Rethinking Multipurpose Spent Nuclear Fuel Casks and Canisters

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Session: IIB: Repository Technologies
Spent Fuel Management Seminar XIX
Institute of Nuclear Materials Management
Washington, D.C.
January 9-11, 2002

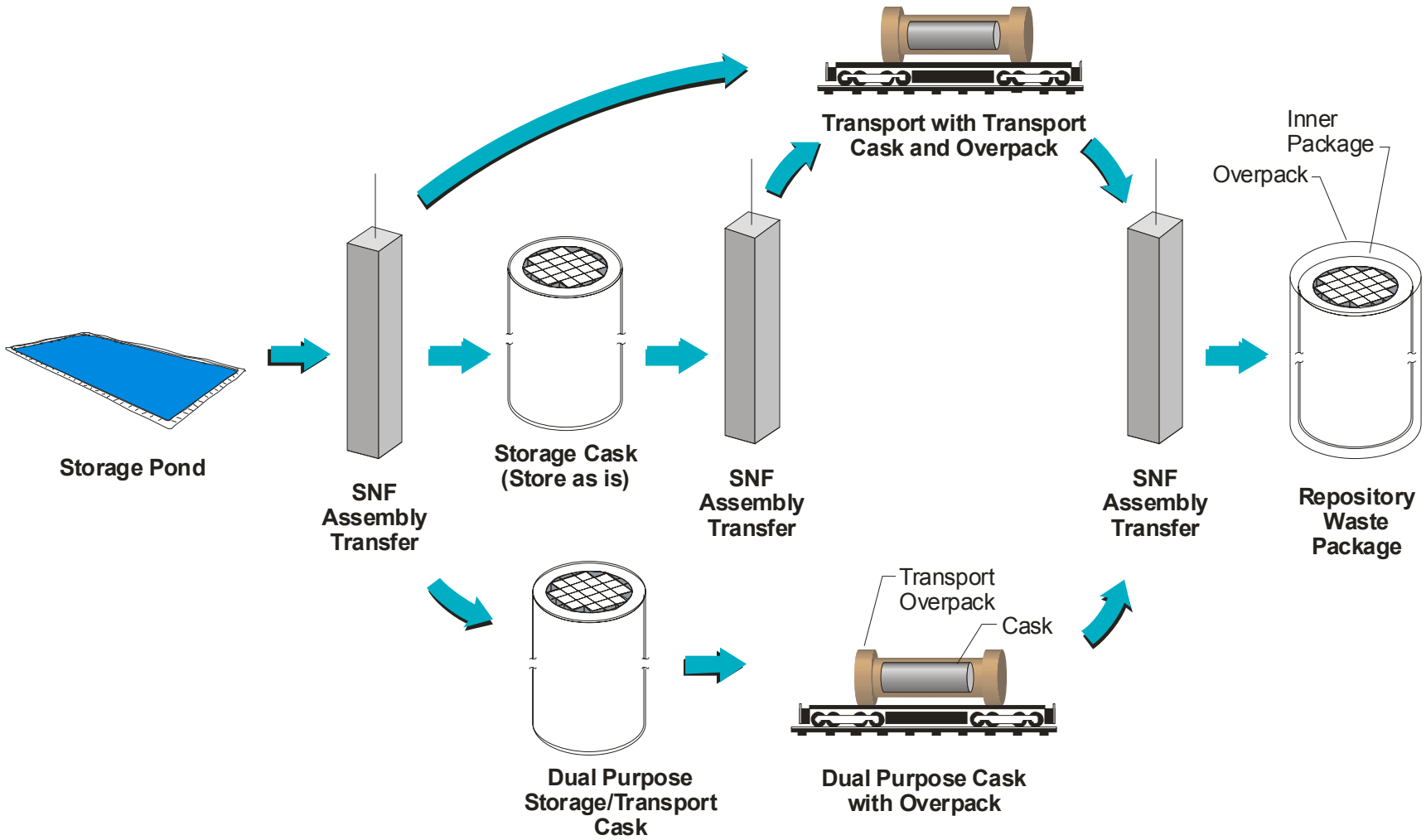
*Managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725. The submitted manuscript has been authored by a contractor of the U.S. Government under contract DE-AC05-00OR22725. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes. File name: Multipurpose.SNF.Seminar.2002.

Path Forward

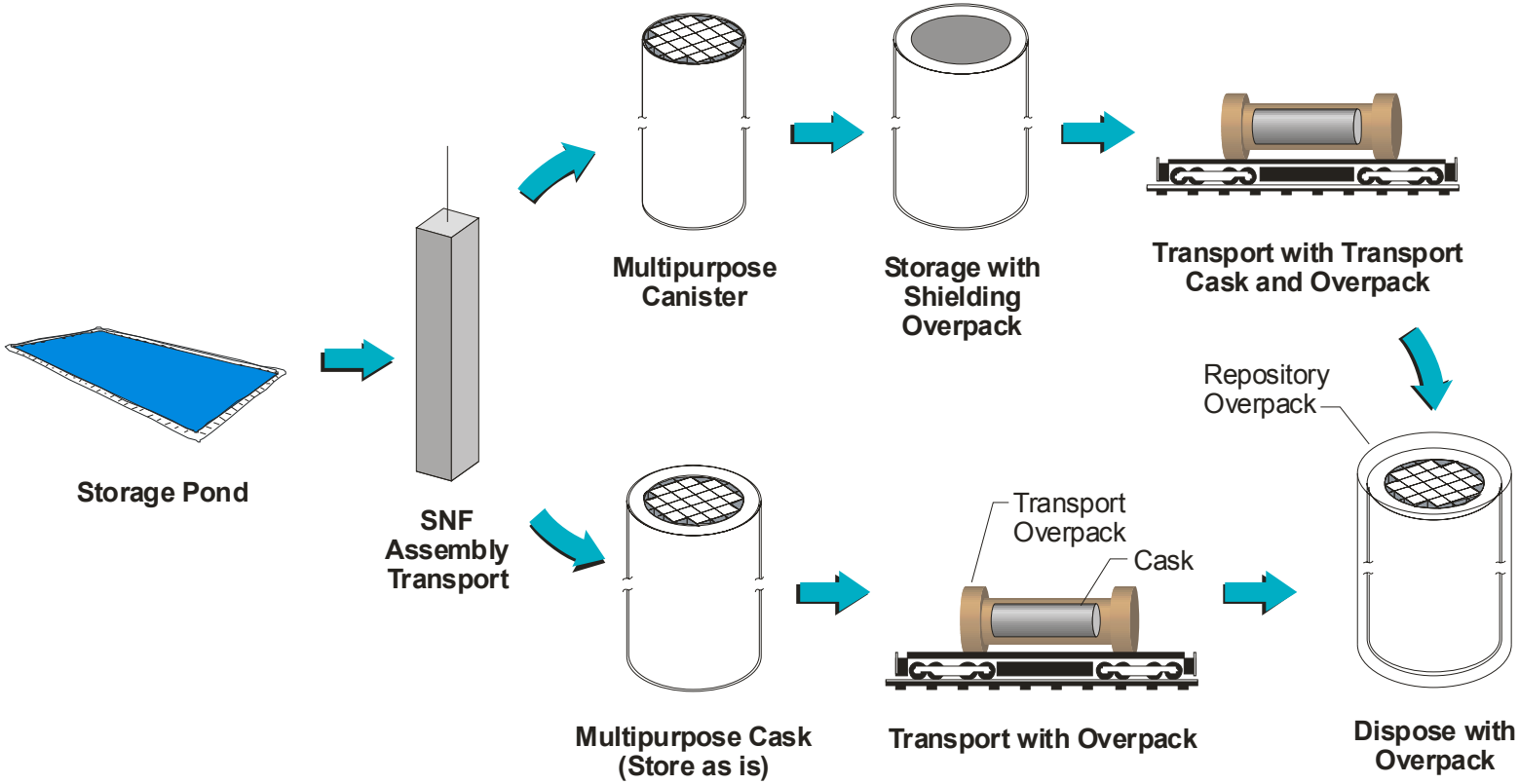
- Alternative strategies for SNF management
- Factors that define preferred SNF management strategies
  - Requirements
  - Institutions
  - Technology
- Multipurpose cask system and conclusions

