U.S. NUCLEAR POWER GENERATION:
PRESENT, FUTURE, AND IMPLICATIONS FOR TRANSPORTATION

Transportation Considerations and Perspectives: Domestic and International

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A NUCLEAR TRANSPORTATION SAFETY SUMMARY

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Transportation Considerations and Perspectives: Domestic and International

Topics

- U.S. Nuclear Infrastructure Council (U.S. NIC) Introduction
- Spent Nuclear Fuel (SNF) Transportation and Restoring the Nuclear Alternative (ReNuAl)
- Spent Fuel Transportation Perception and Safety
- Approach to Addressing Information Inaccuracies
  - Education
    - Comparative Thinking About SNF Transportation
  - Demonstration
    - Building Coalitions and Consensus
- Questions and Discussion

U.S. NIC Introduction

- Hybrid 36-corporate-member successor organization to the U.S. Transport Council
- Not-for-profit advocacy organization for nuclear new build, with multi-disciplinary nuclear capabilities credentials
- Champions policy, consensus and business issues relevant to:
  - Launching the next wave of nuclear plants
  - Building necessary nuclear infrastructure
  - Revitalizing the industry base
  - Resolving key building block issues
  - Meeting SNF transportation and storage needs

SNF Transportation and ReNuAl

- ReNuAl cannot occur without SNF transportation
  - Consolidated Interim Storage (CIS)
  - Repository disposal
  - Reprocessing/Recycle
- Extensive SNF transportation must occur even without ReNuAl
- SNF transportation (and storage) industry already exists and can support full spectrum of nation's needs
  - Technology - proven
  - Regulations - proven
  - Fabrication - extensive and proven
  - Procedures - extensive and proven
  - Safe transportation - extensive and proven

Nuclear Power and SNF Transportation Perception

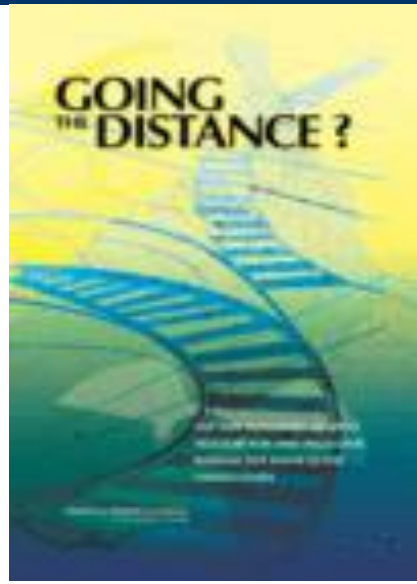
- "Fear of fission" is still a major consideration in ReNuAl
- Nuclear power often demonized with inaccurate information
- Public may perceive inflated risk, not actual or comparative risk
- SNF transport is also subject to "demonization of radiation" attack
- SNF transport opposition typically results from
  - Inaccurate information
  - Agenda bias
    - For instance, "Mobile Chernobyl" themes indicate intent
- SNF transport industry must act on these perceptions to "exorcise" SNF transportation for future benefit of ReNuAl
- SNF transport industry response should be on two fronts

"Nuclear energy ain't so new and it ain't so clear!"
– Howland Owl (*Pogo*, Walt Kelly)

SNF Transportation Safety

- The National Academy of Sciences (NAS) has assessed the safety of SNF transport[1]
- SNF transport safety is proven historically
  - More than 3,500 SNF transports in the U.S. over about 50 years
  - SNF shipments have been made with no documented releases exceeding regulatory limits or harming the public or the environment
- NAS study principal finding:

"The committee could identify no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. Transport . . . is, from a technical viewpoint, a low-radiological-risk activity with manageable safety, health, and environmental consequences when conducted with strict adherence to existing regulations."



