Nuclear Science and Technology Division

Document Review Record

To be completed by author

Date Submitted: September 23, 2004 | **Account Number:** 3530-8062

Author(s): Charles W. Forsberg

Title: Status of Cermet SNF Cask Development in the United States

Peer Reviewer(s):

Final Editing by: Pick from list Other:

The process for clearance and release ensures that (1) the technical content is sound, (2) the government's patent interests are considered, (3) the information released to the public is not classified or otherwise controlled, and (4) DOE regulations are met — including the requirement that DOE's Office of Scientific and Technical Information (OSTI) receive a PDF copy of our technical reports and full conference papers (but not abstracts or viewgraphs). These four steps are carried out by the originating division, the ORNL Patent Counsel (if applicable), an Authorized Derivative Classifier and/or Classification Officer if work involves a non-DUSA (Designated Unclassified Subject Area), and the ORNL Office of Technical Information and Classification (OTIC). ORNL now uses an electronic process (CPPR database) to register documents.

Patent Review

a. **Patent Review Waived:** [✓] Yes [ ] No

Reason: [ ] Previously Reviewed and Cleared by Patent Office* [✓] Nonpatentable Subject Matter

*Cite or attach the previous review and/or case documentation

CWF (Author initials)

(Group leader initials)

b. **Requires Review by Patent Office:** [ ] Yes (Patent officer signature)

Classification/Sensitive Information Review

a. **DUSA, Classification Review Not Required:** [ ] Yes [✓] No

CWF (Author initials)

(Group leader initials)

b. **Potentially Classified or Sensitive, Requires Review by ADC:** [✓] Yes [ ] No

Contains Classified/Sensitive Information: [ ] Yes [✓] No 9/28/04

Classification Level:

(ADC signature)

Export-Controlled Information: [✓] Yes [ ] No

CWF (Author initials)

(Group leader initials)

Author Final Approval: Sept 23, 2004 Date

Group Leader Final Approval: Date

Program Approval (if required): 9/23/04 Date

TI Manager Approval: Date

Division Director Approval: Date

Status of Cermet SNF Cask Development in the United States

Charles W. Forsberg

Russian–American Workshop on Use of Depleted Uranium and Review of International Science and Technology Center (ISTC) Projects
October 18–21, 2004
Moscow, Russia

Oak Ridge National Laboratory
P.O. Box 2008, Oak Ridge, Tennessee 37831-6166
United States of America
E-mail: forsbergcw@ornl.gov

Outline

- **Cermet Cask Description**
- **Design**
- **Manufacturing**
- **Cask Decay-Heat Removal**
- **Repository Behavior**

GNS Storage and Transport Cask

Cermet Cask Description

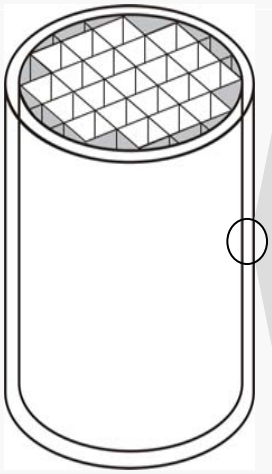
Cermets Combine the Best Properties of Ceramics (Shielding, Hardness, etc.) and Metals (Strength, Ductility, etc.)