Alternative Strategies for SNF Management

Traditional Approaches to SNF Management



Multipurpose Canister and Cask Approaches to SNF Management



The Preferred SNF Management Option Depends On Three Factors

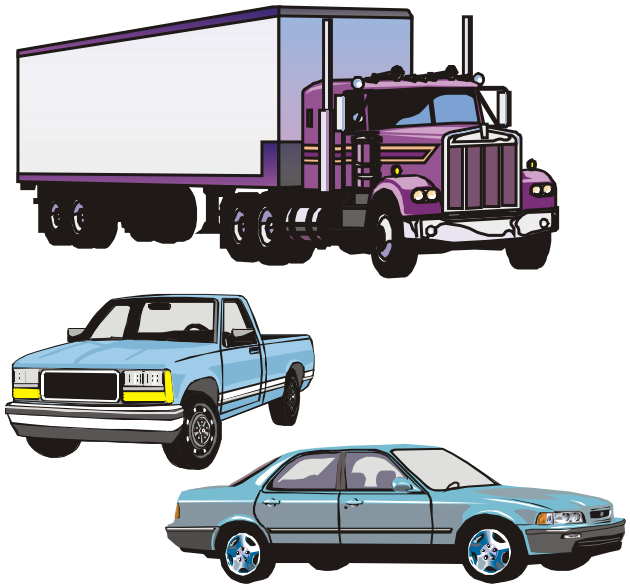
- Requirements
- Technology
- Institutional Structure

Spent Nuclear Fuel Management Requirements

Requirements for Storage, Transport, and Disposal Canisters and Casks Are Converging

Multipurpose Canisters and Casks Become More Attractive As Requirements Converge

The Viability of Multipurpose Systems Depend On How Similar the Requirements Are



Different Requirements

Similar Requirements

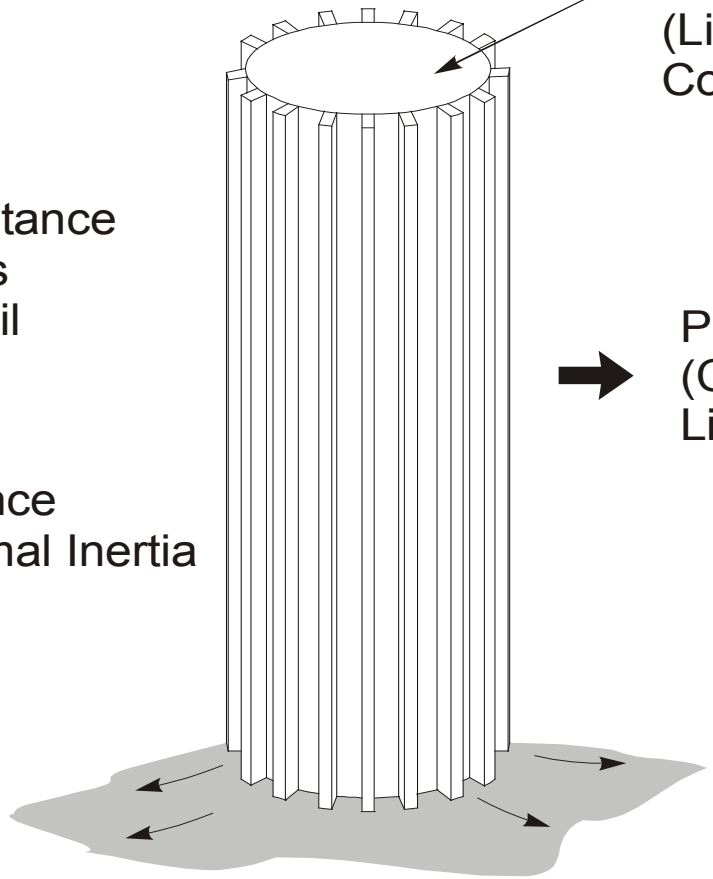
Physical Protection Requirements May Drive Future SNF Storage and Cask Requirements

In Severe Environments, Casks Have Potential Advantages over Pools and Other SNF Storage Methods

(Casks Used In Germany: Aircraft Collision Requirement)

Limited Inventory (Limited Consequences)

Impact Resistance
- Thick Walls
- Cask Recoil



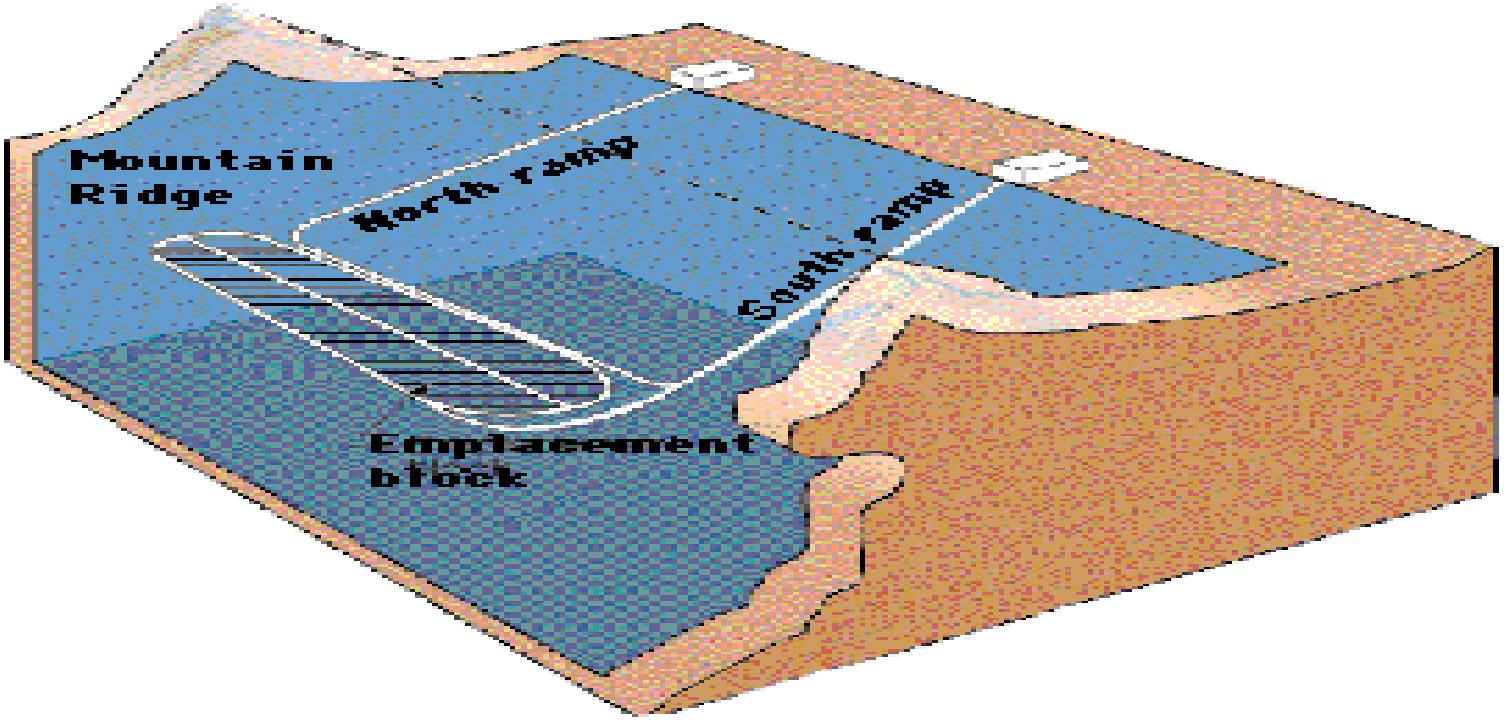
Passive Cooling (Consequence of Limited Inventory)

