SAND2014-0628P

Deep Borehole Disposal Engineering Needs

Deep Borehole Consortium Meeting
Albuquerque, New Mexico

Sandia National Laboratories

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Priority Demonstration

- Identify a suitable demonstration proi
- Adequately characterize the site ar ogic controls for long-term safety
- Design the borehole
- Successfully construct th verify that the borehole meets require
- Demonstrate and ve uccessful canister emplacement*
- Demonstrate s sure
- Demonstrat st-closure safety
- Demonst ated waste management system*

Federal and state legal and regulatory requirements for permitting and operating a demonstration such as NEPA and state regulationof land and water use, and drilling

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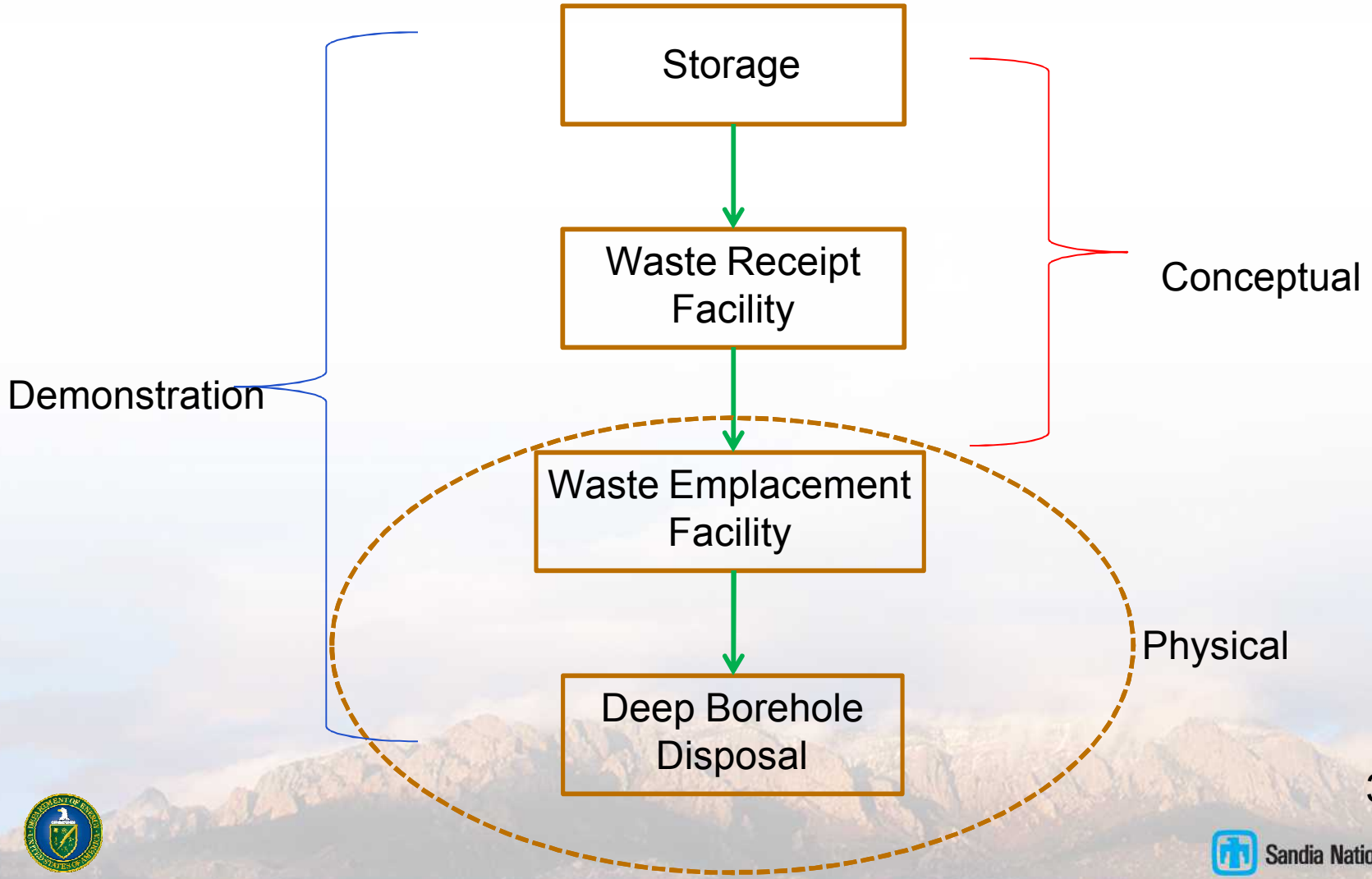
Storage to Disposal



SNF Storage to Disposal

Should SNF be consolidated and packaged at reactor site?