Cermets Are Used for Demanding Applications

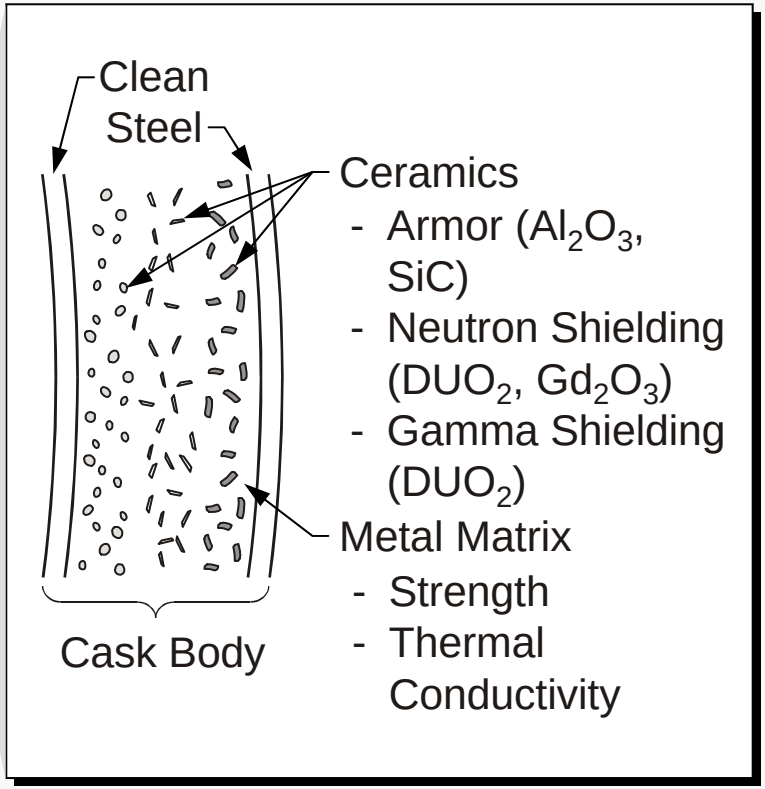
Brake Shoes

Main Battle Tank Armor

Cutting Tools

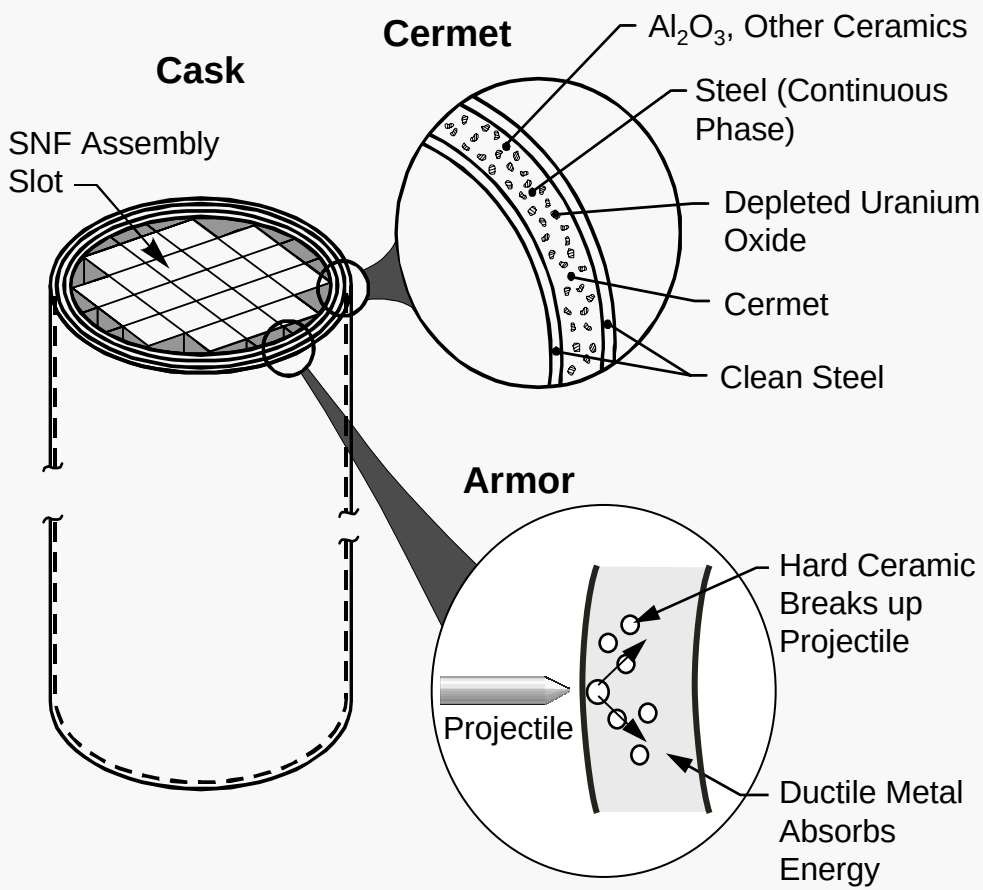


Cermet Body Cross Section



Cermets are the Enabling Technology for a SNF Super Cask

(Ceramics in Metal Matrix to Obtain Advantages of Both)



- **Radiation Shielding**
  - **Gamma: High-Density DUO_2/Other**
  - **Neutron Moderation/Absorption**
    - **Oxygen in DUO_2**
    - **Carbon in SiC/Other**
- **Assault Protection: Traditional Armor**
  - **Ceramic (Al_2O_3, Other)**
  - **Metal**
- **Safeguards and Theft**
  - **Large Mass**
  - **Cermet**
- **Decay Heat Removal**
  - **High-Conductivity Steel Matrix**
- **Geological Disposal**
  - **Criticality (DUO_2)**
  - **Chemistry: Enhanced Eh and pH (Fe, Other)**

Design

Studies are Underway to Define Optimum Cask Design

- **Cask design dependent upon application: storage, transport, and/or disposal**
- **Key questions: What is the optimum cermet for:**
  - **Minimum cask weight?**
  - **Minimum cask dimensions?**
  - **Maximum physical protection?**
  - **Maximum repository performance?**
- **Cermets (ceramics in metals) create performance possibilities that have not been previously explored**

