Standardized Transportation, Aging, and Disposal (STAD) Canister Design

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Nuclear Waste Technical Review Board
June 24, 2015
Golden, Co

Disclaimer

- **It should be noted that this is a technical report that does not take into account the contractual limitations under the Standard Contract (10 CFR Part 961). Under the provisions of the Standard Contract, DOE does not consider spent fuel in canisters to be an acceptable waste form, absent a mutually agreed to contract modification.**
- **This presentation reflects research and development efforts to explore technical concepts which could support future decision making by DOE. No inferences should be drawn from this presentation regarding future actions by DOE.**

Outline

- **Motivation**
- **Responses to NWTRB questions**
  - STAD canister concept
    - Description
    - Differences from earlier standardized concepts
  - Potential timelines
  - Operational impacts of smaller canisters at reactors
  - Repackaging impacts
- **Concluding remarks**
- **Questions/Answers**

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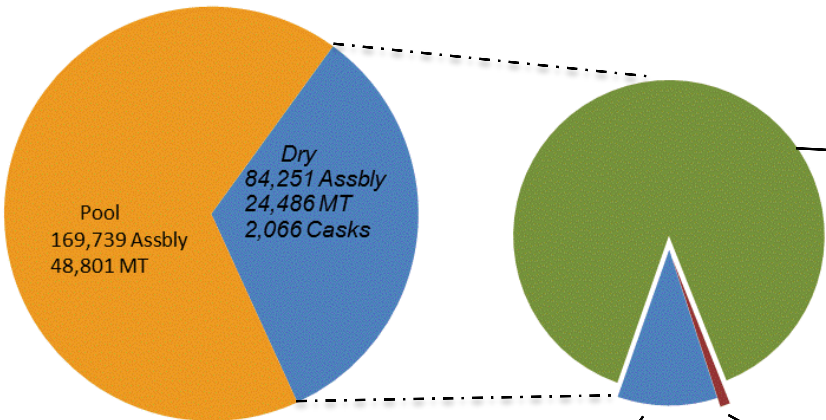
Commercial Dry Storage Inventory is Diverse and Growing

Inventory as of April 7, 2015



1,865 Welded Metal Canisters In Vented Concrete Overpacks
- 74,627 Assemblies
- 88.6% of Dry
- Transnuclear (37%)
- Holtec (41%)
- NAC (20%)

189 Bare Fuel Casks
- 8,758 Assemblies
- 10.4% of Dry

12 Welded Metal Canisters in Transport Overpacks
- 866 Assemblies
- 1.0% of Dry

- *Majority of dry inventory is in large welded canisters*
- *Trend toward higher capacity canisters*

Transnuclear TN-32

Holtec Hi-Star 100

Repository concept-compatible canister systems can potentially simplify the waste management system

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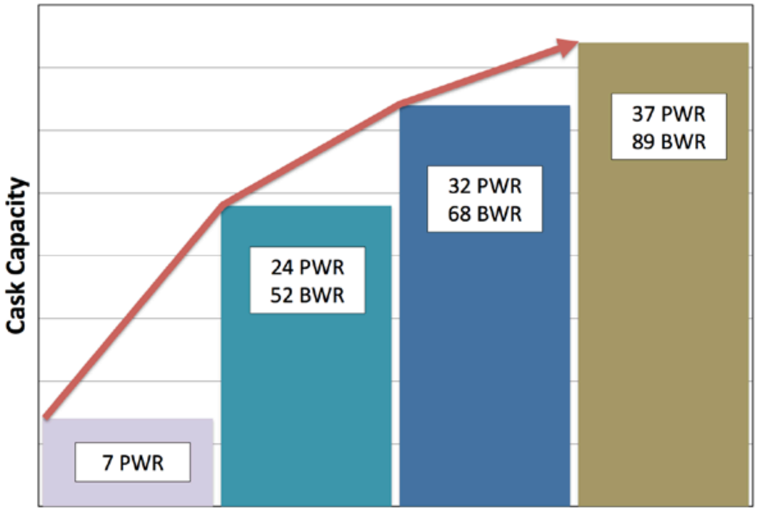
- **There is a lack of integration between storage, transportation, and disposal in the waste management system**
  - Utilities have moved to larger canisters to optimize on their storage needs
  - Large canisters may or may not be disposable
  - If large canisters are not directly disposable, they will need to be repackaged
    - Potential to increase costs, dose, and handling operations
- **A standardized triple-purpose canister system could avoid these issues**
  - Would be designed with disposal in mind (along with storage and transportation)
  - Most likely smaller than current canisters
  - Minimize repackaging