Y

N

Should SNF be consolidated and repackaged at CIS?

Y

N

On-Site Waste Receipt Facility

- Unload SNF from shipping canister
- Consolidate and repackage SNF in disposal canister
- Load canister into on-site transfer cask

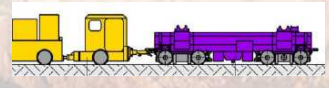
- Unload shipping cask
- Remove disposal canister from cask
- Inspect disposal canister (accept/reject)
- Load canister into on-site transfer cask

Receiving, cleaning, unloading, and decontaminating shipping casks for reuse

Transfer cask

Shipping Cask Handling Area

Waste Emplacement Facility



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Disposal of DOE Cesium and Strontium Capsules

1335 CsCl capsules and 601 SrF_2 capsules in pool storage

Should capsules be placed in disposal canisters at storage site?

Y

N

On-Site Waste Receipt Facility

- Unload capsules from shipping canister
- Package capsules in disposal canister
- Load canister into on-site transfer cask

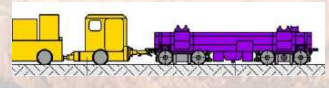
- Unload shipping cask
- Remove disposal canister from cask
- Inspect disposal canister (accept/reject)
- Load canister into on-site transfer cask

Receiving, cleaning, unloading, and decontaminating shipping casks for reuse

Shipping Cask Handling Area

Transfer cask

Waste Emplacement Facility



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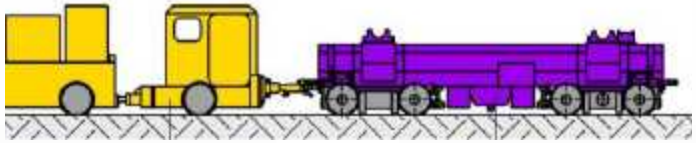
Waste Emplacement

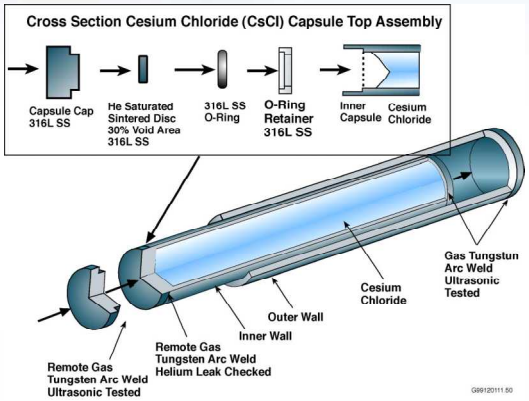
Waste Emplacement Facility



Borehole Emplacement

- Receive on-site transfer cask from the WRF
- Unload transfer cask
- Transfer cask to transference system (rail in reference design)
- Cask moved to borehole and canister unloaded
- Canister attached to underlying canister and drill stem
- Canister lowered in hole on string of 40 canisters
- Emplace canister strings within the emplacement zone
- Seal borehole

Capsule Emplacement in Disposal Zone: Two Options for Cs/Sr Capsules



8 capsules per canister

Option 1

- Would load the capsules end-to-end in waste canisters with an outside diameter of about 0.114 m (4.5 inches), requiring 242 canisters and about 1210 m of borehole length in the disposal zone. This option would result in sub-boiling temperature increases of about 50 ºC and would require a 0.216 m (8.5 inches) diameter borehole
- Sub-boiling temperature increases of about 50 ºC

- Capsules are constructed with inner and outer sleeves of 3136L stainless steel or Hastelloy, and are 2.6 inches in diameter by 19.8 or 20.8 inches in length (Overpacks for 23 leaking cesium capsules are somewhat larger with a diameter of 3.25 inches)
- Cesium capsules primarily contain ^{137}Cs, ^{135}Cs, and barium, and had an average thermal output of 144 W in 2007. Strontium capsules contain ^{90}Sr and zirconium, and had an average thermal output of 193 W in 2007