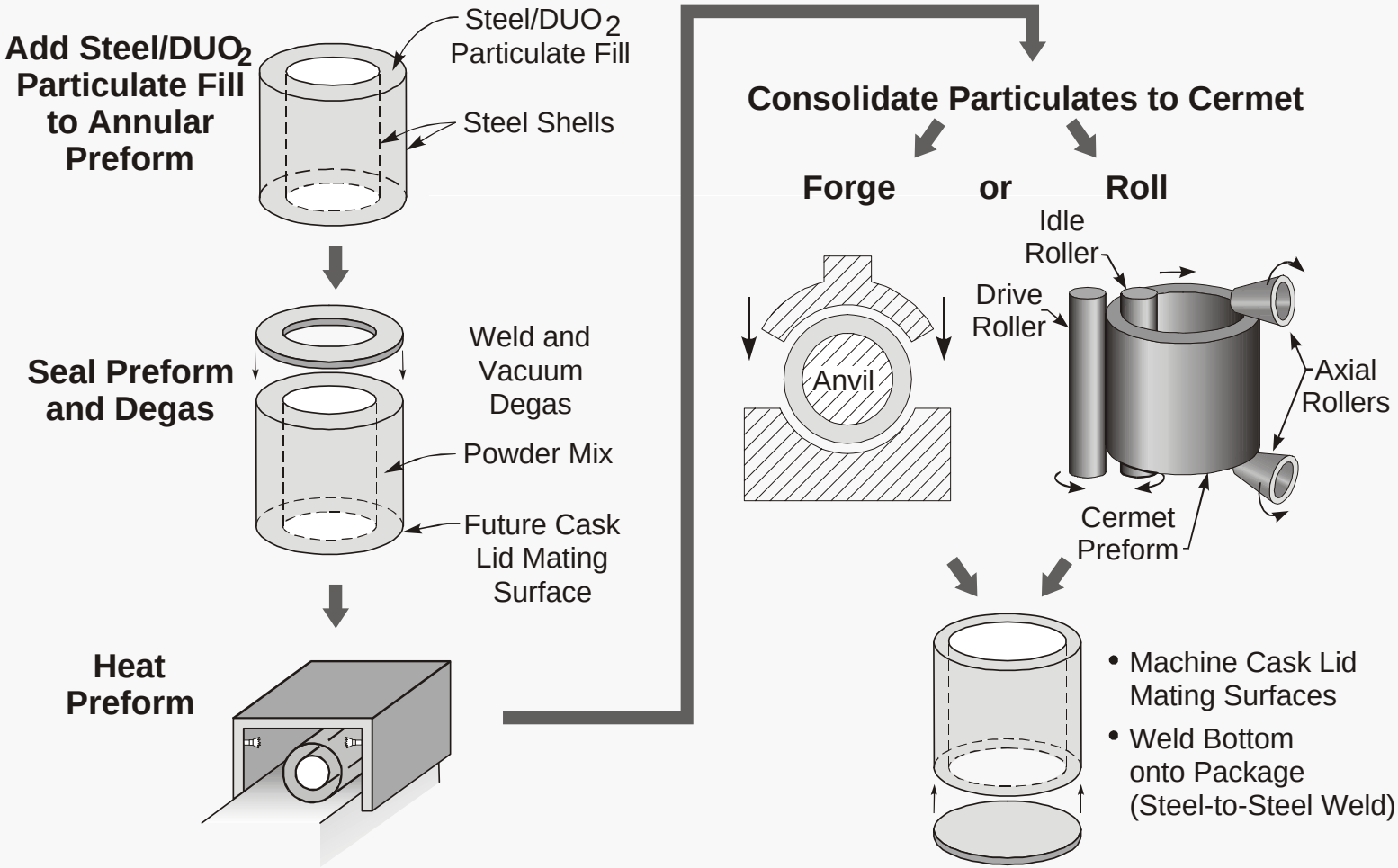
Manufacturing

Low-Cost Manufacturing is the Key Economic Requirement

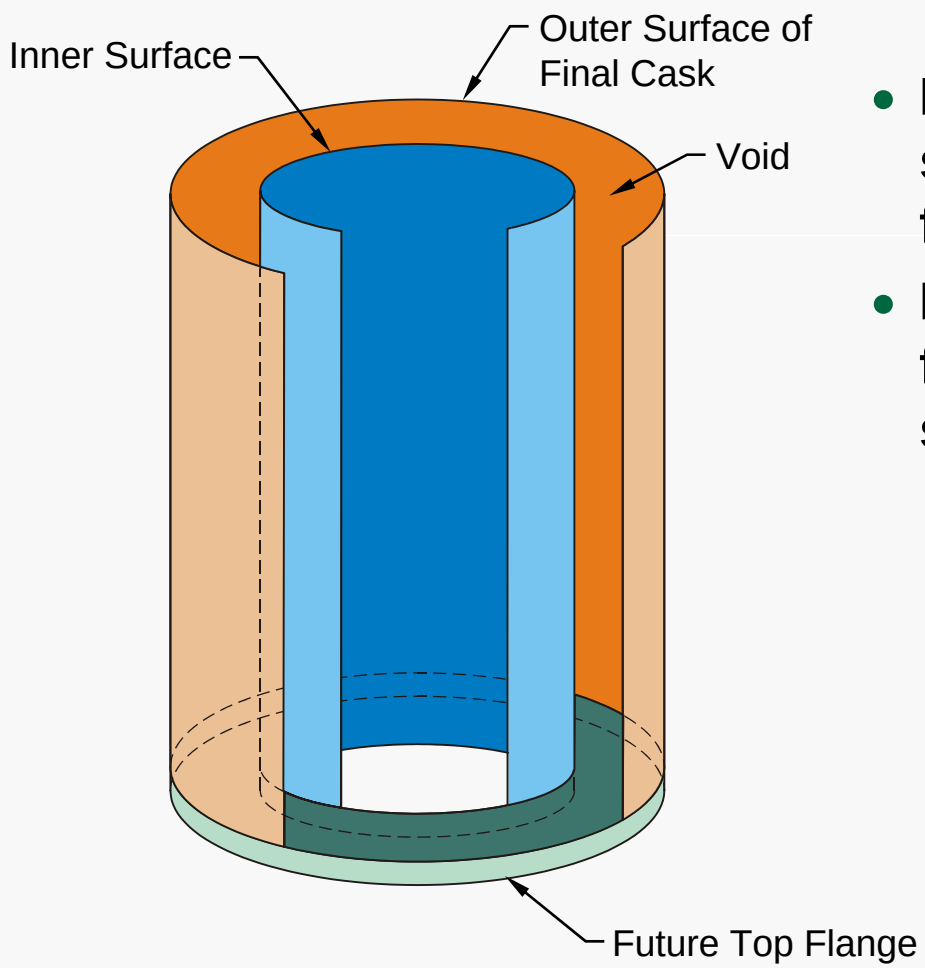
- **Two options being examined**
  - **Casting (Russia)**
  - **Powder metallurgy (United States)**
- **Optimum cask may have different parts made by different processes**
- **In the U.S, manufacturing studies are underway to understand the economics**
- **Initial results in several months**

New Cermet Cask Production Method

(United States: Patent Application Filed)