[1]COMMITTEE ON TRANSPORTATION OF RADIOACTIVE WASTE study published by the National Research Council: *"GOING THE DISTANCE? THE SAFE TRANSPORT OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE IN THE UNITED STATES."* Available from: http://www.nap.edu/catalog.php?record_id=11538#toc

Industry Approach to Addressing Information Inaccuracies

Address inaccurate information: two fronts on parallel paths

Objective is to drive a perceptual shift, build key alliances

- Education
  - Outreach to key public, political, and media groups
  - U.S. NIC to develop PRECEPTS Initiative: Principles, Risk Education and Communications to Enhance Perception of Transport/Storage Safety
- Demonstration
  - Work with the DOE and industry partners to expand knowledge and experience in testing related to low-probability events to further demonstrate safety

PRECEPTS Initiative Education Concepts

- Answer "what if" questions for low probability SNF transport events
  - What is a reasonable, intellectually honest, acceptance criterion for the "worst that can happen"?
- "Worst case" for nuclear radiological events is no worse than "what's normal" for conventional industries and accepted by public every day
- This is *NOT* about reducing nuclear safety standards or regulations – its about thinking on a different level
  - Thinking on a level of "comparative hazard" reduces relative fear
- Objective: achieve comparative thinking to stimulate a perception shift, which can then drive a paradigm shift
- Look briefly at elements to achieve the shift, starting with Education

Gump's Postulate: "Shift happens!"
(but it takes time and effort)

Seven Non-Nuclear Industries: How They Expose the Public to Radiation

- Medical Diagnostics: **Radiation for diagnosis of suspected illness**
- Tobacco Supply: **radionuclide inhalation from cigarette smoking**
- Building Design/Construction: **radon/thoron in-leakage, trapping; inhalation by occupants**
- Potable Water Supply: **radon, radium, uranium in public, private water supplies are consumed by public**
- Aviation: **flying reduces "shielding" from cosmic radiation; crew and passengers are exposed to more cosmic radiation**
- Agriculture: **soil/fertilizer radionuclides increase direct radiation, release radon, thoron, radioactive dust to workers and others**
- Construction Materials: **concrete, brick, building stone, asphalt are rich in radioactivity; people outdoors and indoors are exposed**

Example: Maximum Credible Doses from Sabotage of SNF Transport

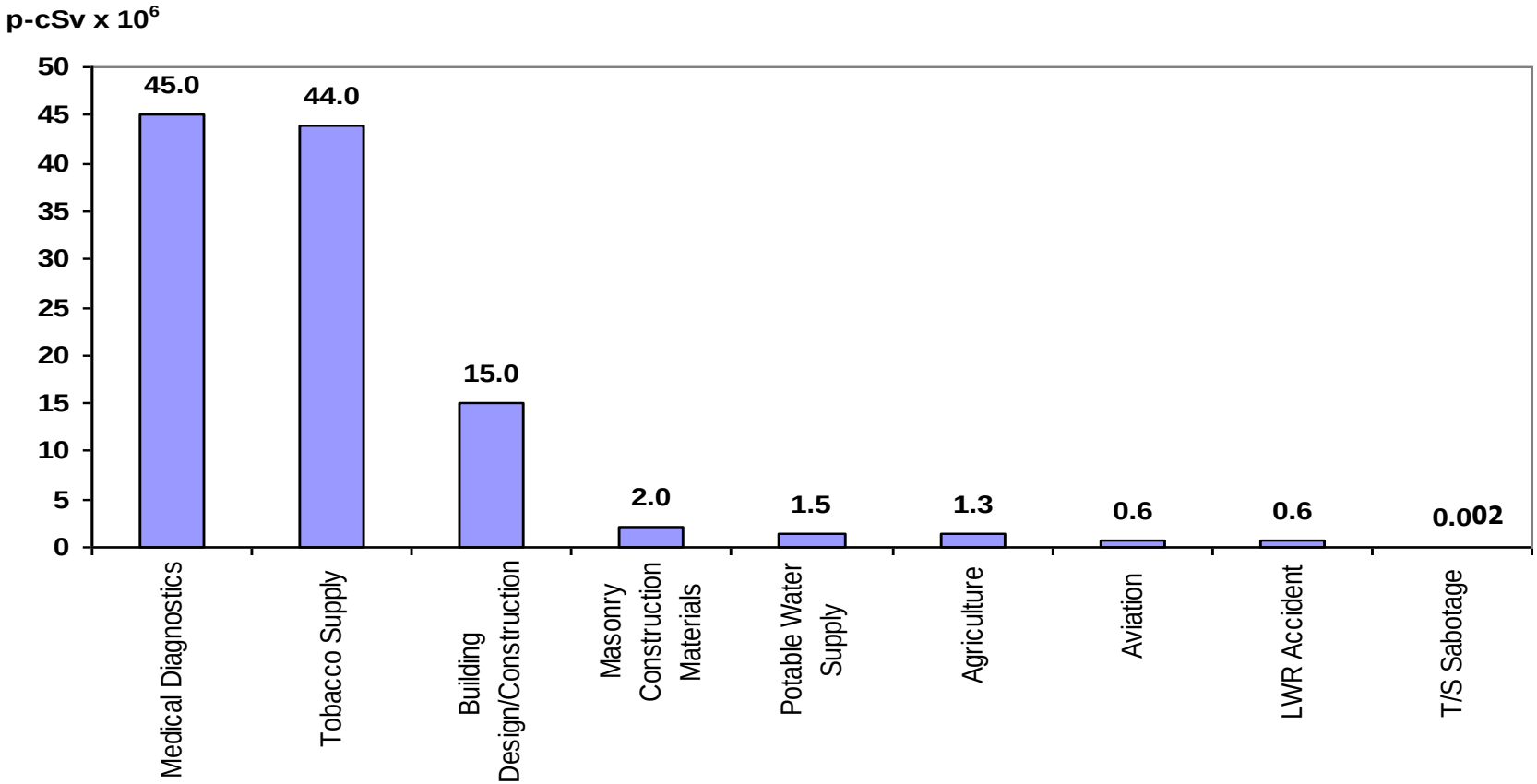
Collective effective dose equivalent (CEDE) to the general public for maximum credible sabotage attack on spent fuel storage or transportation system[1]