Fire Resistance
- High Thermal Inertia
- Drain Fuel

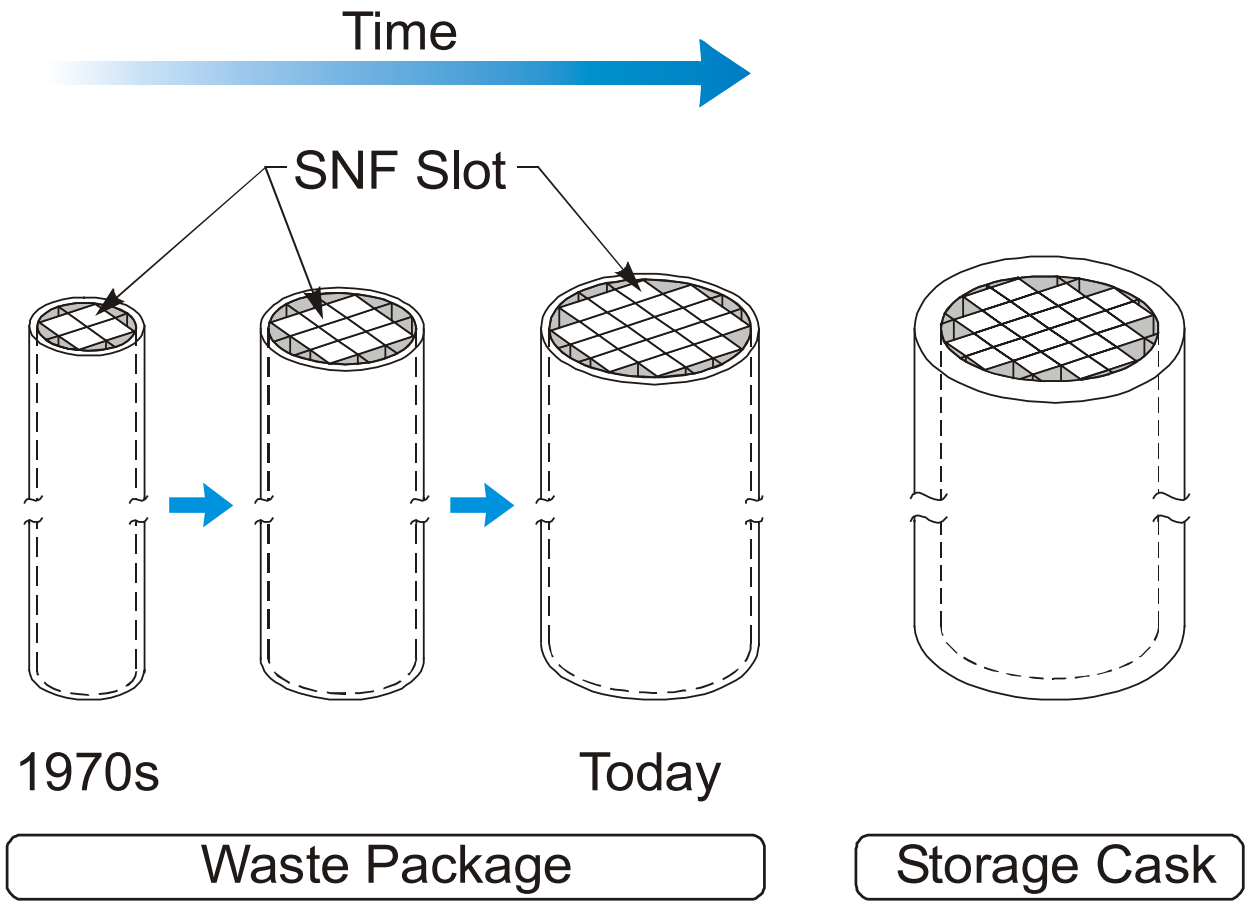
In Severe Environments, Multipurpose Casks Have Advantages over Storage, Transport, and Disposal Containers

- *Transfer Cost*: Cost to transfer SNF between storage, transport, and disposal containers increases with protective requirements
- *Merging Requirements*: If need for resistance to severe events controls cask design, fewer incentives exist for separate storage, transport and disposal containers

Multipurpose Casks Are Viable Only When Requirements Are Well Understood:
Repository Licensing Will Define Requirements



Merging Requirements: Repository Waste Package Capacity Is Approaching SNF Storage/Transport Cask Size



Future Repository Designs May Further Reduce Differences Between Transport/ Disposal Casks and Canisters

- Disposal package size approaching transport package size
- Options for ventilated repository reduce heat-load constraints on waste packages and multipurpose canisters/casks
- Goals to minimize front-end investment in the repository favor multipurpose systems with fewer activities at the repository site

Institutional Structures

Utility Consolidation Will Change the Preferred SNF Management System

Different Utility Structures Imply Different SNF Management Systems

- Few large utilities (France, Germany, Sweden)
  - Centralized SNF storage
  - Few SNF technologies
- Many small utilities (United States)
  - Decentralized SNF storage
  - Many SNF technologies

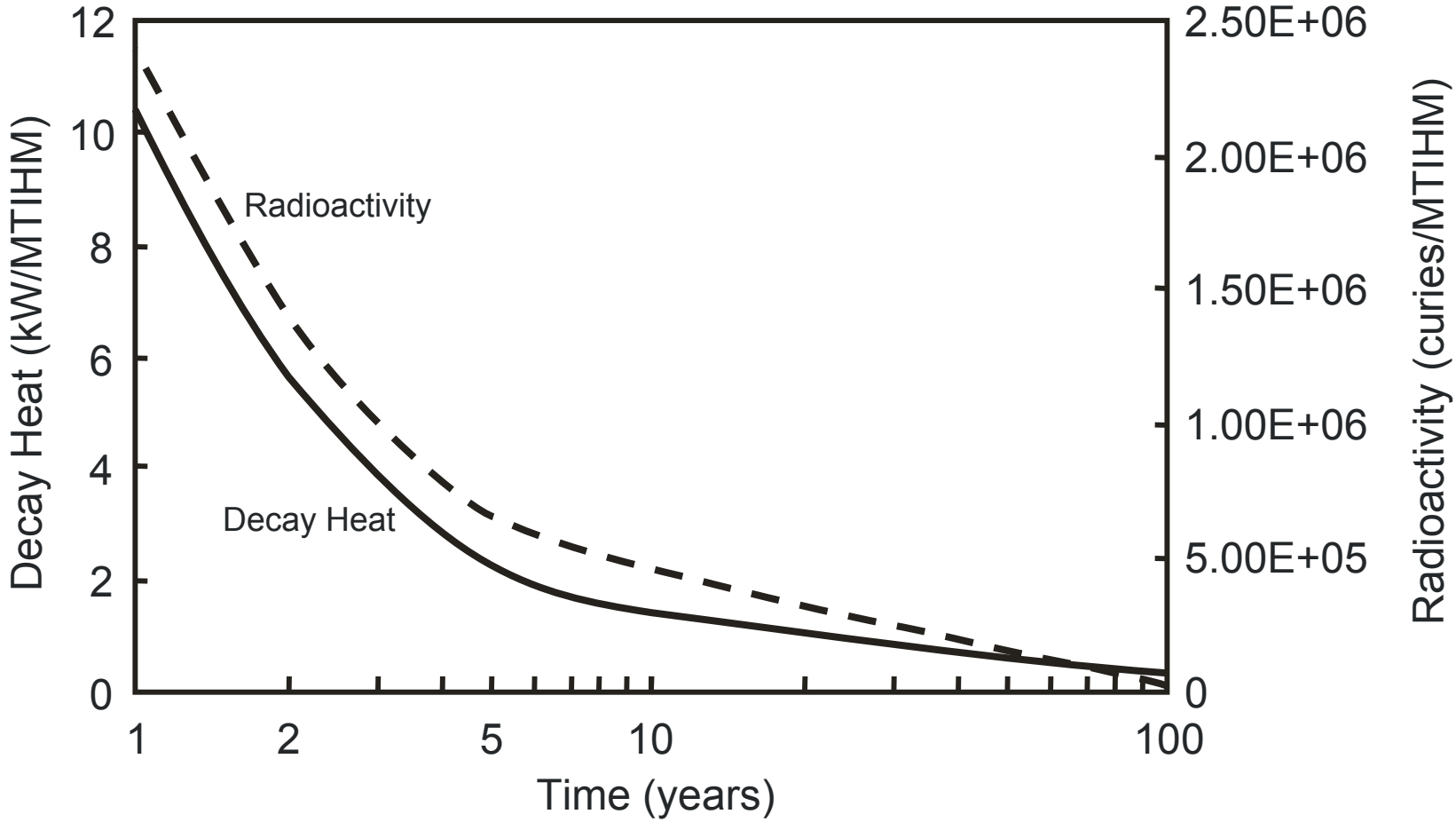
Consolidation of the U.S. Utility Industry into a Few Large Utilities Will Alter SNF Management

- Consolidated siting more likely
- Modified cask design
  - Fewer cask types (more casks of each type)
  - Acceptance of higher manufacturing setup costs if lower per-cask cost
- Altered repository interface (limited number of organizations)
  - Negotiate SNF management interface
  - Increased possibility for multipurpose cask

Technology

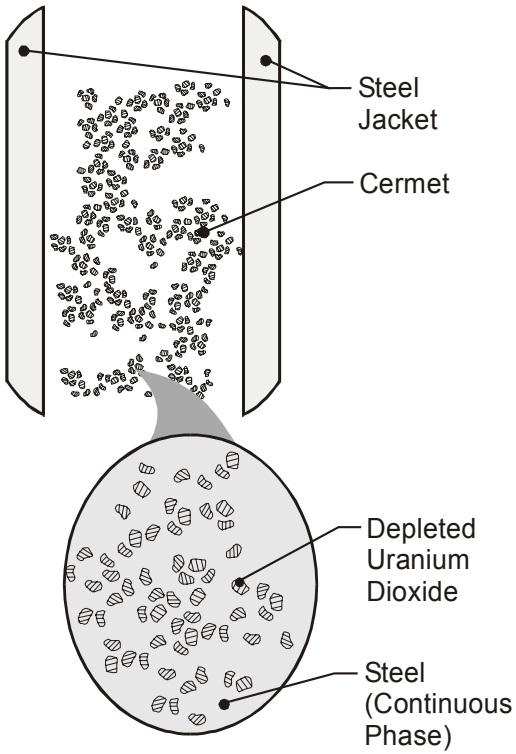
New Technologies May Change System Design

