



# Used Fuel Transportation Considerations

J. Gary Lanthrum  
Principal Consultant  
NAC International

NWTRB  
6/13/2018

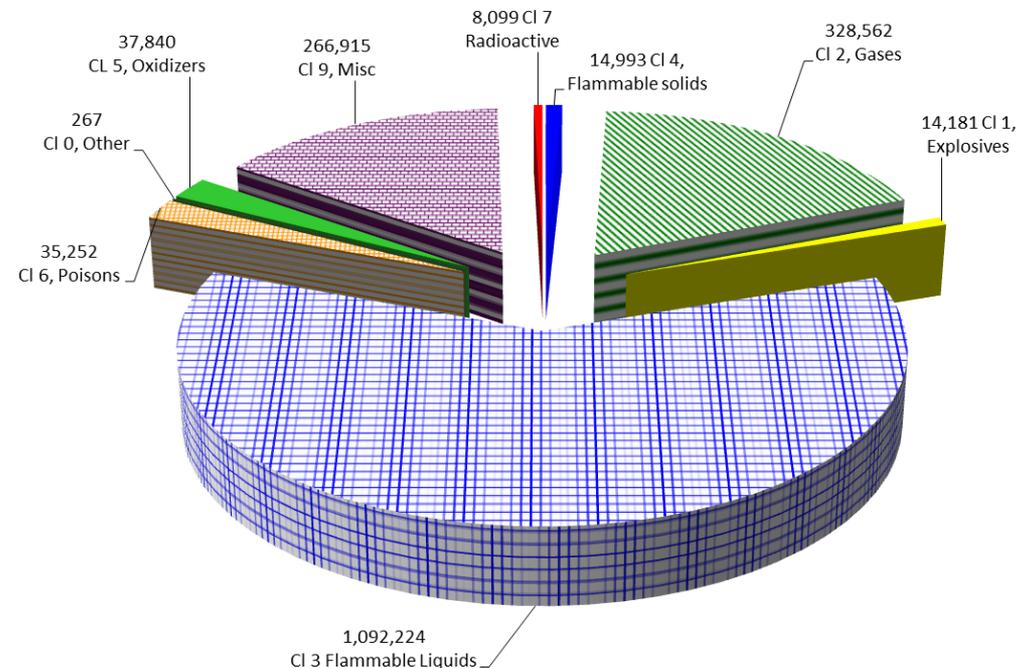
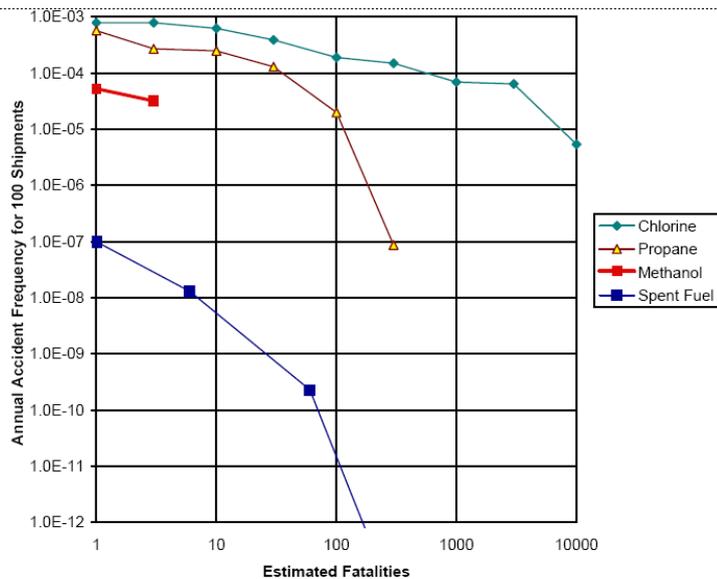


- **Spent Nuclear Fuel Transportation has an enviable safety record**
  - The U.S. nuclear energy industry has completed more than 3,000 shipments of spent nuclear fuel over the past 40 years;
  - Internationally, there have been more than 7,000 shipments of used fuel (over 80,000 metric tons) over many millions of kilometers by land and sea.
  - Although there have been accidents, none of those shipments have ever released any of their radioactive cargo, and there have been no injuries, fatalities or environmental damage as a result of the SNF being shipped.
- **In 2006, The National Research Council's' Committee on Transportation of Radioactive Waste found:<sup>1</sup>**
  - There is no fundamental technical barrier to the safe transport of spent fuel in the U.S.
  - U.S. regulations are adequate to ensure package containment effectiveness over a wide range of transport conditions
  - The accident risk associated with spent fuel shipments is more than three orders of magnitude less than for some other common hazardous materials.