Numerous “Standardization” activities are ongoing in NFST

- **Standardized Canister System Assessment (presented at Fall 2013 NWTRB Meeting) – Expected Completion FY16**
  - Examining system-wide impacts of integrating standardization options into the waste management system
  - Expected to inform future policy decisions (i.e., whether to standardize, how to standardize, where to standardize, what to standardize, when to standardize)
    - Initial evaluation submitted to DOE August 2014
- **Industry Studies on STAD systems – Completed June 2015**
  1. Generic design of small (4 PWR/9 BWR) STAD system (Task Order 18)
  2. Operational impacts and mitigation techniques of loading smaller canisters at reactors (Task Order 21)
- **STAD Specification Requirements and Rationale – Laboratory Draft completed May 2015**
  - Developing specifications for possible, different-capacity STAD canister systems

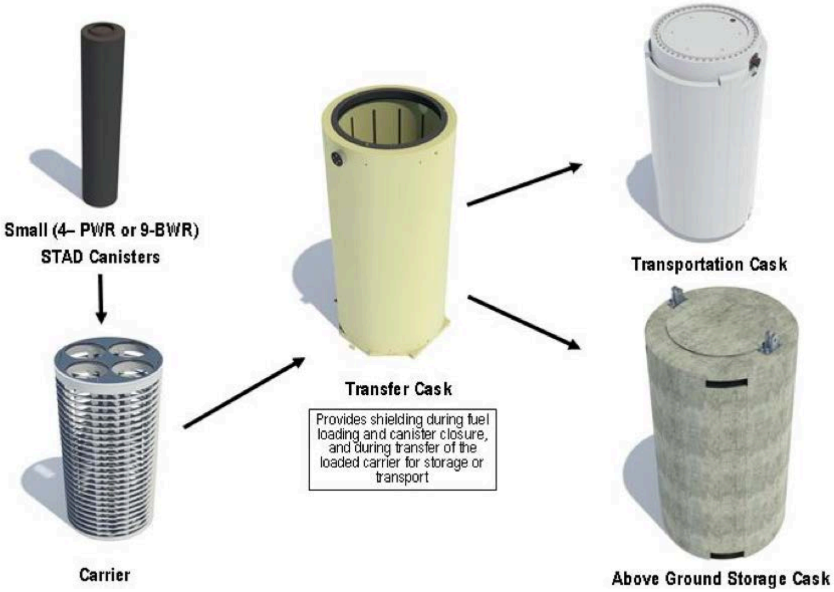
Summary of the published NWTRB questions

- **What are the STAD system concepts and their requirements?**
- **What is the timeline to move forward with the STAD system concepts?**
- **What are the at-reactors impacts of loading the STAD system?**
- **What are the impacts of repackaging?**

Reminder:
In order to implement a standardized canister system into the nuclear waste management system, we must have a firm technical basis

"How does a STAD canister differ from earlier concepts ... and why are the differences required?"

- **The STAD canister systems would differ from past concepts (specifically the TAD concept) in the following ways**
  - Physical characteristics
  - Capacities
  - Handling assumptions
  - Licensing requirements
  - Lifetime
- **These differences are driven by the lack of a known repository geology and design**



EnergySolution's small canister STAD concept

Areva's TN21P TAD Canister

Key Attributes and Capability Differences of Canister Concepts

Parameter	STAD Canister	TAD Canister
Capacity	Three capacities - 4 PWR or 9 BWR - 12 PWR or 32 BWR - 21 PWR or 44 BWR	One capacity - 21 PWR or 44 BWR
SNF enrichment and burnup	PWR and BWR SNF with enrichment up to 5.0 wt.% U-235 and burnup up to 62.5 GWd/MTU	PWR and BWR SNF with enrichment up to 5.0 wt.% U-235 and burnup up to 80 (PWR) and 75 (BWR) GWd/MTU
SNF inventory	Entire commercial SNF inventory for all designs, length and sizes	Limited to those that can fit within a 212-inch external length TAD canister (excludes STP fuel)
Length	Not specified. Multiple lengths based on SNF characteristics	186 in. – 212 in.
Diameter	Not specified. Three diameters based on capacity - Nominally 29 in., 52 in., 66 in.	66.5 in.

