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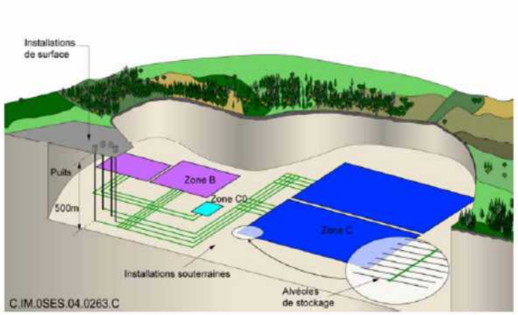

Summary of Nuclear Fuel Cycle Back-End Integration Topics

June 23, 2015

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Why Integrate Storage and Disposal?

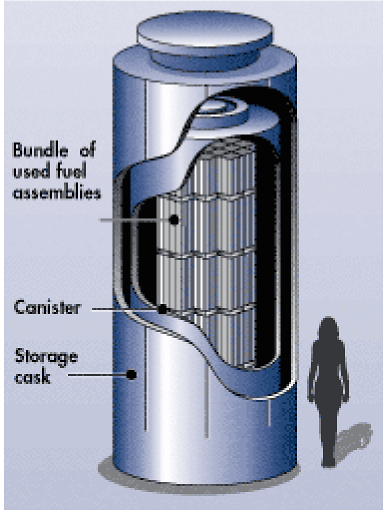
- Fundamental observation:

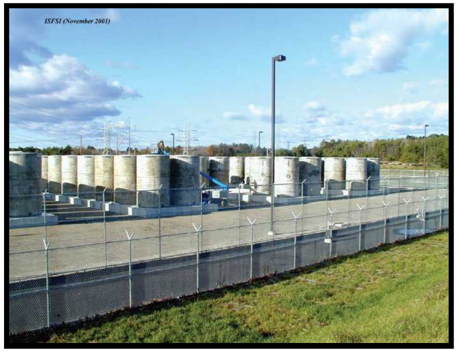
> Placing spent fuel in dry storage in dual purpose canisters (DPCs) is either
>
> 1) a commitment to repackage that fuel in the future, or
> 2) a commitment to construct a repository that can accommodate DPCs
>
> Either option may be possible, but neither is what was originally planned

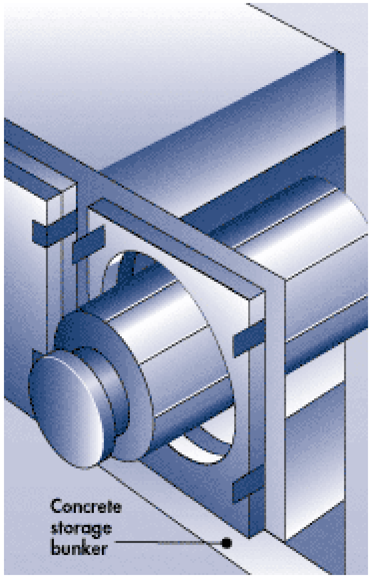
- World-wide, no repositories have been designed to dispose of DPCs without repackaging
  - Yucca Mountain came closest, with TAD (transportation, aging, and disposal) canisters that held 21 PWR assemblies
    - Current DPC designs take up to 37 PWR assemblies
  - Most other nations limit disposal package size to 4 PWR assemblies, primarily for thermal load management

Terminology

- Dual purpose canister
  - A canister that is certified for both storage and transportation of spent nuclear fuel
- Dry cask storage systems
  - The most common type of dry storage cask system is the vertical cask/canister system shown above, in which the inner stainless steel canister is removed from the outer storage cask before being placed in a shielded transportation cask for transport
    - Can be constructed both above and below grade
  - Horizontal bunker-type systems are also in use
- Multiple vendors provide NRC-certified dry storage systems to utilities
- Most DPCs are welded shut, some bolted







Where Are We Now?