Type of CEDE	Year 1 (person-cSv)	Years 2 – 10 (person-cSv)	Years 11 – 50 (person-cSv)	Totals (person-cSv)
External CEDE	770	1,150	1,300	3,220
Internal CEDE	730	1,350	200	2,280
Thyroid CEDE	0	0	0	0
Totals	1,500	2,500	1,500	5,500
Total 50 Year Average Annual Dose to Individual (cSv)	0.0003	0.00005	0.000007	0.00002

[1] Charles W. Pennington, 2010: " A Demonstration of the Comparative Radiological Safety of Commercial Nuclear Power Generation in the U.S." In publication: *The International Journal of Nuclear Governance, Economy, and Ecology*, InderScience Publishers.

Annual Radiation Doses: Maximum Credible Nuclear Events vs Non-Nuclear Industries Shows Comparative "Toxicity"

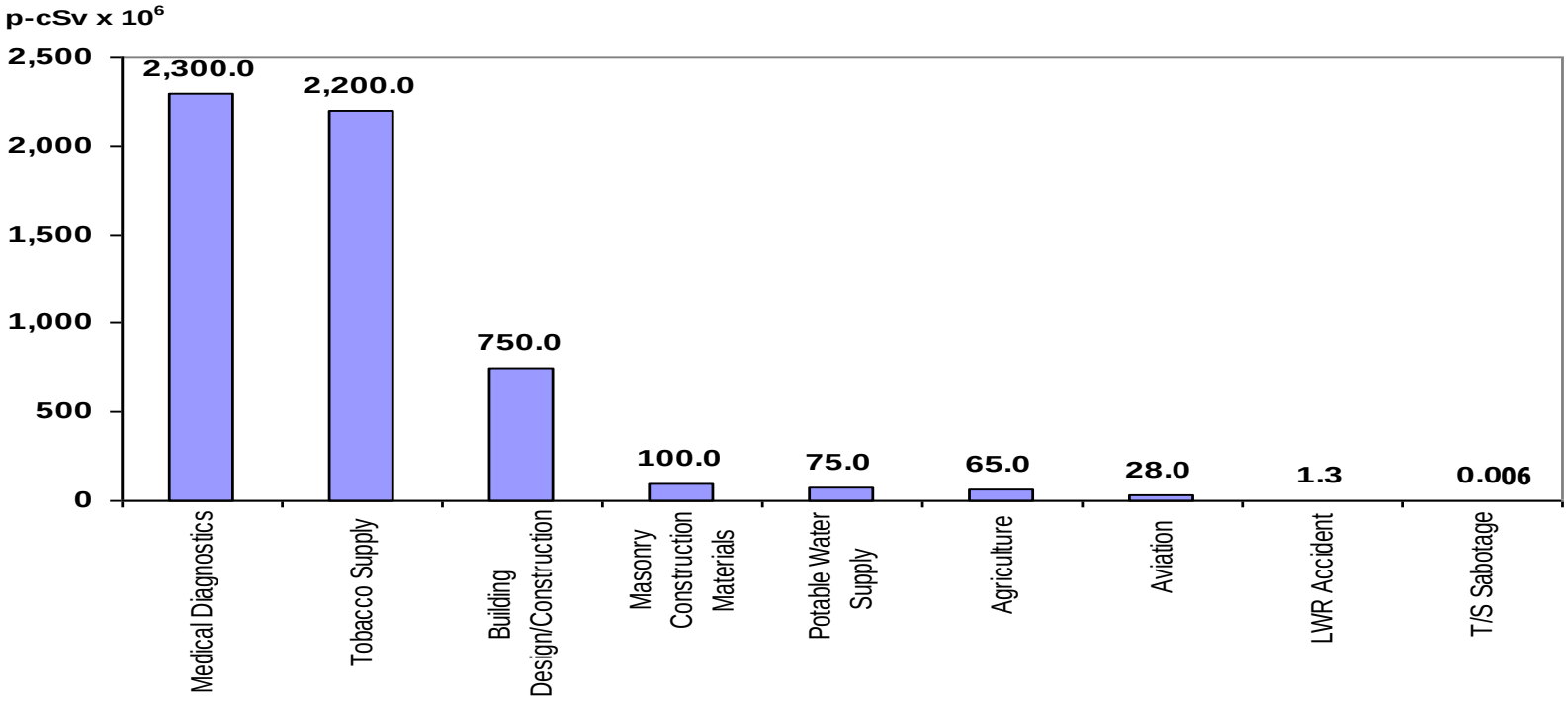
Non-nuclear industry annual CEDE vs. maximum credible U.S. LWR and transport/storage (T/S) accident and sabotage events (person-cSv x 10^6)[1]



1 Charles W. Pennington, 2010: " A Demonstration of the Comparative Radiological Safety of Commercial Nuclear Power Generation in the U.S." In publication: *The International Journal of Nuclear Governance, Economy, and Ecology*, InderScience Publishers

Lifetime Radiation Doses: Maximum Credible Nuclear Events vs Non-Nuclear Industries Also Shows Comparative "Toxicity"

Non-nuclear industry 50 year CEDE vs. bounding U.S. LWR and transport/storage (T/S) accident and sabotage events (person-cSv x 10^6)[1]