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Key Safety Functional Requirements Differences

Parameter	STAD	TAD
Structural	No requirements beyond meeting 10 CFR Parts 71 and 72	Several requirements based on potential structural loads at YMP facilities (both operational and natural phenomena)
Thermal during loading, storage, and transportation	Maintain cladding temperature below 400^{o}C	Same
Thermal during disposal	Design the canister internal structure to maintain the cladding temperature below 400^{o}C based on two disposal-related boundary conditions (heat output and canister surface temperature) for each of the three canister sizes	Design the canister internal structure to maintain the cladding temperature below 350^{o}C

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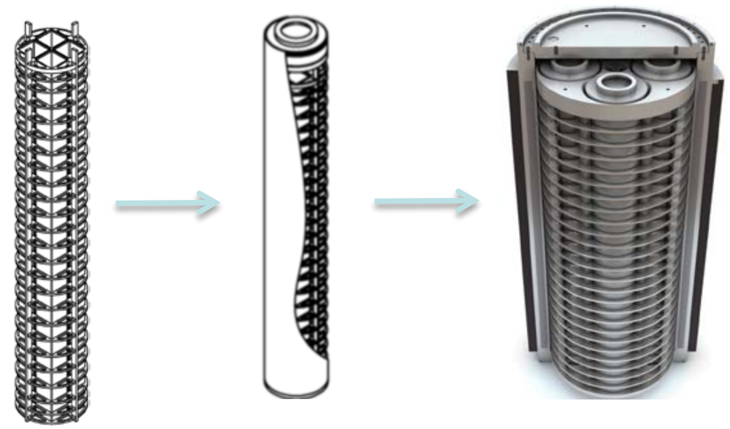
Key Safety Functional Requirements Differences

Parameter	STAD	TAD
Radiation protection and shielding	No requirements beyond meeting 10 CFR Parts 71 and 72	Several requirements based on Yucca Mountain Repository facilities and planned operations
Criticality, neutron absorber material	Borated stainless steel with 11 mm thickness (based on 10,000 years worth of corrosion at a rate of 250 nm/yr)	Same
Criticality, burnup credit	PWR SNF criticality safety basis must rely on burnup credit	No requirements beyond meeting 10 CFR Parts 71 and 72
Criticality, transportation	Transportation HAC criticality shall be based on moderator exclusion	No requirements beyond meeting 10 CFR Part 71
Storage Confinement	The canister shall constitute the confinement boundary per 10 CFR 72 (dual welded closures)	Risk-informed performance-based requirement to meet specific leak rates limits
Transportation Containment	No requirements beyond meeting 10 CFR Part 71	Same

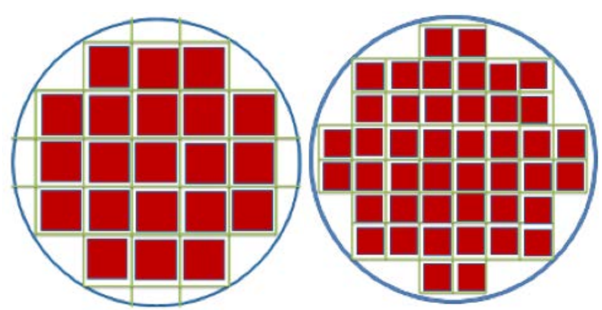
Will DOE pursue other STAD sizes?

- **Yes, DOE is evaluating a range of STAD sizes in ongoing systems analyses as well as the development of the STAD Performance Specification**
  - 2 sizes based on Energy*Solutions* study recommendations
    - Small: 4PWR/9BWR
    - Medium: 12PWR/32BWR
  - 1 size based on AREVA study recommendations
    - Large: 21P/44BWR



4-PWR Basket, Canister, and Transportation carrier

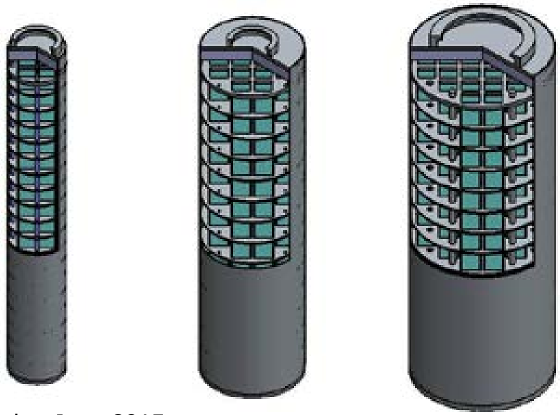
12-PWR Basket 32-BWR Basket
(Not to scale)



21-PWR Basket 44-BWR Basket

What is DOE's plan to advance the STAD through licensing before a repository is ready?