<sup>1</sup> The report on this study was published as a book titled: "***Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States***". This report is available at <http://www.nap.edu/catalog/11538/going-the-distance-the-safe-transport-of-spent-nuclear-fuel>

# National Research Council Study

Shipments of SNF are lower risk than other hazardous material shipments, and there are far fewer of them.



## Maintaining the Enviably Safe SNF Transportation Safety Record

So, given the exemplary safety record of SNF shipments to date, the low risk associated with each shipment and the very low number of shipments, is any work necessary to address SNF transportation safety prior to beginning shipments to a consolidated storage facility?

Well, perhaps.

- The SNF transport safety record to date is due to extraordinary care by both the industry and its regulators.
- That standard of care has been applied to the hardware and processes in use today, but:
  - Future shipments will face new requirements and operational challenges not yet experienced.
- Addressing new requirements and first time project tasks with the same standard of care as current SNF transportation activities will ensure the enviable safety record continues.

# Challenges to Maintaining the Enviably SNF Transportation Safety Record

There are aspects of shipping commercial SNF & HLW from dry storage that have not been previously addressed. These activities include:

- First time domestic use of a new generation of large, rail transportation casks;
- Resolving complicated logistics associated with a plethora of “package” certifications, particularly for challenging DOE SNF;
- Providing federal funds for training and technical assistance to public safety officials as required by Section 180(c) of the Nuclear Waste Policy Act (NWPA).
- Loading these transport casks with large SNF canisters at shutdown sites where operating plant infrastructure no longer exists;
- Managing the operational logistics for 6 special rail cars that won't fit onto the sidings at most shutdown reactor sites;
- Dealing with multimodal shipments for transport away from many shutdown sites that no longer have rail access;
- First time use of new route selection regulations for shipment of commercial SNF by railroads.

None of these issues are show stoppers, but doing too many new things at once can be distracting and that can compromise safety.

From your experience at OCRWM, what technical issues caused the greatest concern for adversely impacting the successful implementation of a transportation program?

- a. Transporting High Burnup (HBU) Spent Nuclear Fuel (SNF);
- b. Getting transport certificates for DOE SNF;
- c. Uncertainties over the formulation of vitrified HLW affecting transportation Certificates of Compliance (CoC);
- d. The overall complexity of the transportation system;
- e. Lack of transportation integration with storage and disposal, especially between the private sector and the federal government. The proposed use of a Transport, Ageing and Disposal canister (TAD) was a flawed attempt to address this challenge. Something new is needed.

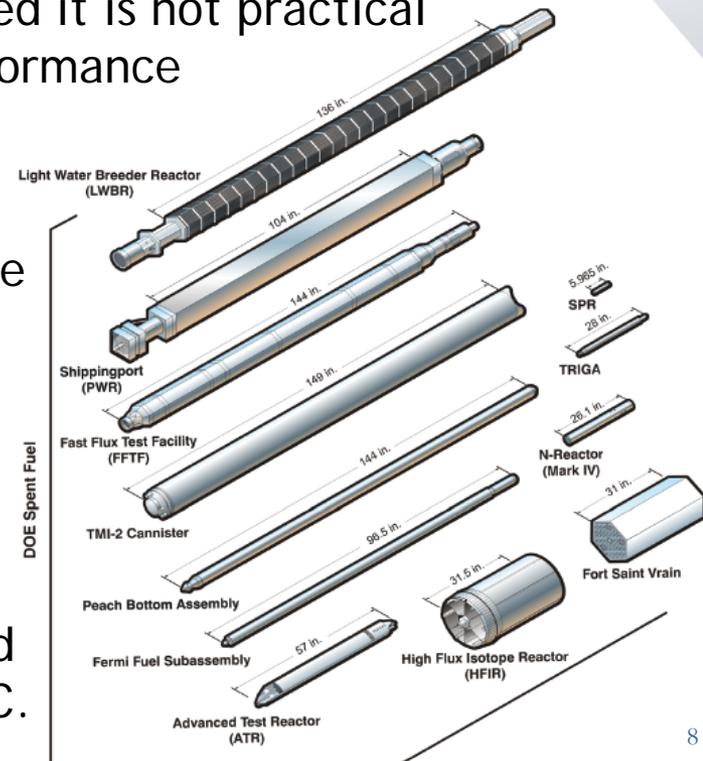
All Commercial SNF can be transported in current package CoCs. The NRC defines “Packaging” as the container that materials are shipped in. They define “Package” as the packaging together with its radioactive contents as presented for transport.