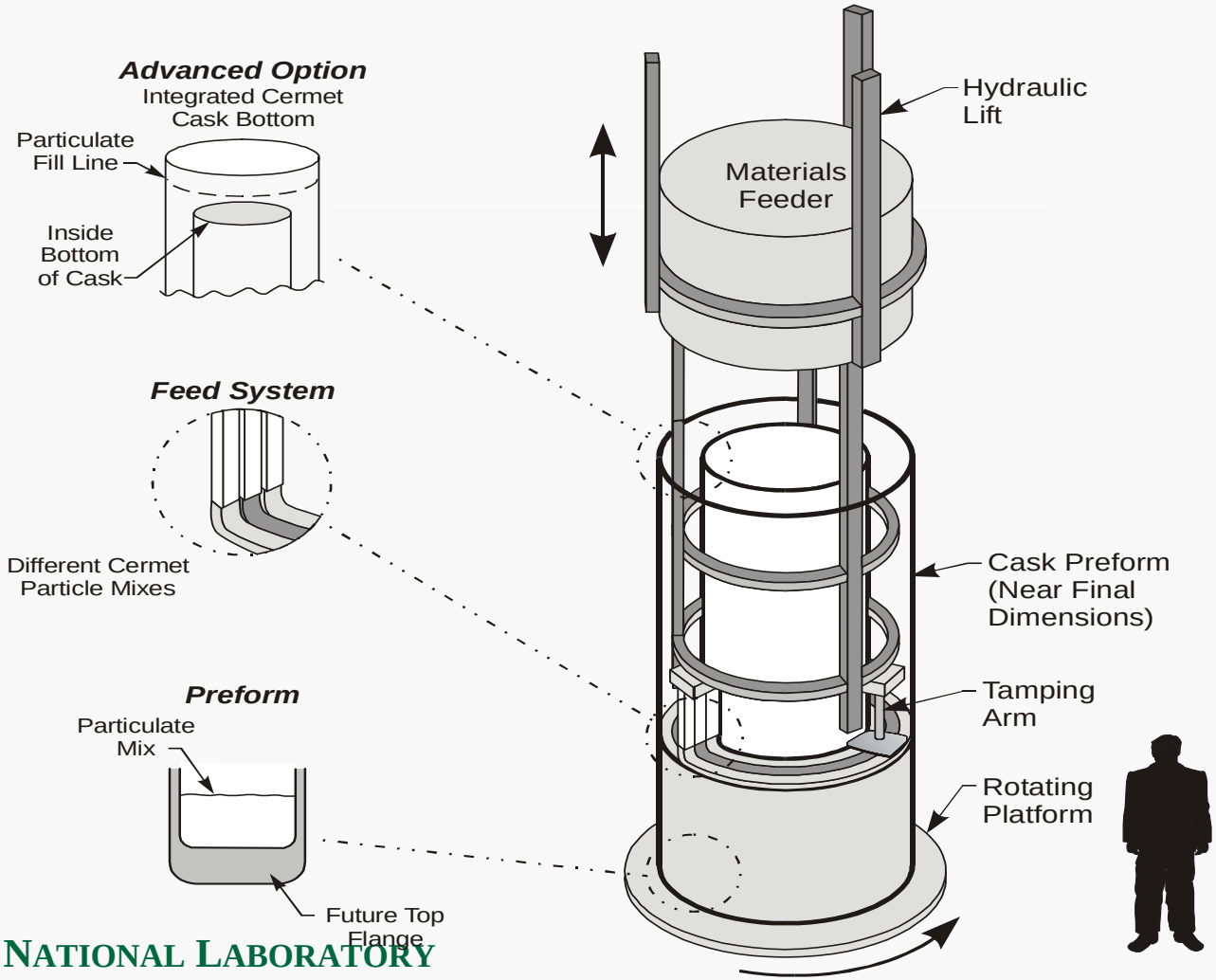


Step 1: Manufacture of Cask Preform

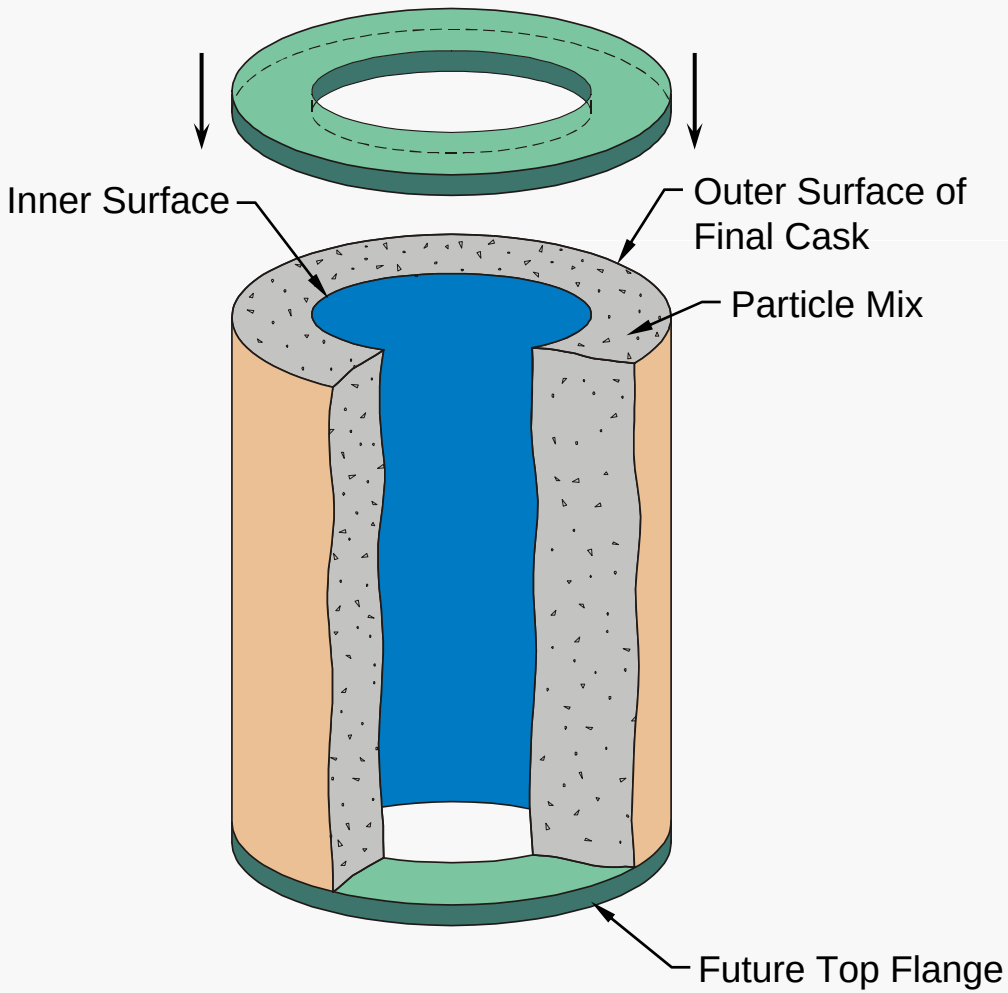


- **Preform dimensions are slightly larger than the final cask**
- **Preform becomes the final inner and outer surfaces of the cask**
  - **Wall thickness: 1-3 cm**
  - **Flange**
    - **Thickness: 10-20 cm**
    - **Face for lid**