- **DOE is still evaluating implications of selecting a STAD canister system prior to identifying a site-specific repository design (Standardization Assessment)**
  - Initial standardized canister evaluation (completed August 2014)
  - Another more-fully developed evaluation will be completed in Sept. 2015
- **DOE may elect to do detailed development as part of a demonstration project (as suggested by AREVA in their feasibility study report in 2013)**
  - This decision will not be tied to the development of a specific repository



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"What is DOE's expected schedule for design, fabrication, and license of the STAD system…?" How does it impact the pilot interim storage facility?

- **No decision on the use of a STAD system, therefore DOE does not have a schedule for certification and fabrication of the STAD system**
  - Any schedule would be dependent on future decisions related to if, when, and under what conditions STADs would be deployed
  - If a demonstration project, as suggested by AREVA, were to be initiated, the schedule would be based on factors related to the scope of the demonstration
- **A STAD canister is NOT needed to support DOE's strategy to begin operations of a pilot interim storage facility**
  - DOE's strategy for operations of a pilot interim storage facility is focused on accepting SNF from shutdown sites

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"What would be the operational impacts of using small STAD canisters at spent fuel pools at operating reactors?"

- **Smaller canisters would incur more cost and require longer load times to implement**
  - This is why utilities have moved to larger canisters
- **However, there are optimizations that could be implemented that would minimize this cost and schedule impact**
- **Energy*Solutions'* team including NAC International, Exelon Nuclear Partners, and Booz Allen Hamilton studied a number of aspects**
  - Analyzed loading canisters using current procedures
  - Researched potential optimizations related to improved methods and parallel operations that could be used to minimize the at-reactor impacts
  - Provided cost and loading time comparisons
  - Identified site-specific concerns for loading smaller systems

Smaller canisters are more expensive, though at-reactor process improvements can be significant

- **Loading time per assembly for PWR canisters as a function of capacity**

	Hours / Assembly		Percent Increase vs DPC	
	Baseline	Optimized	Baseline	Optimized
DPC	3.51			
Large STAD	5.26	4.36	50%	24%
Medium STAD	8.33	7	137%	99%
Small STAD (in carrier)	7.98	4.87	127%	39%

- **Loading cost per assembly for PWR canisters as a function of capacity**

	Loading Costs / Assembly		Percent Increase vs DPC	
	Baseline	Optimized	Baseline	Optimized
DPC	$ 3,539			
Large STAD	$ 5,716	$ 4,744	62%	34%
Medium STAD	$ 9,195	$ 7,710	160%	118%
Small STAD (in carrier)	$ 9,934	$ 7,643	181%	116%

- **Capital cost per assembly for PWR canisters as a function of capacity**

	Capital Costs / Assembly	Percent Increase vs DPC
DPC	$ 37,380	
Large STAD	$ 43,925	18%
Medium STAD	$ 53,816	44%
Small STAD (in carrier)	$ 76,706	105%

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What are the repackaging implications? What facilities are needed and where would they be located?

- **Repackaging could be complicated:**
  - Increases total fuel-handling operations
  - Complicates pool operations and increases worker doses if performed at reactor sites
  - Requires development and deployment of on-site repackaging systems if performed at shut-down reactor sites
  - Generates additional low-level waste including discarded dry storage canisters
- **Repackaging could be reduced or eliminated provided either:**
  - Direct disposal of existing dry storage canisters is proven acceptable
  - Standardized storage, transportation and disposal canisters are developed and deployed
- **Otherwise, ~206,000 BWR and ~277,000 PWR assemblies may have to be repackaged**
  - If the status quo continues, ~11,000 canisters may need to be opened

Location of repackaging if needed would have system-wide impacts

- **Repackaging at reactors would be challenging**
  - Operating sites: Impact operations
  - Shutdown sites: Build new facility or pools
- **Repackaging at ISF or repository would offer flexibility**
  - Purpose-built facility (minimize dose, maximize throughput)
- **Repackaging may impact transportation**
  - Probably more canisters to move (if not performed at repository)
- **Empty canisters, overpacks, and materials generated in repackaging process would have to be managed**
  - Low-level waste on the order of $9500 / assembly
    - Assume 350 ft^3 / canister; 37 assemblies / canister; $1000 LLW / ft^3
  - NOTE this is MORE than the cost to load the assembly in any canister

Conclusion

- **Implementation options for a possible STAD canister are currently being analyzed**
  - With most recent information, better understanding of local and system-wide impacts of standardization are possible
- **DOE is keeping multiple options on the table as standardization options are being evaluated**
- **Repackaging would be expensive and challenging**
  - Unless all DPCs are disposable, some repackaging WILL occur
- **In order to implement a standardized canister system into the nuclear waste management system, we must have a firm technical basis**
  - At this time, DOE has not made a decision as to whether to proceed with a STAD canister system