- This progress was market driven, and is being resolved by a joint effort of the public & private sectors. Sales of canisters for dry storage at utility sites rely on having packaging certified for transport of the canistered contents. Similar market drivers do not exist for DOE SNF.
  - Commercial SNF is licensed for transport as part of a “package” by detailed analysis of fuel specific performance characteristics.
  - HBU fuels can currently be transported in damaged fuel cans.
  - It is likely that R&D funded by the DOE & NRC will eventually allow most HBU fuels to be transported without confinement in damaged fuel cans. Current R&D projects funded by DOE at utility sites with industry participation are providing useful data.

# NWTRB Question #1b DOE SNF

DOE SNF has more varied and complicated performance characteristics.

- There are several hundred distinct types of DOE SNF with varying levels of enrichment and burnup.
- The 2008 Waste Acceptance System Requirements Document (WASRD) requires Federal Waste Custodians (EM & Navy) to characterize and package SNF and HLW for shipment to a repository. DOE/EM decided it is not practical to perform detailed analysis of fuel specific performance characteristics for all of these fuel types.
- A 2007 MOA between EM & RW requires RW to design, obtain NRC certification and fabricate the transportation cask system for EM SNF and HLW
- Absent fuel specific performance characteristics, it is hard to imagine how RW, its successors or vendors can obtain NRC Package Certification for this content. An effort by EM to obtain moderator exclusion for standard canisters was halted after meetings with the NRC.



# NWTRB Question #1c

Like Commercial SNF, DOE HLW has market drivers to ensure transport options exist

- DOE/EM incentivized the private sector to develop stand-alone dry storage and transportation capability for HLW at West Valley. This allowed permanent structures to be taken down. HLW is now loaded into dry storage casks in transportable canisters.
- NAC was selected as the vendor for HLW dry storage systems at West Valley. The systems used mirror hardware and processes developed for SNF dry storage.
- WV HLW overpacks store 5, 24" diameter WV HLW canisters in a vertical concrete cask

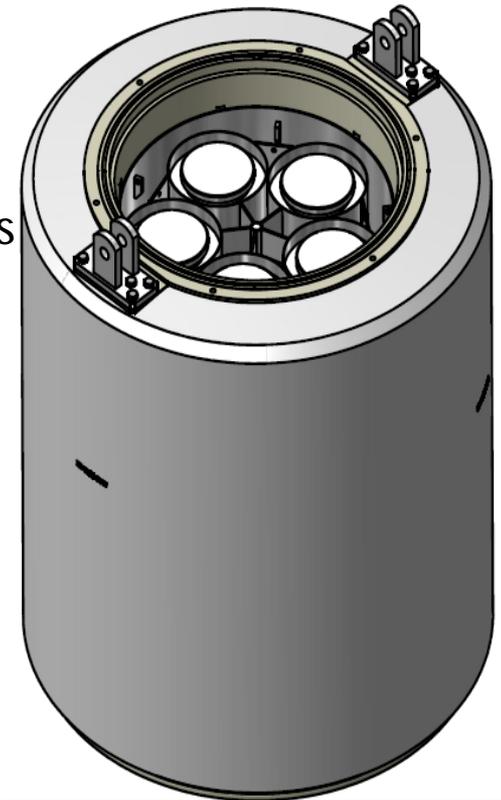


West Valley High Level Waste  
Canister Test Fit In Overpack

## NWTRB Question #1c

Transport and Yucca Mountain Waste Acceptance for Vitrified HLW Canisters is based on specific loadings of radionuclides in Lanthanide Borosilicate Glass.

- Rev 18 to the CoC for the NAC STC Transport cask includes HLW as approved content.
- The LA for Yucca Mountain covered specific formulations of Lanthanide Borosilicate Glass and HLW loadings for vitrified waste canisters.
- PNNL continues to explore improvements in glass formulations that would allow increased concentrations of HLW and different glass formulations in vitrified waste logs.
- Increasing from 13 wt% to 26 wt% loadings may be possible. This would improve waste processing throughput, but would require revisions to the Yucca Mountain License Application and to the Certificate of Compliance for transporting HLW.