SNF Cask Heat Removal and Shielding Control Design: New Materials and Designs May Reduce These Constraints

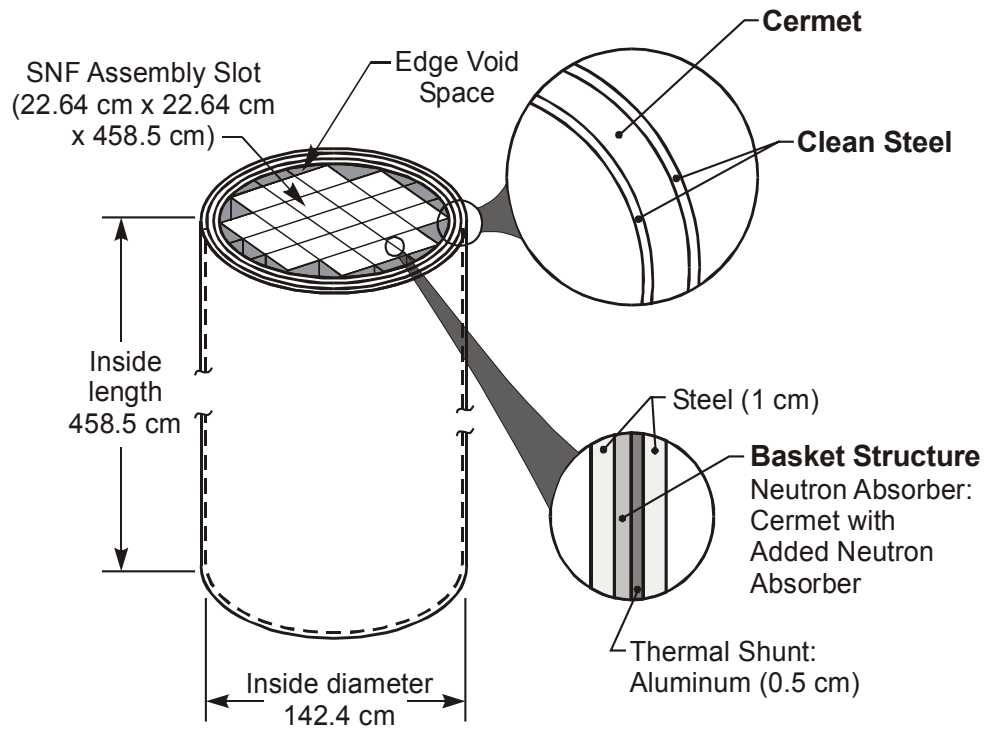


Example of a New Material: Cermet Multipurpose Casks

Cermet

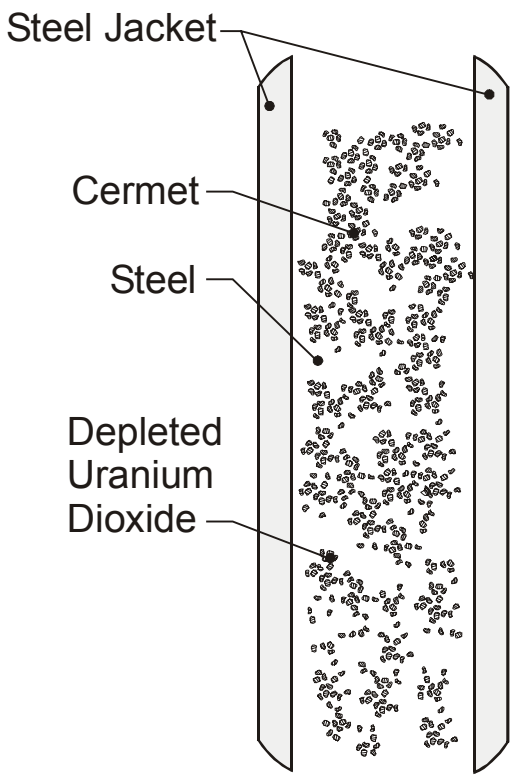


Multipurpose Cask



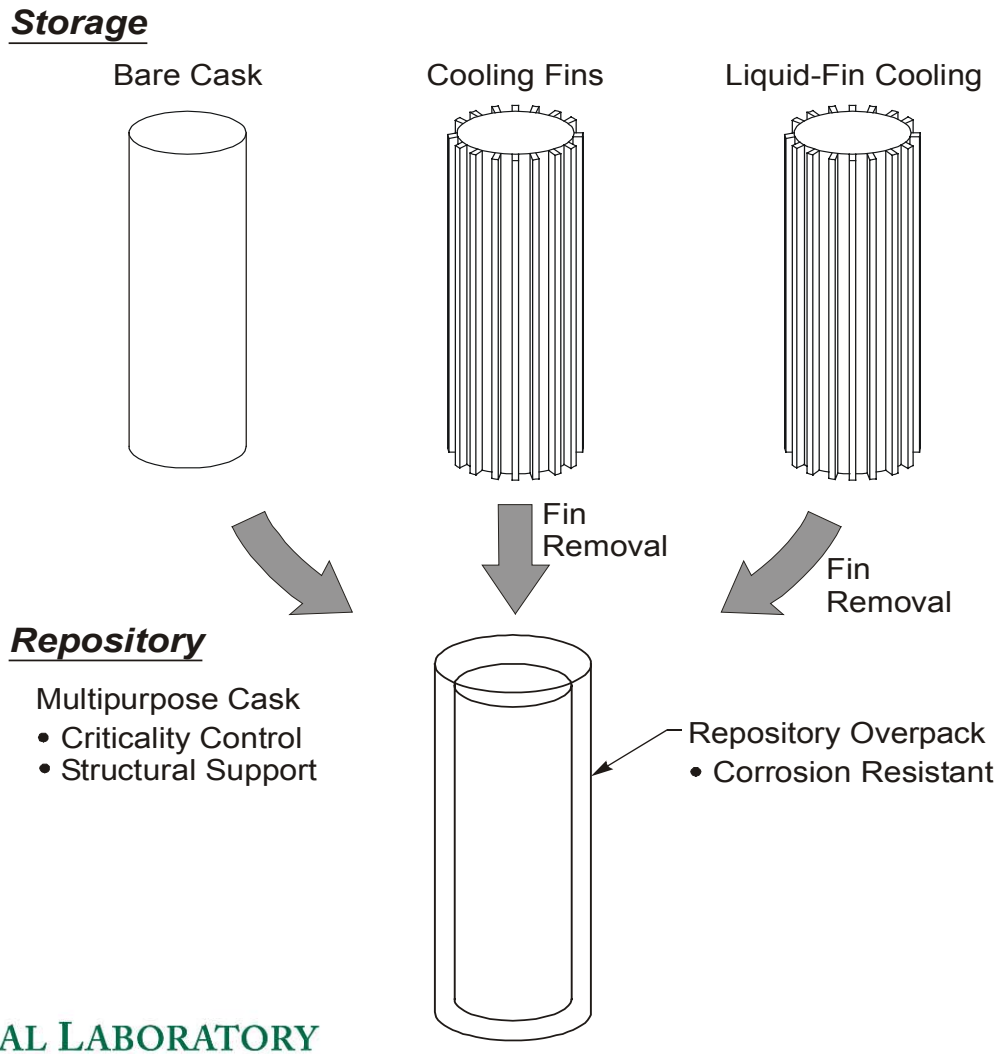
Cermets May Be Technically the Best Shielding Material for Multipurpose Casks

(Requirements Eliminate Better Shielding Materials)



- Gamma Shielding Better Than Steel
  - Steel: 7.86 g/cm^3
  - DUO_2: 10.9 g/cm^3
- Neutron Shielding
  - High density oxygen (DUO_2) moderator
  - Other neutron absorbers can be added
- Meets Requirements
  - High thermal conductivity
  - Adjustable properties to maximize accident/assault resistance
  - Avoids materials unacceptable to repository
    - Uranium metal
    - Cement
    - RCRA metals
    - Organics