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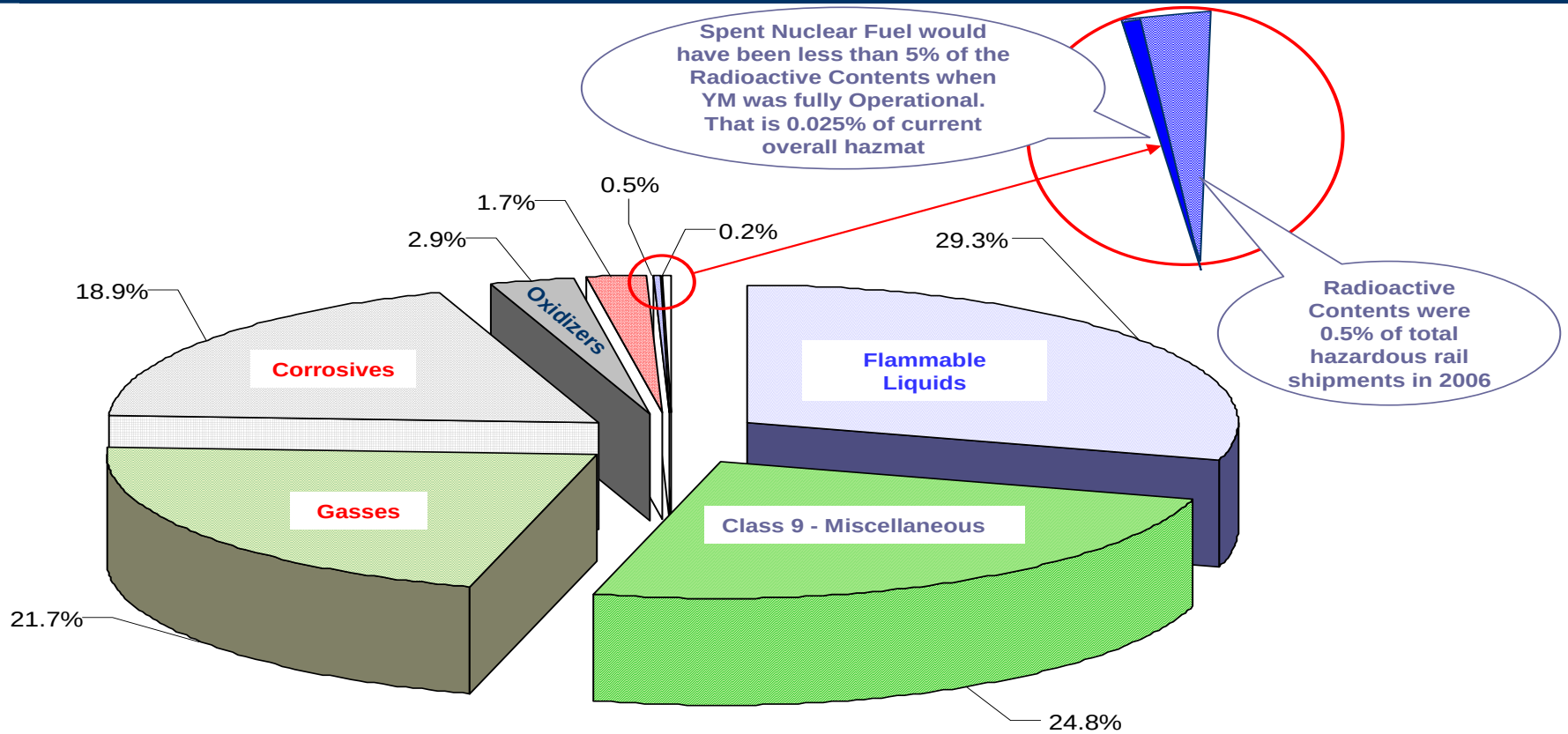
Comparative Hazard: Other Elements of Education

Public cannot differentiate between hazard and toxicity. This is another element of education

- Concept of "hazard" entails two major components
  - Toxicity or harm, once accessed or encountered; this is addressed above by comparing actual radiation doses from seven non-nuclear industries with hypothetical worst case doses from nuclear events
  - Accessibility (quantity, availability, and probability)
- Access consideration is why water is more hazardous than anthrax
- Need to educate key populations at both levels of hazard concept

Access Example: Relative Volumes of Rail Shipments by DOT Hazard Class*



Class 3, Flammable/Combustible Liquids 29.3%	Class 9, Misc Hazardous Material 24.8%
Class 2, Gases 21.7%	Class 8, Corrosive Material 18/9%
Class 5, Oxidizers 2.9%	Class 6.1, Poisonous Materials 1.7%
Class 7, Radioactive Material 0.5%	Class 4, Flammable Solid, Dangerous when wet 0.2%

*Data from Association of American Railroads Annual Report of Hazardous Materials Transported by Rail, Calendar Year 2006

Access Example:
Comparative Volume and Dispersion of Wastes

Coal

~ 32,000,000 tons of air for combustion

3,425,175 Tons coal average 11,900 BTU/Lb

32,621 rail gondola cars

8,865,558 Tons CO_2

25,875,600 Tons N

51,246 Tons SO_2

23,652 Tons NOx

685,000 Tons ash (fly, bottom and slag)

70% goes to dry landfills = 479,500 tons

~ 4,800 rail cars or 15,000 Legal Wt Trucks

All is radioactive with U, Th, Ra, Rn, Po

Nuclear (PWR)

