use of normal means(?) [10CFR72.122(l) *Retrievability]*
- <u>THE issue</u>: performance standards and public radiation risk involve the following
  - **Very low probability of worst case events**
  - **Very low probability of worst case content "dispersal or reorganization"**
  - **Very low probability of optimal moderator ingress**
  - **Very low probability of packaging breach**
  - **Very low probability of any release**
  - **Very low probability of dose impact on public health and safety**
- When the incredible [~$10^{-13} \pm 10^{-2}$], with negligible public radiation risk, dominates the design bases and licensing, maybe there's a better way
- We are moving into new regimes never considered by regulations that require licensing to assure health and safety while not unnecessarily constricting design
- Public radiation risk should be influencing regulatory proportionality for licensing new conditions, configurations, burnups, and situations
- How can this be achieved?

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**I never let my education get in the way of my learning.
– Samuel "Mark Twain" Clemens**

Observations (continued)

- More extensive risk-informing of the licensing process ***or*** regulation changes are possible courses of action
- But regulations are regulations; more risk informing of the licensing process is an improvement and more timely than regulation changes
- NUREG-1864, the pilot probabilistic risk assessment of dry storage, is an **excellent** start by the NRC in risk-informing spent fuel storage, even though it is still **very** conservative. But an average risk of 1.2E-13 per cask per year over 20 years for all events is an early indicator of hazard
- Something similar should be done for transport
- Risk-informing the licensing requirements for the issues cited above offers improvement in design, licensing, and public safety
  - This is **not** about *"dumbing down"* packaging design – those requirements should **remain** at the current state of high safety and let technology advances improve them even more; packagings are sufficiently robust to minimize public radiological risk
  - This is about *"smartening up"* our package analysis assumptions, methods, and requirements for new conditions, configurations, burnups, and situations (some may call this "conservative realism")

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Life can only be understood backwards, but it must be lived forwards. - Søren Kierkegaard

Final Thoughts

- First, NRC and industry <u>may</u> need better *technical* exchange on issues
- Second, NRC and industry should examine new licensing approaches that account for the radiation-risk-informed threat to the public
- Third, I would say NRC and industry should work with more

>> Reason and Reasonability <<

- "Reasonable assurance of adequate protection" is still the mission
- Licensing can only be understood backwards, but it must be applied forwards [thanks, Søren]. Looking backward, I see large safety margins
- My view is that licensing proportionality requires a closer balancing of regulatory requirements with radiation risk
- And, as another consideration, licensing deferred is licensing denied
- Therefore, in light of our industry's trends, action would seem to be appropriate, maybe even called for

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Backup Material

Commercial Spent Fuel Storage and Transportation Comparative CEDE: Past, Present, and Future

Industry	Current Annual CEDE (Person-cSv)	Estimated Previous 50 Year CEDE (Person-cSv)	Projected 50 Year CEDE (Person-cSv)
Aviation	>0.6 million	>12 million	>28 million
Building Design/Construction	>15 million	>430 million	>750 million
Potable Water Supply	>1.5 million	>38 million	>75 million
Agriculture	>1.3 million	>52 million	>65 million
Construction Materials	>2 million	>78 million	>100 million
Tobacco Supply	>44 million	>3 billion	>2.2 billion
CT Medical Diagnostics	>44 million	>1 billion	>2.2 billion
Total for 7 Non- Nuclear Industries	>108 million	>4.6 billion	>5.4 billion
Commercial Spent Fuel Storage and Transport. Supporting growth to 300 reactors over next 50 years; 2 scenarios: A and B	<0.00008 million	<0.002 million	A. Without Breach Events: <0.008 million B. With 10 Credible Breach Events: <0.07 million

Comparative CEDE to U. S. populations above background from seven non-nuclear industries and from commercial spent fuel storage and transport