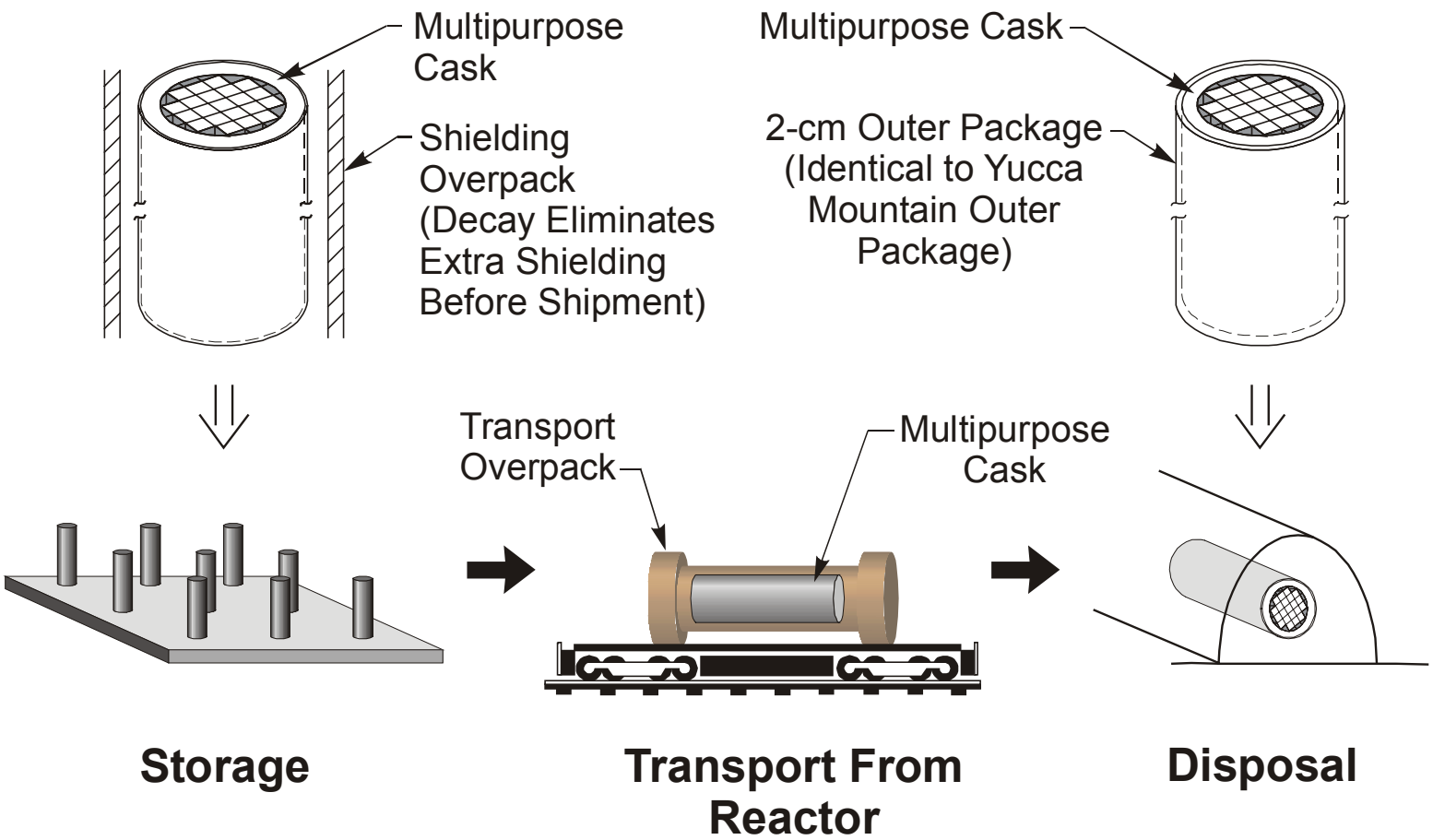
Design Can Address Multipurpose Cask Constraints
(Outer Repository Package Is Supported by the Inner Package: Cask Protrusions Must Be Removable Before Disposal)



Example of Multipurpose Cask System

There Are Multiple Configurations of Multipurpose Cask or Canister Systems

Multipurpose Cask System



Example Multipurpose Cask System

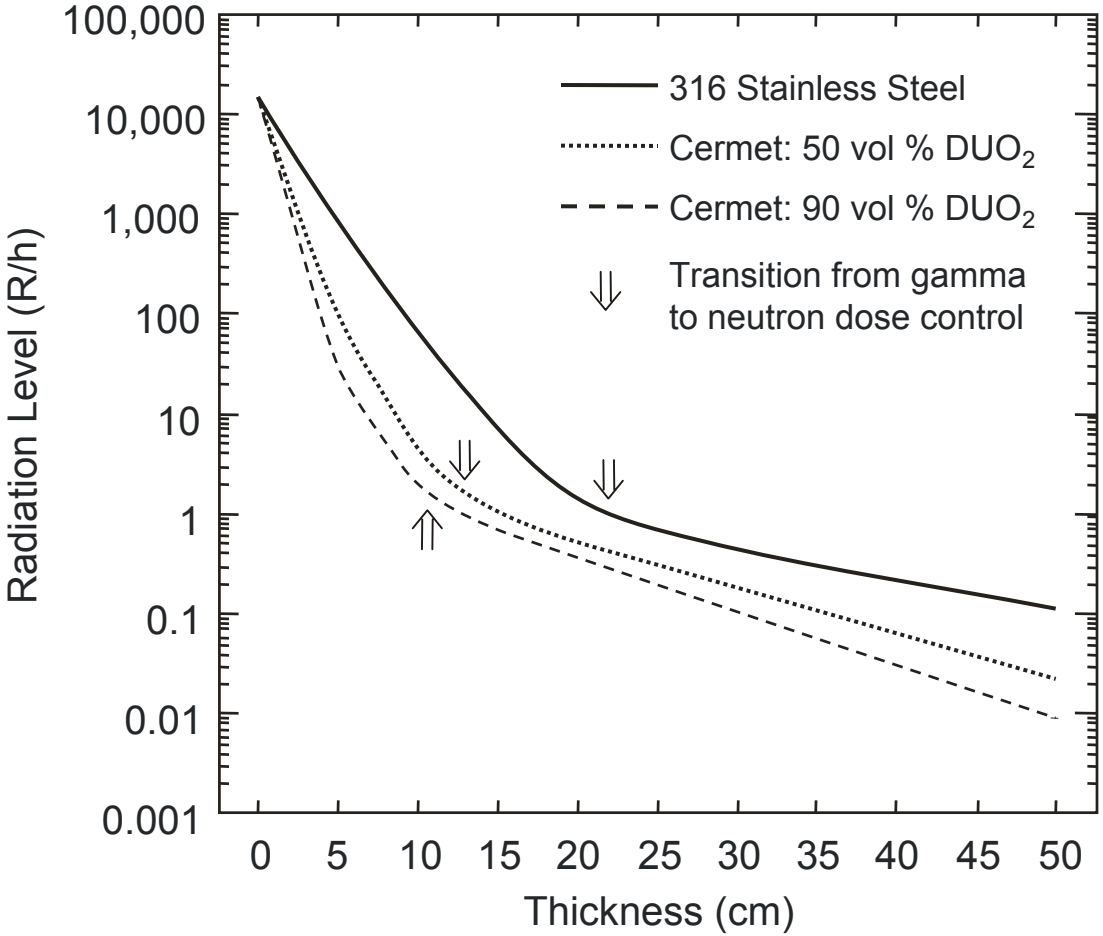
- Cask functions
  - Criticality control
  - Radiation shielding
  - Physical protection
  - Support of external waste-package overpack
- Storage overpack functions (optional)
  - Added shielding until decay of short-cooled SNF
  - Augmented short-term cooling

Conclusions

- Requirements for SNF storage, transport, and disposal casks are converging
- New technologies benefit multipurpose canisters and casks
- Utility consolidation will alter SNF management strategies; may enable multipurpose systems
- The benefits of multipurpose casks are increasing relative to those for separate storage, transport, and disposal casks
- The preferred option is unclear, but factors favorable for multipurpose systems are increasing

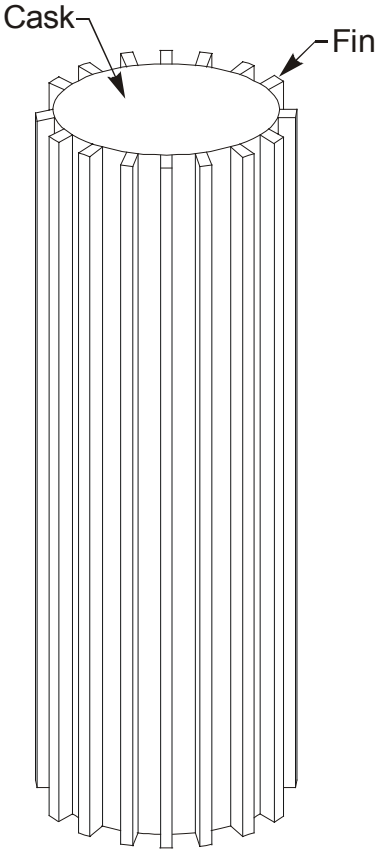
Added Information

Shielding Effectiveness (R/h) of Different Materials
(Source Term from 21-PWR Yucca Mountain Waste Package)