Step 2: Empty Preform is Mounted Upside Down on Turntable and Filled with Cermet Particulate Mixture

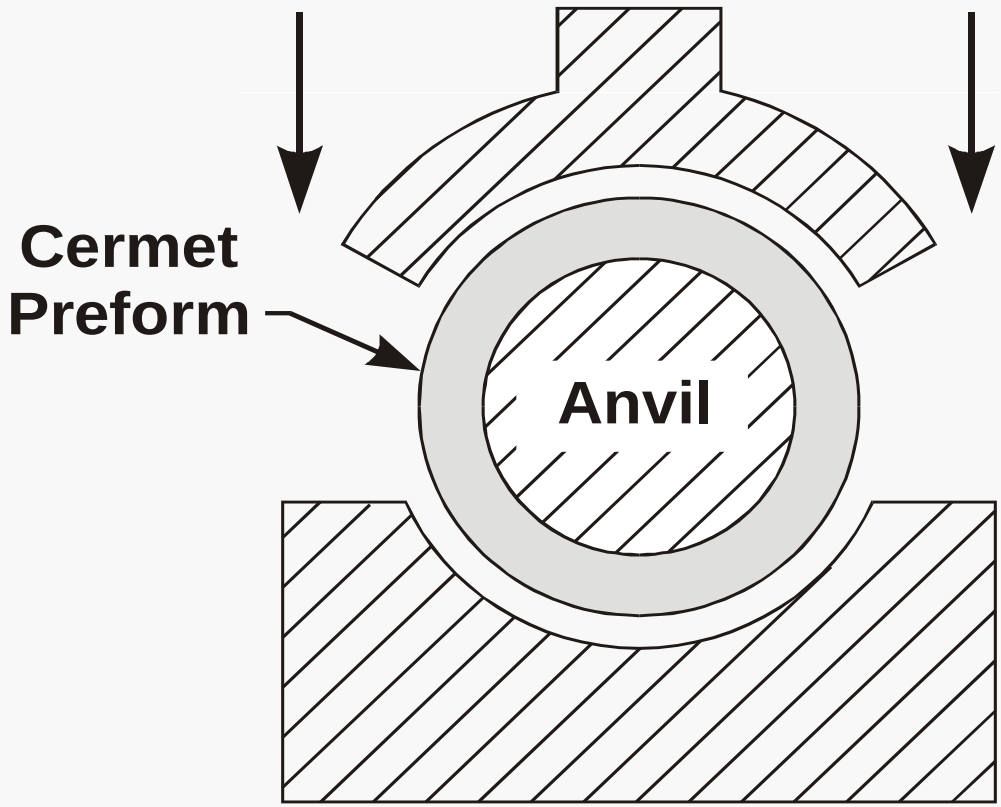


Step 3: Loaded Preform is Sealed and Degassed

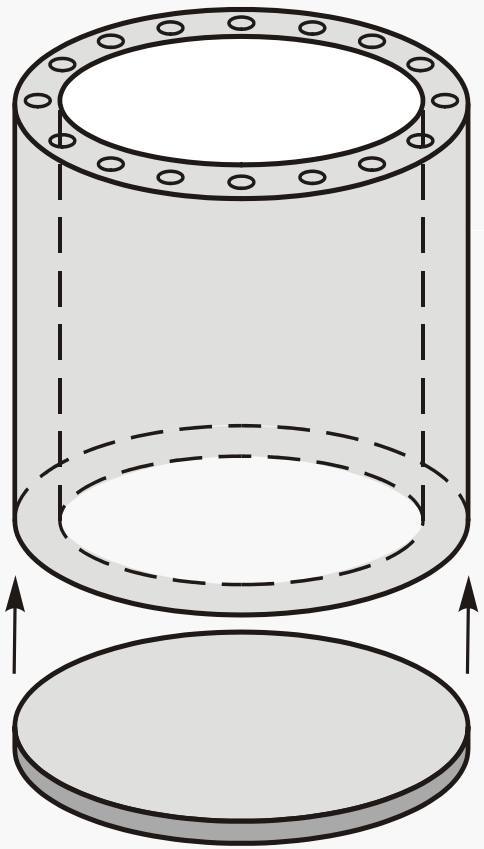


- **Weld annular ring to seal preform**
- **Degas**
  - **Heat**
  - **Vacuum**
- **Send sealed package to forging operations**