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NUREG-1864 Results

Table 19. Summary Table of Dry Cask Storage Risk Calculations

Stage: Initiating Event	Initiating Event Frequency	Probability of release from fuel rod and MPC	Radionuclides released	Probability of Release from Containment	Consequences	Risk
1: Fuel assembly dropped	$2.2x10^{-3}$	$6.4x10^{-2}$	NG	1	$1.5x10^{-12}$	$1.9x10^{-16}$
2	Not Applicable					0
3: Transfer cask dropped	$5.6x10^{-5}$	1	NG	1	$1.0x10^{-10}$	$5.6x10^{-15}$
4: Transfer cask dropped	$5.6x10^{-5}$	$1.0x10^{-6}$	All	$1.5x10^{-4}$	$3.6x10^{-4}$	$3.0x10^{-18}$
5: Transfer cask dropped	$5.6x10^{-5}$	$1.0x10^{-6}$	All	$1.5x10^{-4}$	$3.6x10^{-4}$	$3.0x10^{-18}$
6: Transfer cask dropped	$5.6x10^{-5}$	$1.0x10^{-6}$	All	$1.5x10^{-4}$	$3.6x10^{-4}$	$3.0x10^{-18}$
7: Transfer cask dropped	$5.6x10^{-5}$	$1.0x10^{-6}$	All	$1.5x10^{-4}$	$3.6x10^{-4}$	$3.0x10^{-18}$
8: Transfer cask dropped	$5.6x10^{-5}$	$1.0x10^{-6}$	All	$1.5x10^{-4}$	$3.6x10^{-4}$	$3.0x10^{-18}$
9–10	Not Applicable					0
11–17: Transfer cask dropped	$5.6x10^{-5}$	$1.0x10^{-6}$	All	$1.5x10^{-4}$	$3.6x10^{-4}$	$3.0x10^{-18}$
18: Lowering transfer cask thru equipment hatch 100 ft drop	$5.6x10^{-5}$	0.020	NG	1	$1.0x10^{-10}$	$1.1x10^{-16}$
			OT	$1.5x10^{-4}$	$3.6x10^{-4}$	$6.0x10^{-14}$
19	Not Applicable					0
20: MPC drop (19-ft drop)	$5.6x10^{-5}$	0.28	NG	1	$1.0x10^{-10}$	$1.6x10^{-15}$
			OT	$1.5x10^{-4}$	$3.6x10^{-4}$	$8.5x10^{-13}$
21: MPC drop (19-ft drop)	$5.6x10^{-5}$	0.28	NG	1	$1.0x10^{-10}$	$1.6x10^{-15}$
			OT	$1.5x10^{-4}$	$3.6x10^{-4}$	$8.5x10^{-13}$
22–24	Not Applicable					0
25	Not Applicable					0
26–33: Storage cask dropped	-	0		X		0
34: tipped by seismic event	$7.0x10^{-7}$	$1.0x10^{-6}$	All	X	$3.6x10^{-4}$	$2.5x10^{-16}$
34: struck by aircraft	$6.3x10^{-9}$	0.014	All	X	$3.6x10^{-4}$	$3.2x10^{-14}$
34: struck by meteorite	$3.5x10^{-14}$	1	All	X	$3.6x10^{-4}$	$1.3x10^{-17}$
34: heated by aircraft fuel	$3.7x10^{-9}$	0		X	N/A	0
TOTAL 1ST YR RISK						$1.8x10^{-12}$
Subsequent Years of Storage						
34: tipped by seismic event	$7.0x10^{-7}$	$1.0x10^{-6}$	All	X	$3.6x10^{-4}$	$2.5x10^{-16}$
34: struck by aircraft	$6.3x10^{-9}$	0.014	All	X	$3.6x10^{-4}$	$3.2x10^{-14}$
34: struck by meteorite	$3.5x10^{-14}$	1	All	X	$3.6x10^{-4}$	$1.3x10^{-17}$
34: heated by aircraft fuel	$3.7x10^{-9}$	0		X	N/A	0

Notes: "NG" = noble gases
"OT" = radionuclides other than noble gases
"All" = noble gases and all other types of radionuclides released
"X" = probability of release from containment in the storage phase is not applicable

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Comparative Hazard: Why Spent Fuel Storage and Transport Are So Safe

- Concept of "hazard" entails two major components
  - Toxicity or harm, once accessed or encountered;
  - Accessibility (quantity, availability, and probability)
- Access consideration is why water is more hazardous than anthrax
- Need to educate key stakeholders on both levels of hazard concept
- Public does not routinely differentiate between hazard and toxicity
- Spent fuel "may" have more hazardous materials than other industries (but ^{210}Po and other U and Th primordial series daughters are more hazardous than ^{239}Pu and ^{137}Cs, per EPA's FGR 13, EPA 402-R-99-001)
- However, spent fuel, by design, serves as a robust containment for its radionuclides. Other industries are also not regulated to assure no access, and do not control access by design, to hazardous materials. Spent fuel storage and transport industry packages are regulated.
- Licensing of nuclear storage and transportation and the applicable regulatory requirements leave public, politicians, and interest groups with solid impression that there is "something wrong with nuclear storage and transportation." The facts show just the opposite.

Examples

- Packaging design has proven to be robust; risk of release due to breach of containment or confinement, especially with canistered spent fuel, is infinitesimal
- Canistered systems offer safety increase for moderator exclusion, content release
  - Water in the containment but not the canister
  - Permit defense as in ISG-19 of testing to support canister integrity
  - Modify staff historical position that exceptions permitted by 71.55(c) cannot be used for general design approval
- If moderator exclusion cannot be used, this may be offset by licensing approaches that permit consideration of
  - Fuel disruption (less reactive) with more mechanistic (realistic) fuel particle distribution (the heavy fuel particles will set up their own moderator exclusion by gravity)
  - More burnup credit during accident analyses, since the fission product poisons are there
  - Ready retrievability of fuel to include use of vacuum systems and grapples in a hot cell
  - Reducing administrative margin in max Keff = 0.95 (e.g., setting acceptable Keff at 0.98, post accident, as is allowed in 10CFR50.68)
  - Exceeding Keff = 0.95 does not result in risk-informed radiological impact on the public