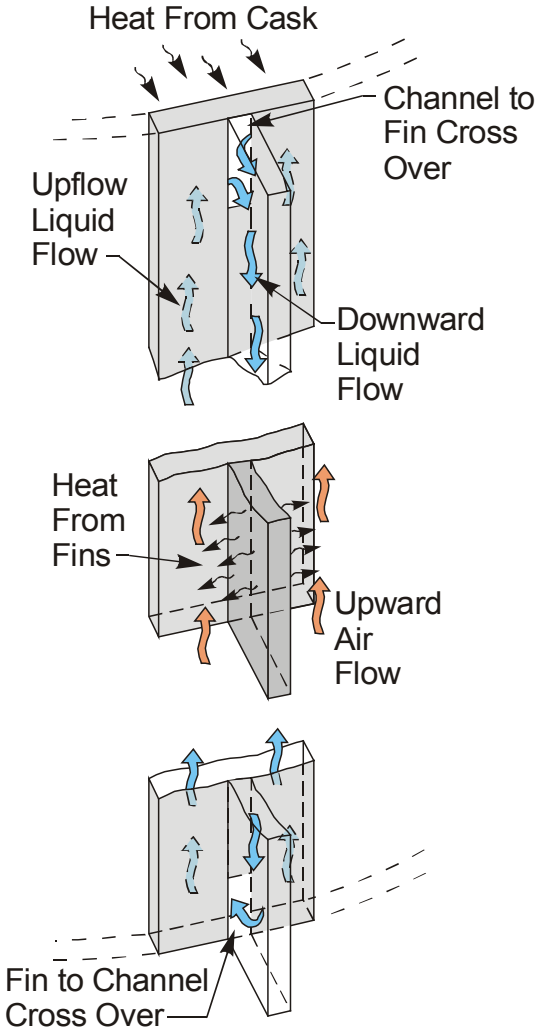


Liquid-Fin Cooling

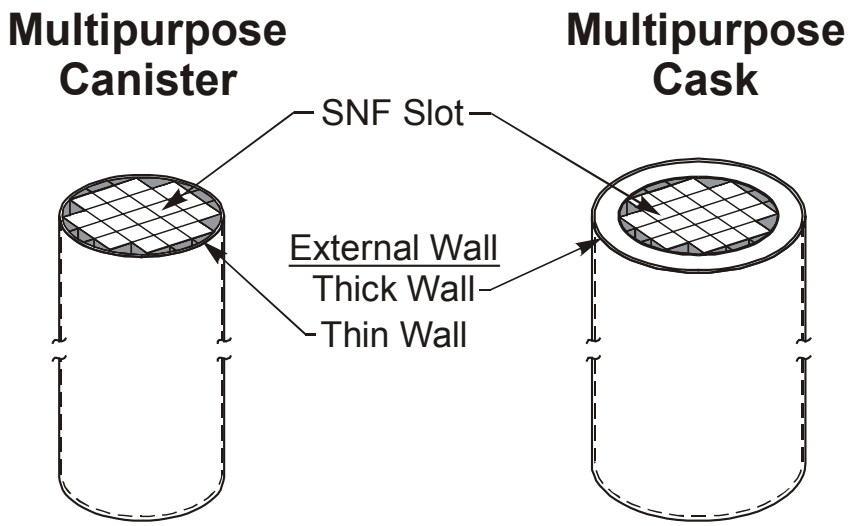
Cask

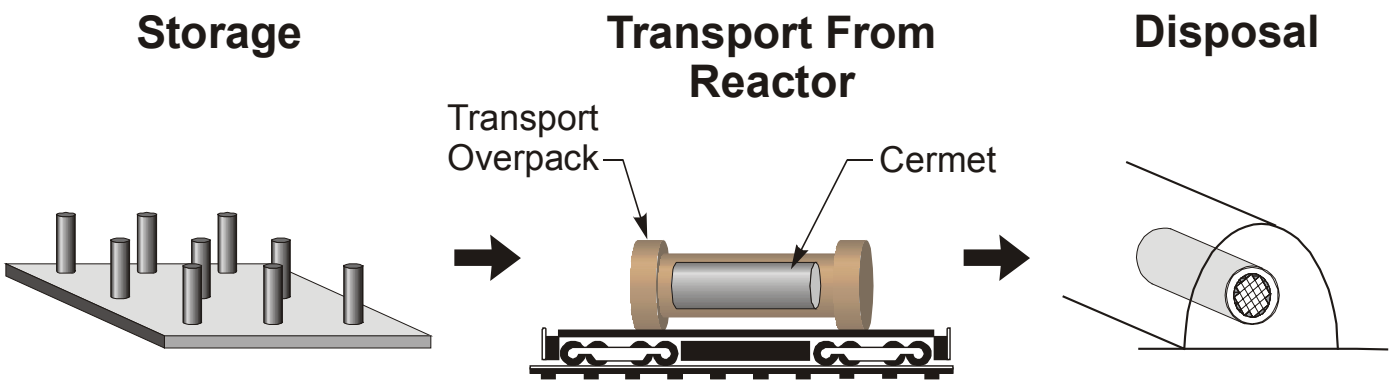


Liquid-Filled Fin



Multipurpose Casks and Canisters



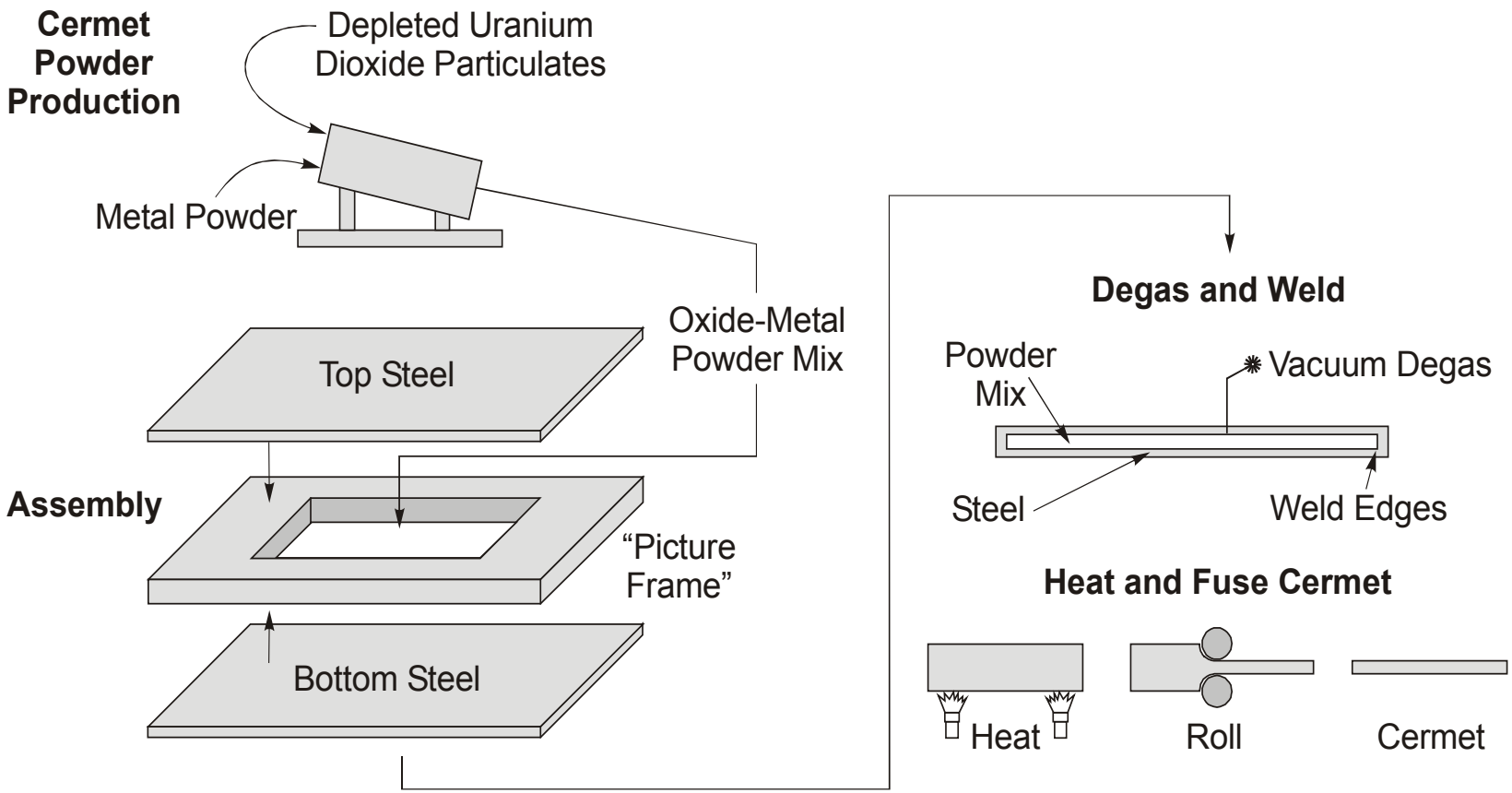


Sandwich Construction of Cermets

- Radioactive uranium is contained by exterior steel layers (no contamination)
- Construction maximizes strength, with strongest components on the outside
  - Interior steel layer
  - Cermet
  - Exterior steel layer