28 Tons 5% enriched Uranium Fuel

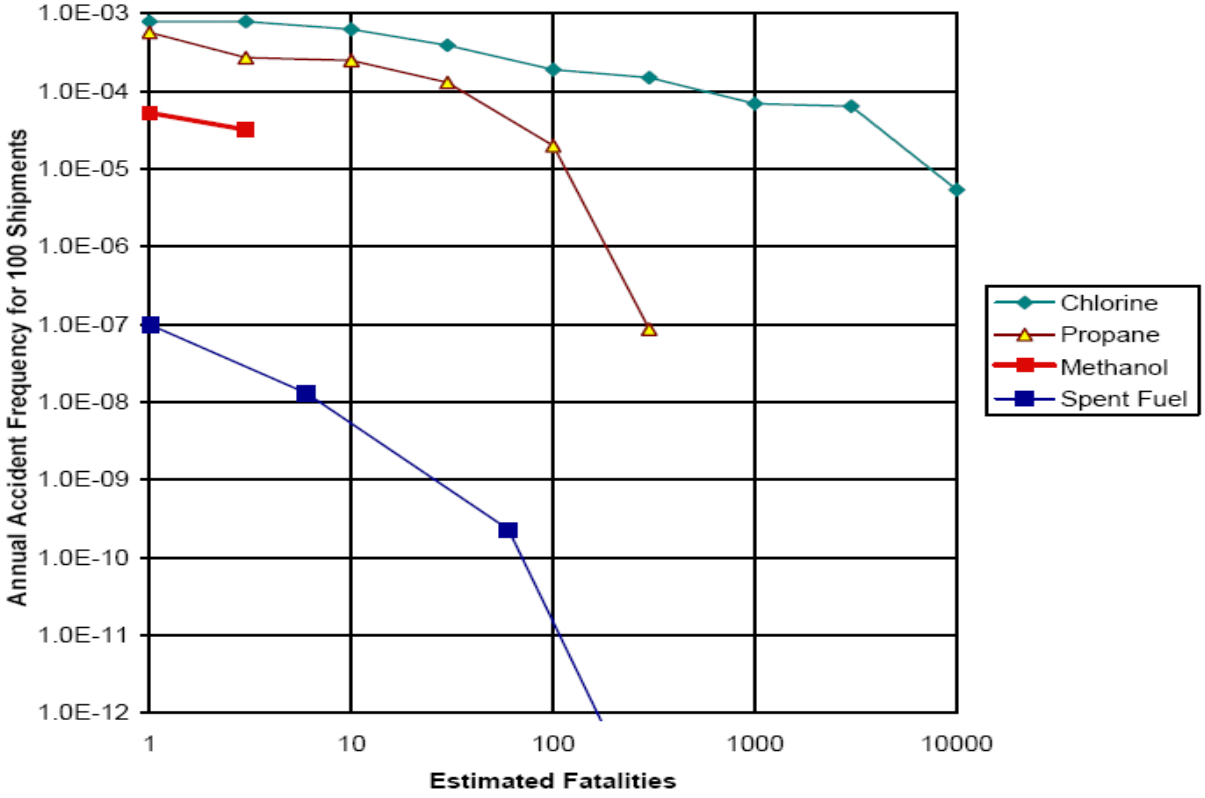
5 legal weight trucks

28 Tons Used Nuclear Fuel

9 legal weight trucks using GA-4 Casks

- new

Results: Comparative Risk of Hazardous Materials Shipments



Source: National Academies' "*Going the Distance, The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States*"

Demonstration: Building Coalitions and Consensus

- Even with education we also need demonstration to forge an effective consensus and build coalitions agreeing on safety
- Much of the difference between actual and perceived risks in society may proceed from the following:
  - Few shipments per year means emergency responders and the public aren't familiar with SNF or the safety protections designed into the packaging and shipment process
  - No definitive, objective, unclassified data available to assess the consequences of security incidents. Security risks are presented to the public by parties with differing intentions and varying opinions about the consequences of threat incidents
  - No recent demonstrations of accident safety or emergency response capability with commercial SNF casks

What Do These Differences Mean for Future SNF Shipments?