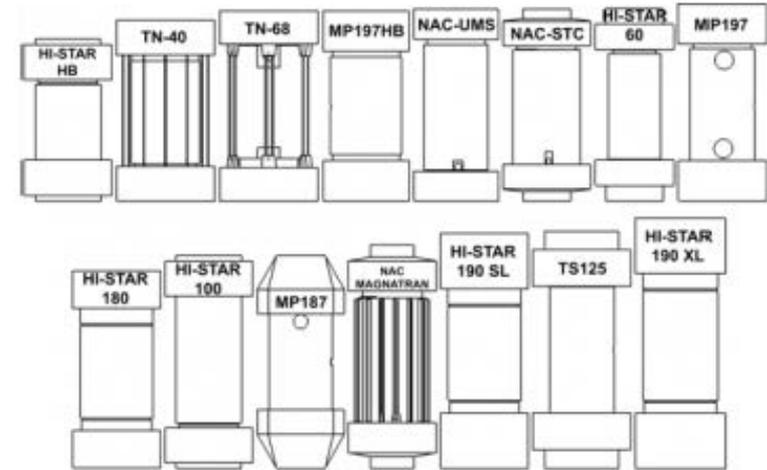


**5 canisters of HLW in a NAC transfer cask waiting for the overpack lid to be installed**

# NWTRB Question #1d System Complexity

There are a number of challenges tied to the unnecessary complexity of the transportation system

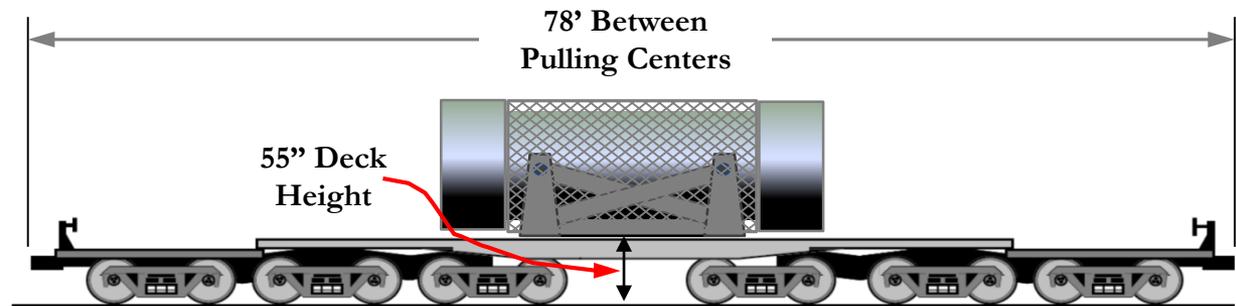
- One challenge with commercial SNF transport is the range of packaging sizes currently certified for transporting specific canisters. Currently, 15 cask designs are required to transport all SNF content by rail. That could be reduced to 3-4 designs with vendor incentives.
- The approach for transfers from storage to transport at shutdown sites varies considerably from site to site, and is more complicated than transfers at operating plant sites.



# NWTRB Question #1d

Processes and agreements need to be established for operating & storing 6 special rail cars that won't fit onto most shutdown reactor sites while waiting for transport casks to be loaded

- New rail cars have to be developed and tested to meet AAR S-2043 requirements. Protocols for real-time monitoring of onboard systems (truck hunting, bearing temperature, etc.) on these rail cars have not yet been developed or approved.
- High capacity rail cars meeting the AAR S-2043 235 spec are long. A flat bed 12 axle car with 300 ton capacity is 78' between pulling faces.
- A standard DOE shipment of 3 cask cars, 2 buffer cars and 1 escort car requires over 400' of parking space. That isn't available at most reactor sites.
- Establishing protocols and conducting Table-Top coordination exercises before shipments begin will contribute to safe & efficient operations.



# NWTRB Question #1d

Identifying viable intermodal transfer points for shifting casks from heavy haul trucks to rail cars will be a challenge for these cargoes.

- Large, intermodal facilities exist in the US, but are not conveniently located near nuclear power plants.
- New procedures and portable equipment for making SNF cask transfers from trucks to trains will be needed.



- The private sector could be incentivized to develop common hardware, processes and plans that could be used. Standardizing these operations will reduce overall costs and contribute to safe operations.

What unexpected challenges were encountered in planning the OCRWM transportation program and what steps were taken to minimize the impacts of these surprises?

- a. Inconsistent, and steadily declining funding and slipping start-up dates
  - i. Reduced effective interaction with the private sector over rail car modeling, cask optimization, transport dry-runs and emergency response exercises.
  - ii. Management believed that severe cost cutting in the transportation program was warranted because of the safe SNF transport history. Scarce resources were diverted to justify transportation plans.
  - iii. Limited funding meant cask procurements had to be prioritized. Uncertainties with the transportation queue made that impossible. No procurements were let, and no cask optimization was funded.
- b. Reconciling repository and routing decision schedules with the need to fund 180(c) emergency response support 3-5 years before the first shipment.