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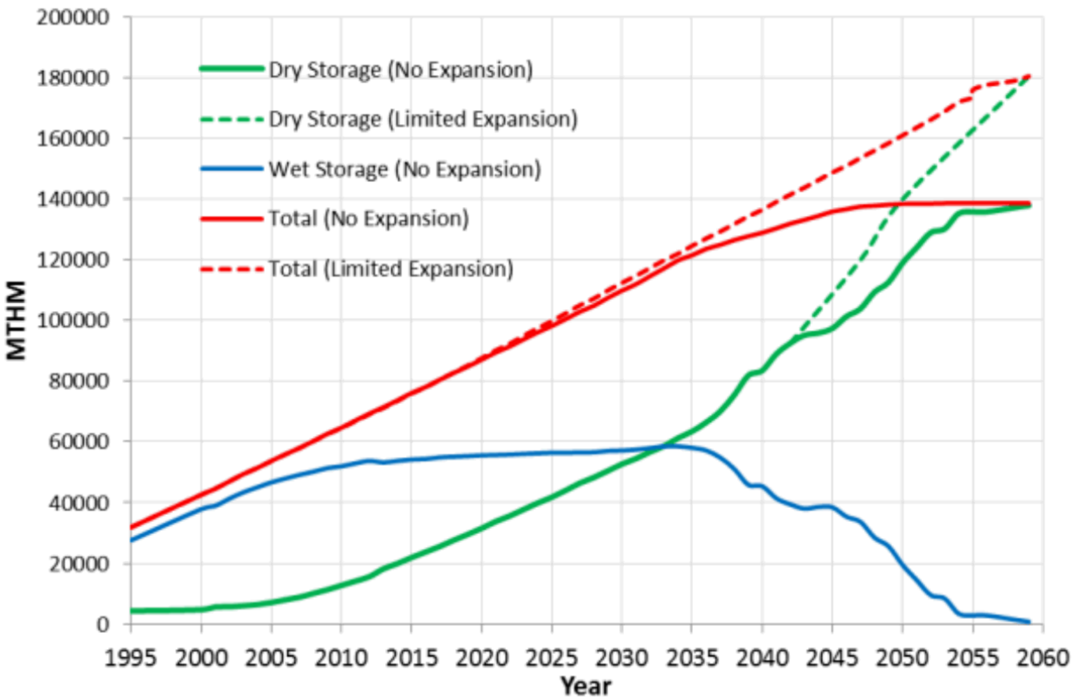


Source: Hardin, E., C.T. Stockman, E.A. Kalinina and E.J. Bonano 2013. "Integration of Long-Term Interim Storage of Spent Fuel with Disposal." ASTM Committee C26-Nuclear Fuel Cycle Workshop, Avignon, France. 17-21 June, 2013.

Approx. 71,000 MTHM (metric tons heavy metal) of SNF in storage in the U.S. (as of 2013)

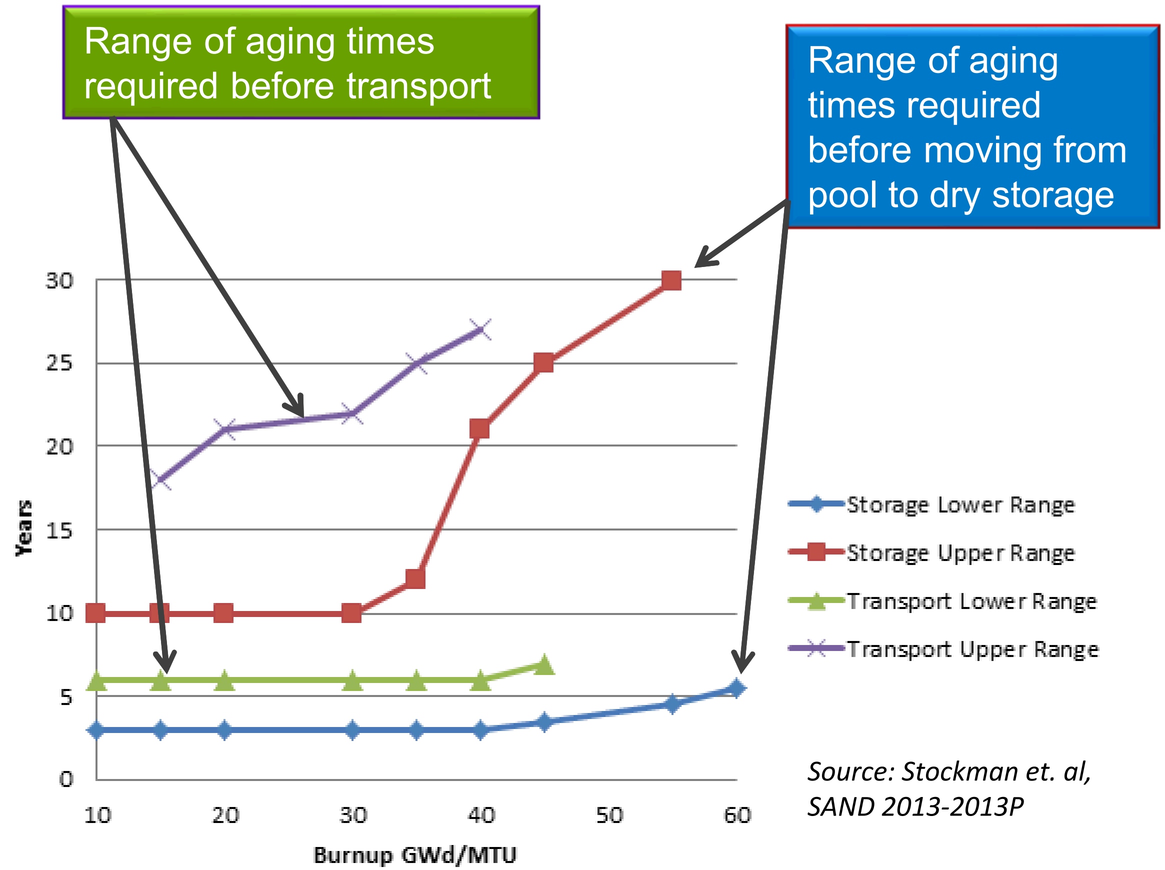
- 22,000 MTHM in dry storage at reactors, in approximately 1850 cask/canister systems
- Balance in pools, mainly at reactors