Option 2

- Would require 61 disposal canisters (~32 capsules per canister) and about 305 m of borehole length in the disposal zone of a 0.43 m (17-inch) diameter borehole
- Possible above-boiling temperature increases increases in the host rock of over 200ºC

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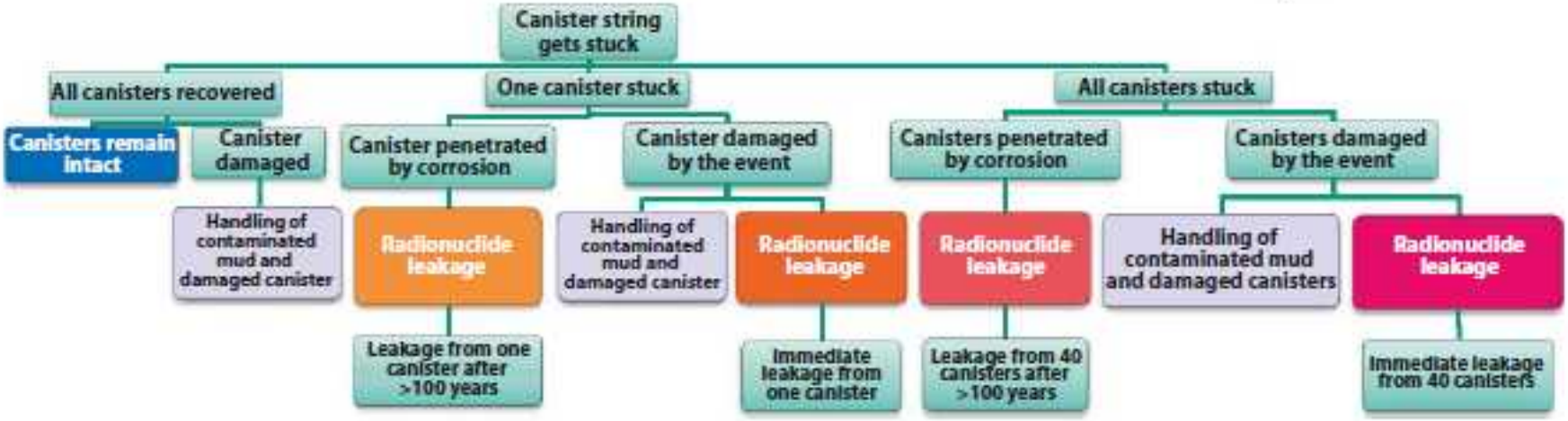
Down-Hole Accidents



From: Bertil Grundfelt, Radiological consequences of accidents during disposal of spent nuclear fuel in a deep borehole, ISSN 1651-4416, SKB P-13-13, July 2013

$$R = P \times C$$

Regulatory Challenges: Storage, Transportation, and Security

- **There are several agencies which promulgate rules governing the transport, storage, and disposal of radioactive material**
  - 10 CFR part 71 - Packaging and transportation of radioactive material
  - 10 CFR part 72 - Receipt, handling, storage, and transfer of spent fuel or high-level radioactive waste, and reactor- related greater than class c waste
  - 49 CFR – DOT regulation for control of radioactive material transport
  - CFR part 191 and 10 CFR part 60 - Existing regulations for disposal of high-level radioactive waste or spent nuclear fuel at locations other than Yucca Mountain

Regulatory Challenges: Siting, Drilling, and Operating

- **As a Federally funded project, compliance with the NEPA is a requirement.**
  - The project scope and duration are of a magnitude that would likely require an Environmental Assessment not an Environmental Impact Statement

- **Requirements for permitting a deep borehole disposal demonstration project vary among states and for Federal versus private land**
  - Drilling, land, and water use permits

Engineering Challenges

- Borehole Design
- Borehole Construction
- Waste Handling
- Test Canisters
- Canister Loading Operations
- Surrogate Waste Emplacement
- Down-Hole Accidents/Operational Retrievability
- Regulatory Requirements
- Seal Design & ***Closure***

Summary

- **A systems view should be taken for the Demonstration - all steps between storage and disposal**
  - Physical vs conceptual demonstration
  - Use of existing equipment
  - Level of detail for conceptual components
  - Regulatory and licensing requirements
  - Closure
- **Pre-closure monitoring/emplacement processes, technologies, and bh design should sufficiently reduce the risk of down-hole accidents**