“Picture-Frame” Method for Cermet Production

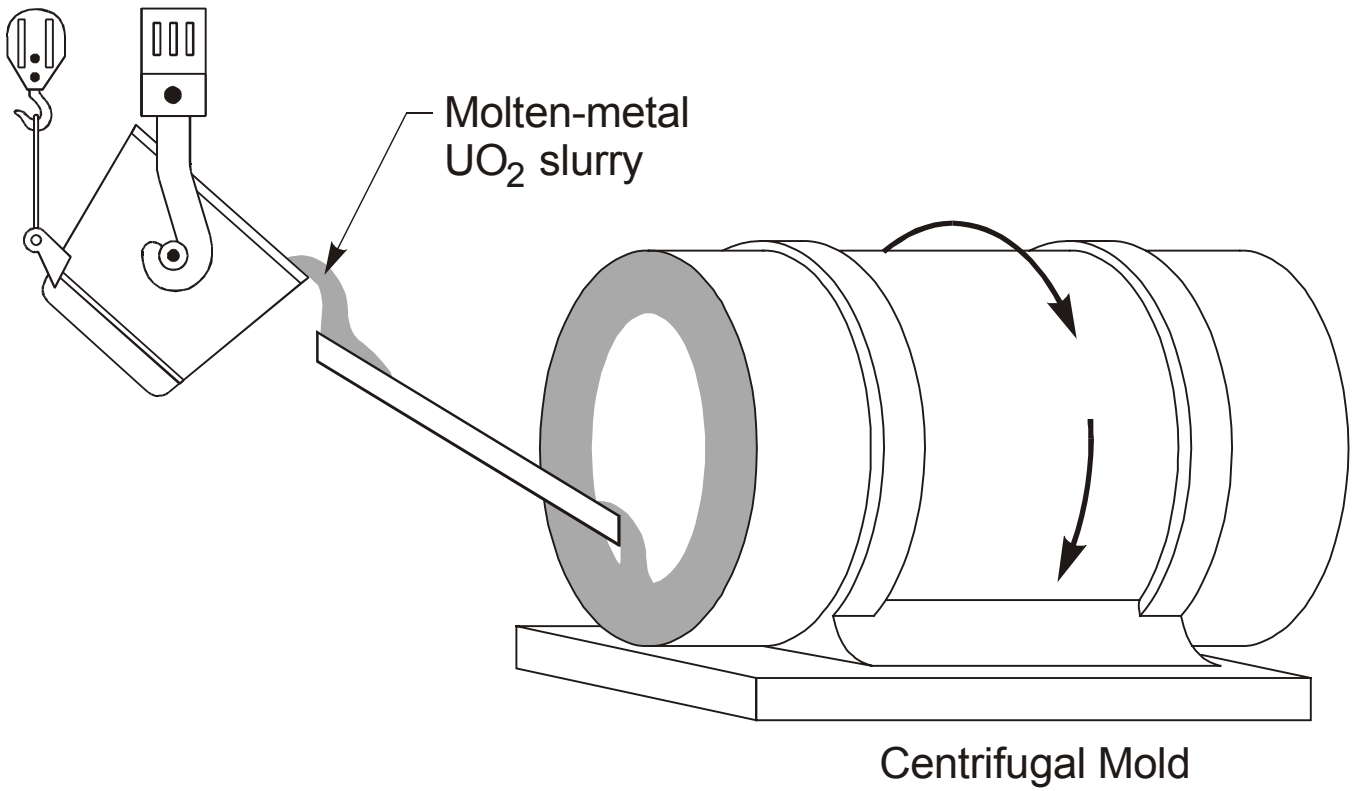
(Used for Some Nuclear Reactor Fuels and Nonnuclear Applications)



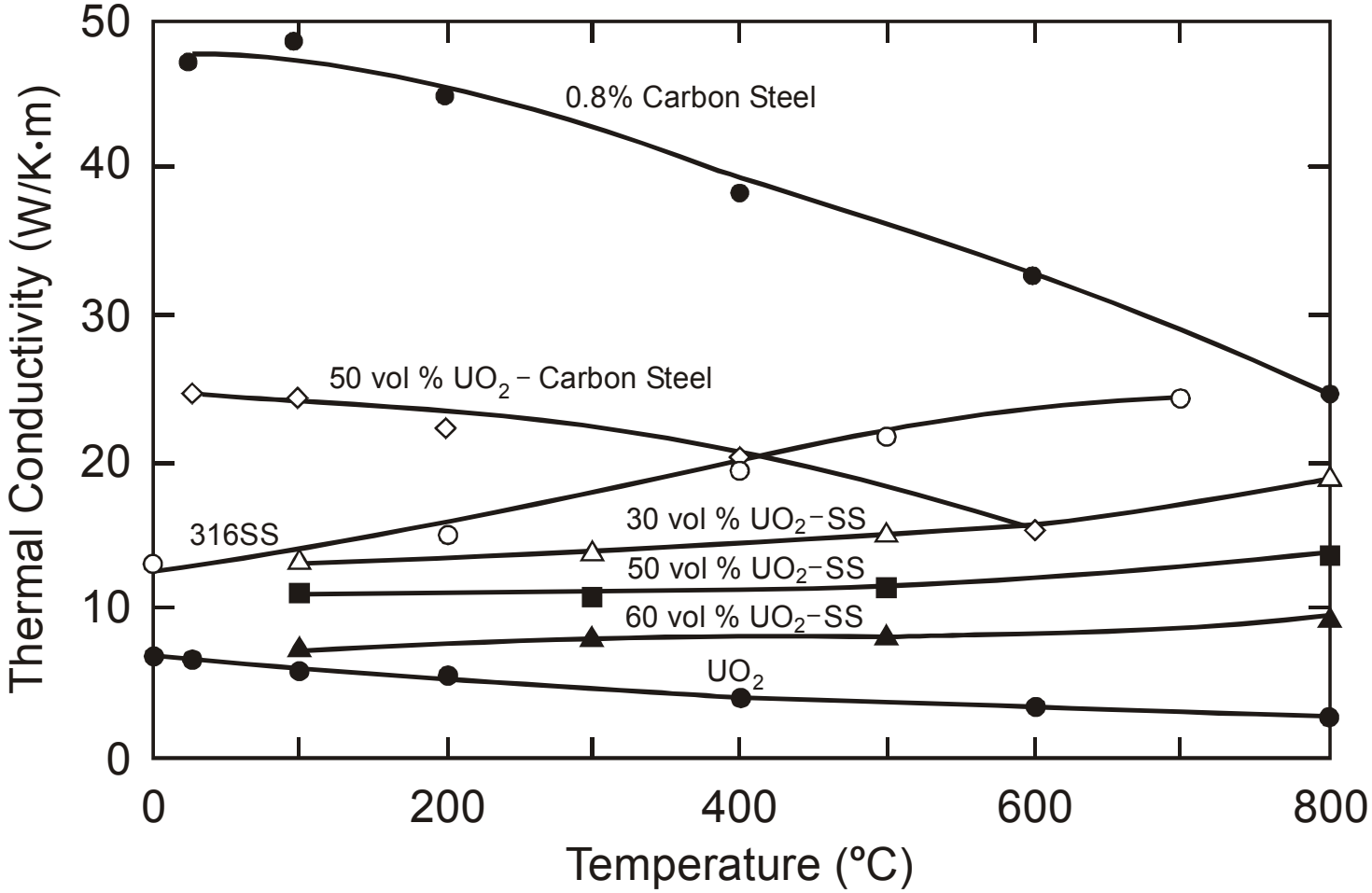
Spin Casting May Allow Low-Cost Cask Body Fabrication

- Some nonnuclear cermets are manufactured by molten-metal ceramic-particulate slurry casting with solid ceramic particles
- Spin casting is used for sewer pipe and other low-cost products
- R&D is required to develop the method for DUO_2-steel cermets