Approx. 2000 MTHM of SNF generated nationwide each year

- Approximately 200 new DPCs are loaded each year because reactor pools are essentially at capacity

Other Considerations: Transportation

- DPCs may require decades of aging to cool spent fuel before they can be transported
  - High-burnup fuels may require longer aging
  - Cooling times are design-specific (i.e., larger DPCs require longer cooling times)



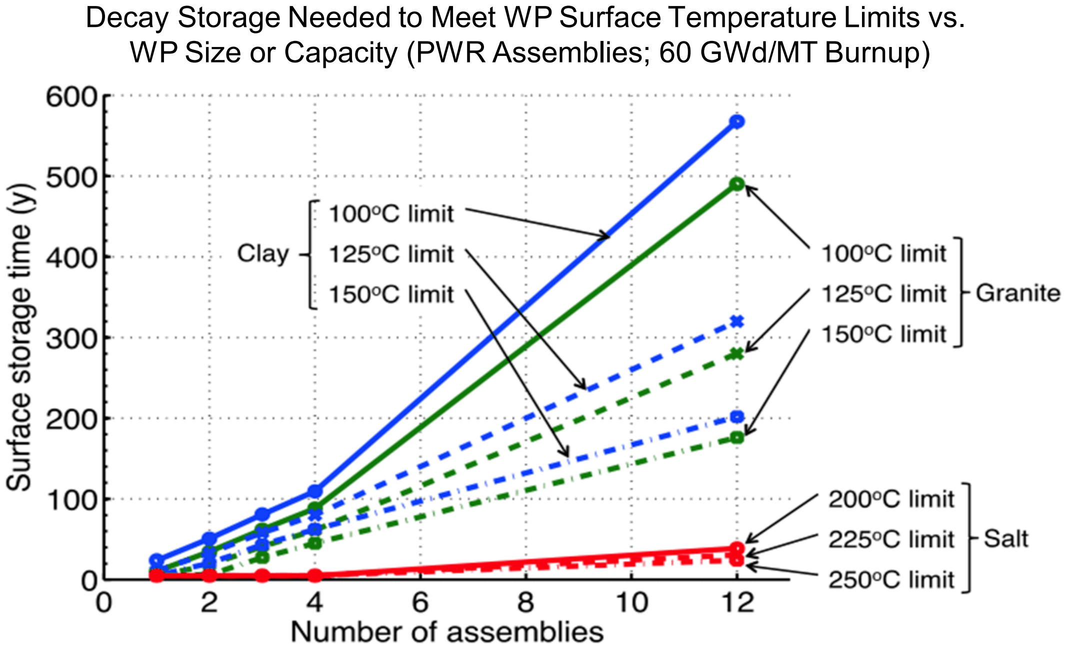
Minimum cooling times for multiple cask/canister systems, based on NRC certificates of compliance for specific designs.
Variation in times is due to the diversity of the current inventory, dominated by DPC size and heat transfer capabilities.