Step 4: Cermet Consolidation by Hot Forging (Several Forging Options)



Step 5: Cask Finishing Operations



- **All finishing operations involve steel preform (No contact with cermet)**
- **Cask bottom is welded to the cask body**
  - **Option for integrated cask bottom**
  - **Option requires complex forging operation**
- **Cask machining**
  - **Machine lid surface and bolt holes**
  - **Cask surfaces**

Cask Decay Heat Removal

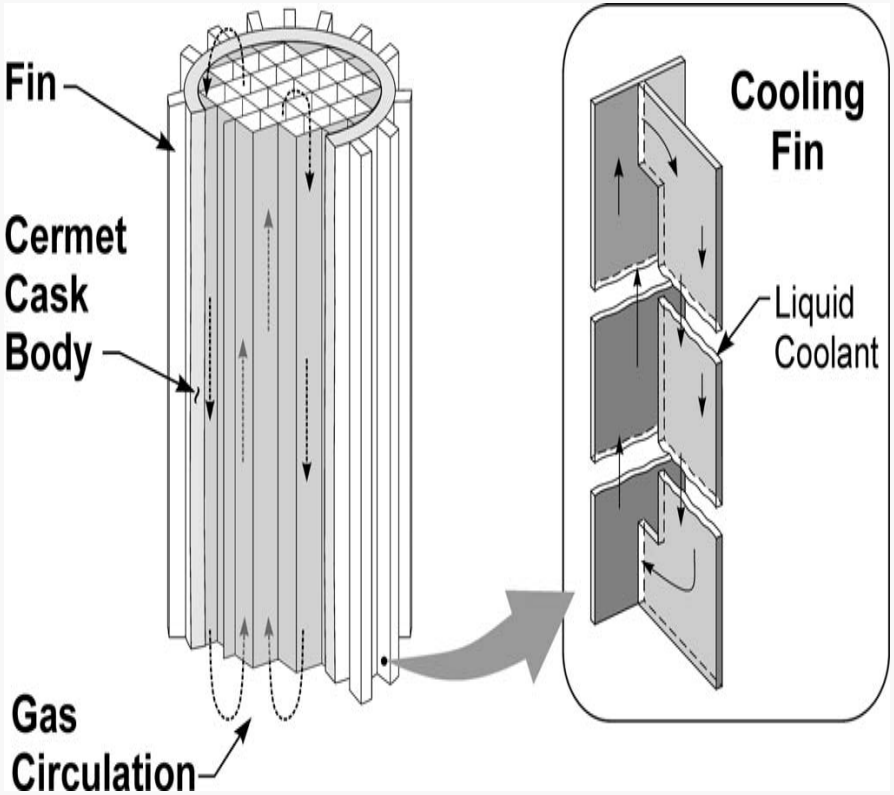
The Other Constraint in Cask Design

U.S. Utilities want High-Capacity Casks for Short-Cooled Spent Nuclear Fuel (SNF)

- **Cermets increase cask capacity for a given weight constraint**
- **With improved cask, SNF decay heat then limits cask capacity and incentives for cermet casks**
- **Limited studies undertaken on how to improve cask SNF heat removal**

High-Performance Heat Removal Requires Efficient Heat Transport Across Three Barriers

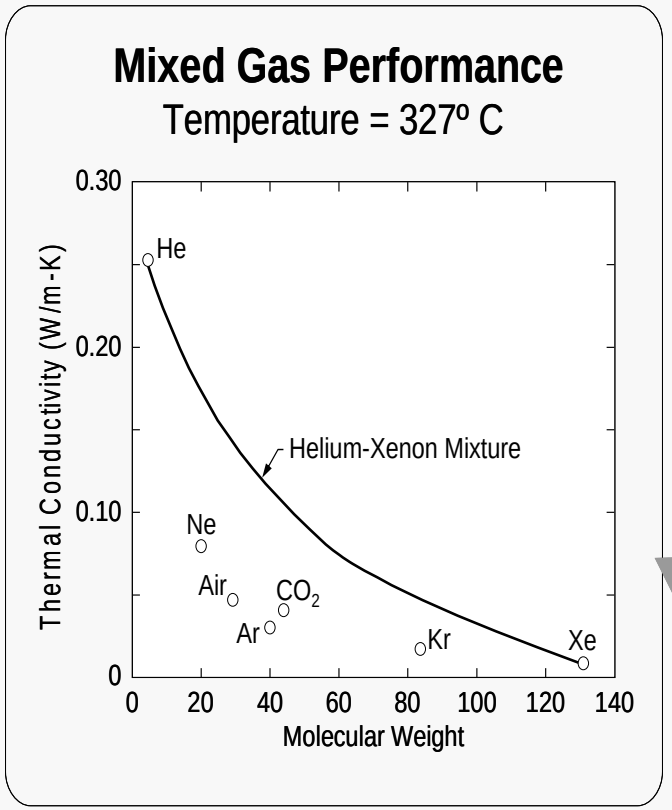
(Improved Heat Transport For Two Barriers)