- ReNuAl and any disposition scenario for SNF and HLW will require future shipments from utilities, research reactors, and DOE sites to processing, storage, and/or disposal facilities;
- Future transports will include protected shipments of MOX fuel to power plants;
- Absent significant efforts to address uncertainties and concerns about future commercial SNF (and DOE HLW) shipments there will be barriers and delays to shipment campaigns;
- There are several demonstration efforts that could ameliorate these concerns and help build consensus and coalitions about SNF shipments in the future to avoid barriers and delays . . .

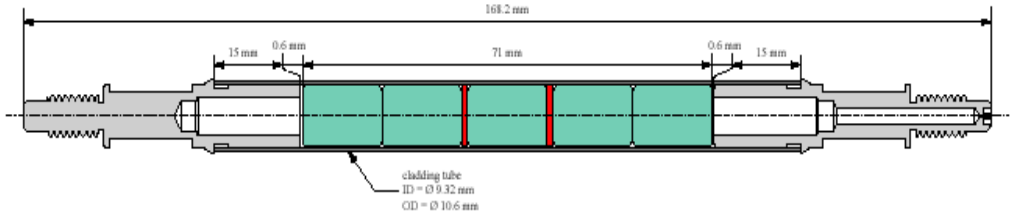
Effort 1: Updated Severe Accident Transportation Test

- A full scale, severe accident test of SNF shipping casks has not been performed in the U.S. since 1977
- Cask certification involves more detailed analyses since the last tests

- Plans for a severe accident test of a rail-sized cask were developed, but funding for tests was never provided
- Severe accident testing provides an opportunity to assess the performance of these casks in unlikely situations under actual conditions
- In addition to collecting data to benchmark models, such testing would also provide an opportunity for first responders to work with an actual accident scene in a response exercise.

Effort 2: Completion of Sabotage Consequence Tests

- The U.S. initiated an agreement with France, Germany, and the UK to conduct sabotage tests on actual spent nuclear fuel in a controlled environment
- Tests and modeling with surrogate materials have been completed with promising results
- Test chambers for actual spent fuel have been developed, but conduct of actual tests and review of data is awaiting funding
- Completion of tests would provide objective data on consequences of spent fuel sabotage to allow assessment of additional threat mitigations, if needed;



Test Chamber

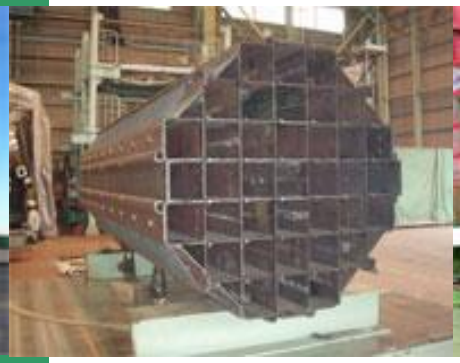
Surrogate DUO_2 test targets

Effort 3: Conduct Tabletop and Full Scale Commercial SNF Accident Exercises With Emergency Responders

- Partner with emergency responders to develop exercises that benefit their communications and command and control planning
- Conduct these exercises in conjunction with educational programs using actual SNF shipping casks
- Communicate the results of severe accident tests and sabotage consequence tests as part of outreach effort
- Begin this process 3-5 years in advance of major shipping campaign for maximum benefit;

Gump's Law: "Safe is as safe does."

SNF Transportation Conclusions

- Whatever options are pursued for long term SNF management, there will be a transportation component that cannot be ignored
- Whatever options are pursued for SNF management, the associated transportation will remain a VERY minor part of overall hazmat transportation in this country
- The current regulatory framework ensures that SNF shipments pose a low safety risk
- Even with a small volume of actual transportation operations and low risks, there will be considerable attention given to any SNF shipments
- There are education and demonstration efforts that can reduce both the actual and the perceived risks for SNF shipments
- There are additional R&D efforts that can fill in knowledge gaps over the transportation implications of long-term storage
- Active pursuit of these efforts now will ensure SNF shipments can be planned and completed as scheduled
- They will also lend strong support for the ReNuAl enterprise.

QUESTIONS AND DISCUSSION