Other Considerations: Thermal Load Management in Repositories

Temperature limits based on current international and previous U.S. concepts:

- 100°C for clay buffers and clay/shale media (e.g., SKB 2006)
- 200°C for salt (e.g., Salt Repository Project, Fluor 1986)

Final temperature constraints will be site- and design-specific



Thermal conductivity for all media selected at 100°C.

Source: Hardin et al. FCRD-USED-2012-000219 Rev. 2. 2012

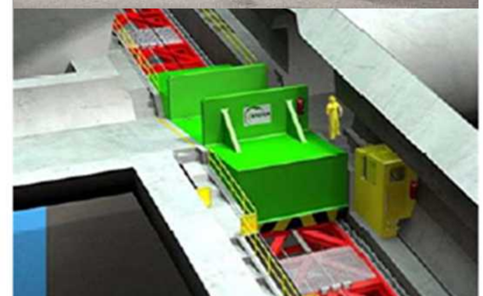
Repository thermal constraints can be met by
1) Aging
2) Ventilation in the repository
3) Decreasing package thermal output (size and burn-up)
4) Increasing package and drift spacing in the repository

Other Considerations: Criticality Control in Repository Environments

- Some already-loaded DPCs pose complications for licensing analyses of postclosure criticality control
  - Flooding by groundwater following canister degradation is a pre-requisite for criticality in any waste package
  - Al-based neutron absorbers used in some DPCs will degrade in water
  - Resulting reactivity increase can be offset by
    - High-reliability disposal overpacks
    - Uncredited margin in SNF configurations
    - High chloride content in groundwater (e.g., in salt)
  - Other options include
    - Open DPCs before disposal to add criticality controls
    - Include consequences of postclosure criticality in long-term performance estimates
  - Case-by-case analysis of individual DPCs may be needed for licensing (function of enrichment and burn-up)

Other Considerations: Waste Package Size

- DPCs are massive, but not unprecedented
  - TAD canisters proposed for YM are in the range of sizes of existing DPCs
  - With disposal overpack and transport shielding, total mass could be on the order of 150 metric tons
- Size poses engineering challenges for handling during both transportation and disposal, but options are available



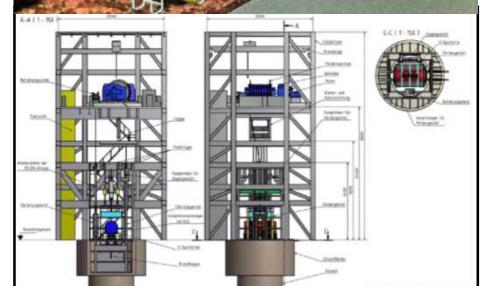


Image sources:
(upper two) Fairhurst, C. 2012. Current Approaches to Surface-Underground Transfer of High-Level Nuclear Waste. Itasca Consulting Group, Minneapolis, MN.
(middle) www.wheelift.com
(lower) Hardin, et. al. FCRD-UFD-2013-000170, 2013.

Possible Options

- Introduce a standardized canister to be loaded at reactors in the future (work in progress led by ORNL)
  - Selection of a standardized transportation, aging, and disposal canister (STAD) is repository-design specific
  - Loading STADs directly from reactor pools (as was originally envisioned for the YM TADs) is unlikely to happen before perhaps 2030, by which time more than 50,000 MTHM of SNF will be in DPCs
    - Later dates for repository and STAD selection will mean more fuel in DPCs
  - Lack of present incentive for utilities to use standardize canister

- Repackaging of SNF from DPCs to STADs at a consolidated storage facility?
  - Cost and schedule of repackaging
  - Management of additional LLW stream (DPCS carcasses)

- Disposal of DPCs and STADs in separate repositories?

- Cost considerations–number of handling operations, number of packages, repository design, and complexity of licensing

Conclusion

- Integrated approach to spent fuel management should include consideration of storage, transportation, and disposal
- Optimal solutions change as the amount of fuel in dry storage increases
- Impacts on system-level costs and schedule of sub-optimal approaches are potentially large

References

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