Prior to shipping radioactive wastes, which inter-agency (DOT, NRC, State regulator, etc.) coordination activities required the most effort and most lead-time? Please give examples of lead times.

- a. Considerable time was spent with the Federal Railroad Administration at the Department of Transportation - years
- b. Interactions with the Association of American Railroads over the AAR-S-2043 Operating Standard for SNF railcars. It isn't just the approval process for the railcars, but how operating systems like real time tracking of truck hunting and bearing temperature will affect shipments. - years
- c. Negotiations with Railroads & the Surface Transportation Board over transport tender price gouging - years
- d. State permits will be required for Heavy Haul operations - those are usually pro-forma, but were expected to be more complicated for shipments of SNF

Based on your experience, what are the top-priority technical issues you recommend that DOE focus on now to prepare for an efficient and effective transportation program?

- a. Improved integration of transportation with storage and disposal requirements.
  - i. Between the private and federal systems
  - ii. For multiple repositories
  - iii. Determining how and where that integration will take place;
- b. Better integration of EM and repository program plans for transportation and disposal;
- c. Begin negotiations with the Association of American Railroads on how operating aspects of the AAR-S-2043 Standard will be implemented.
- d. Complete negotiated settlements with remaining railroads;

### Improved integration of transportation with storage and disposal requirements between the private and federal systems

- A new generation of private consolidated interim storage facilities is being licensed. How will this integrate with requirements in the NWPA? At least one utility/plant (SCE/SONGS) is considering off-site storage of its SNF as a private initiative.
- Is there a waste form that would be acceptable to any repository, and still allow efficient transportation and storage?
- Should changes that improve integration be implemented at utilities, or at a consolidated storage location?
- What role should DOE/DOJ play in this new world? I believe there are opportunities for win-win-win arrangements in the context of private storage initiatives with some federal involvement. What is needed to allow those conversations to begin?

### Better integration of EM and Repository Program plans for transportation and disposal

- Update the Integrated Interface Control Document (IICD) and the Memorandum of Agreement (MOA) between EM & the Repository Program to reflect current plans for obtaining Certificates of Compliance for shipping EM/SNF. Bring in the private sector to help with this.
- Maintain a dialog between EM & the Repository Program on HLW forms that could viably be added to the waste acceptance criteria for a repository. Update the Waste Acceptance Systems Requirements Document as appropriate.

### Begin operational discussions with AAR over how their operating standard will be implemented

- AAR S-2043 has requirements for monitoring truck hunting, wheel bearing temperatures, accelerations and wheel flat conditions.
  - Where will this information be monitored?
  - Who will have access to this data?
  - What needs to be done when conditions fall out of specification?
    - Do out of spec rail cars stop a train immediately?
    - Does the train proceed to a safe harbor?
    - Is maintenance scheduled after delivery of the cargo?
    - Who gets to make these calls?

### Complete negotiated settlements with remaining railroads and the Surface Transportation Board

- Settlements have been reached with Union Pacific, Burlington Northern Santa Fe and Norfolk Southern railroads.
- Most of the rail lines on the eastern seaboard are CSX track and no settlement between DOE & CSX has been negotiated. This needs to be a priority since most of the nuclear power plants are in the eastern part of the country.

# Conclusions

As the National Academy of Sciences aptly noted in 2006, there are no fundamental technical barriers to the safe transport of spent fuel in the U.S.

- That said, transportation safety relies on both technical and human operations. Human errors are more likely when doing unfamiliar tasks. Training on new processes, procedures and equipment used to transport canistered SNF from shutdown sites is needed so they become as familiar as operating plant shipments.
- Some SNF content destined for repository disposal is not currently covered by existing CoCs. Some HLW formulations are being studied that cannot currently be transported. The transportation organization needs to close those gaps.
- Pilot storage & transportation projects could be used to resolve outstanding issues with training, emergency response preparedness, rail cask testing, parking for rail consists, intermodal transfers and other outstanding transportation issues.
- Although not transportation specific, lack of hardware integration between transportation, storage & disposal makes an inefficient waste management system.
- Private sector cask & transportation vendors have the technical capability, operational experience and the hardware needed to close the gaps that currently exist in transportation capability. The benefits of WIPP's extended dry-run shipment exercises to their eventual transportation success should be considered when planning shipments of SNF & HLW.