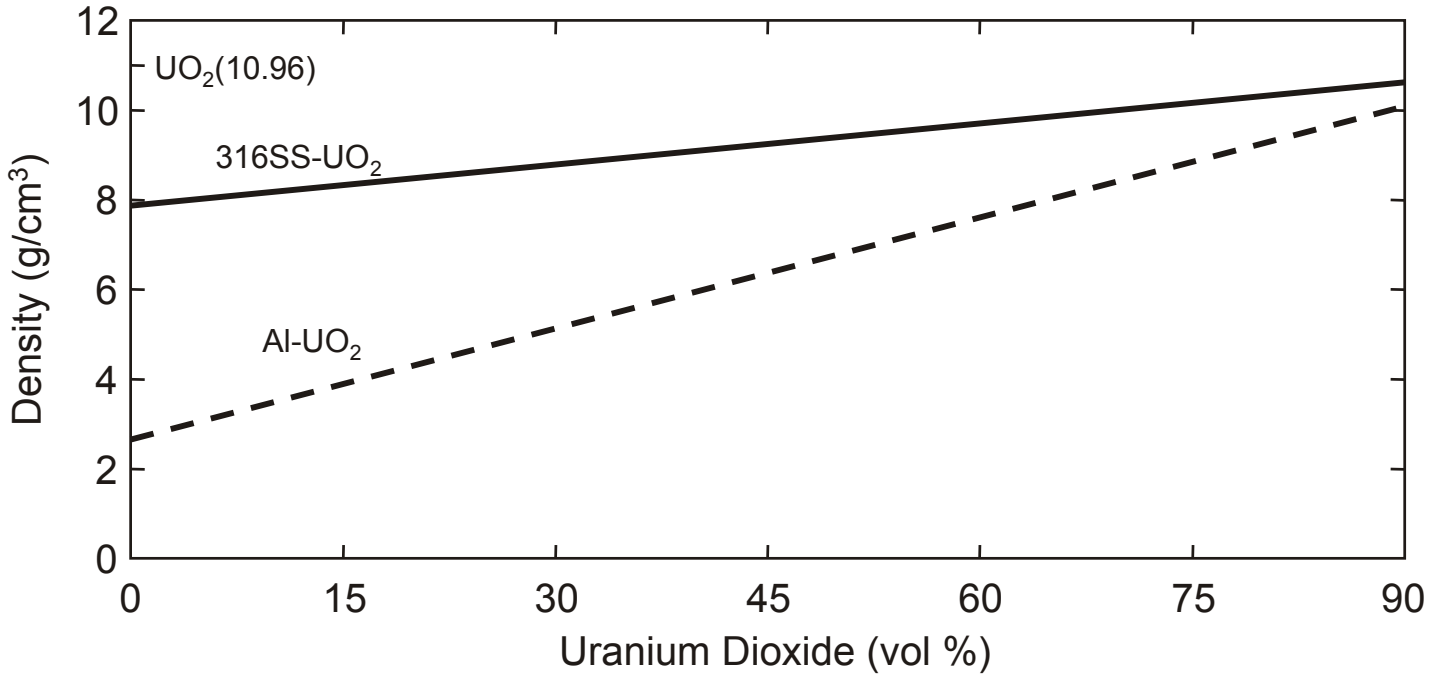
Spin Casting of Cermet Cask Body
(Future Option)



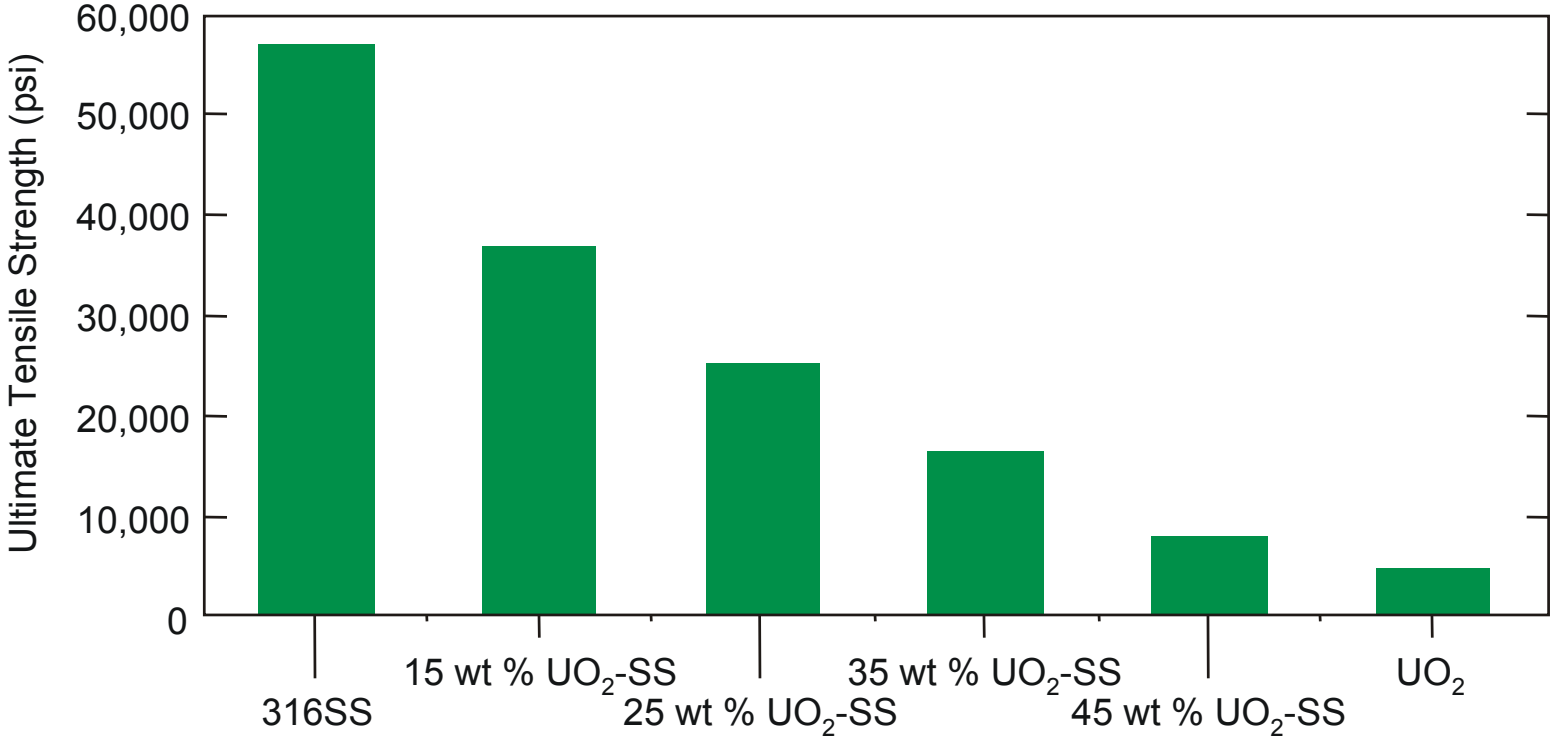
Thermal Conductivity as a Function of Temperature for Cermets and Other Materials



Cermet Density as a Function of UO_2 Volume Fraction



Strengths of Cermets and Other Materials
(Caution: Strength Dependent on Fabrication Method)



Changing Physical Protection Requirements Narrows the Difference Between Storage, Transport, and Disposal Casks

Frank J. Denicola / New York Times

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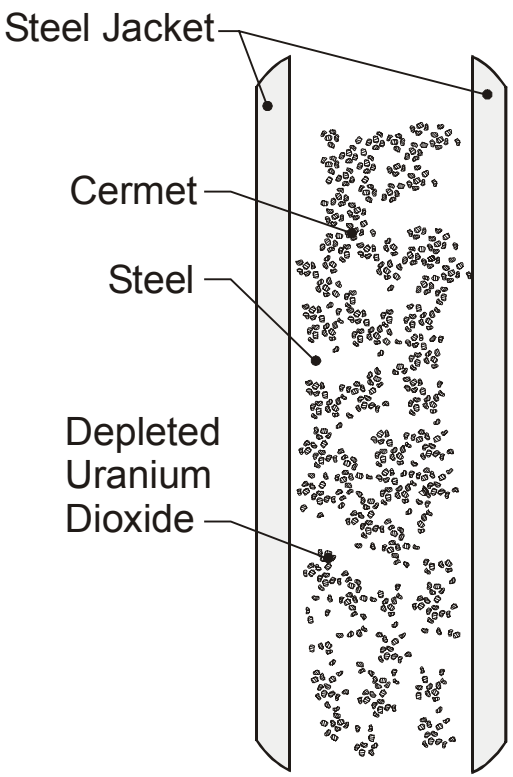

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- Good Physical Properties
  - High thermal conductivity
  - No organics (no fire, acceptable to repository)
  - Adjustable properties to maximize accident/assault resistance