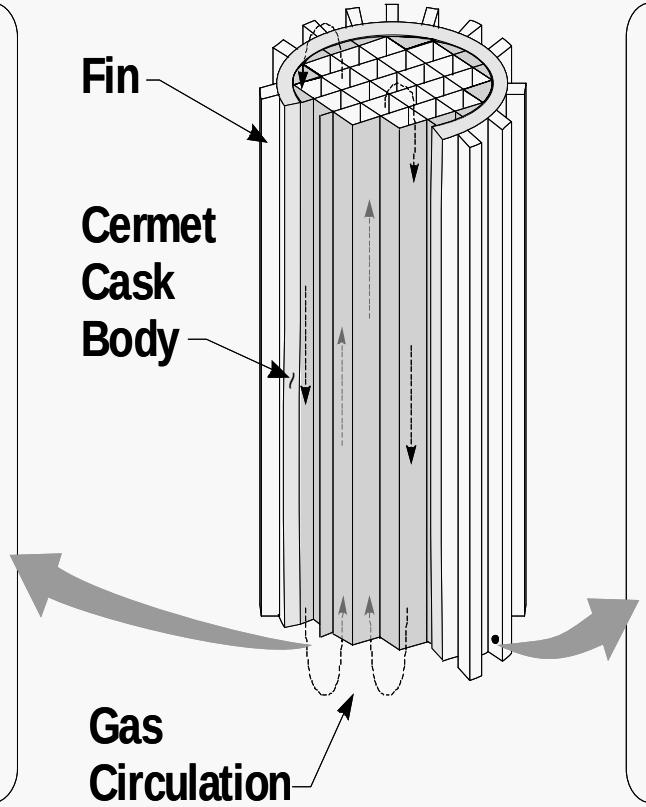


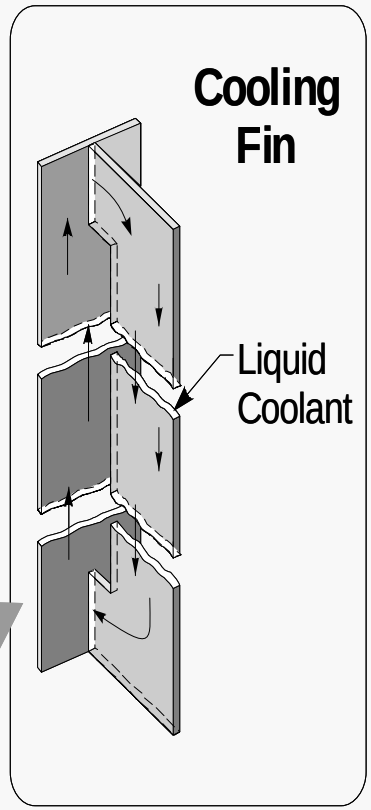
- **Heat transport from SNF to cask wall**
  - **Enhanced Gas Convection**
- **Conduction through cask wall**
  - **Metal matrix**
- **Heat transport from cask wall to air**
  - **Liquid cooling**
  - **High surface area**

Cask Cooling Improved by Liquid-Cooled Fins and Special Gas-Mixtures in Basket

04-099







Repository Behavior

Significant Uncertainties in U.S. Repository Program

- **U.S. Federal courts have asked for redefinition of repository performance goals**
  - **Licensing may require demonstration of repository performance for longer periods of time**
- **Current repository design emphasizes corrosion-resistant waste package**
- **If repository licensing period is extended, there are greater incentives to consider geochemical barriers such as DUO_2 to *demonstrate* repository performance**

Conclusions

- **Continued interest in cermet casks**
- **Increasing interest in casks for storage and transport**
- **Two methods identified for cask manufacture**
- **Repository performance goals uncertain; increased incentives for *provable* methods to improve repository performance**

Backup Slides
Backup Slides
Backup Slides
(Not Translated)

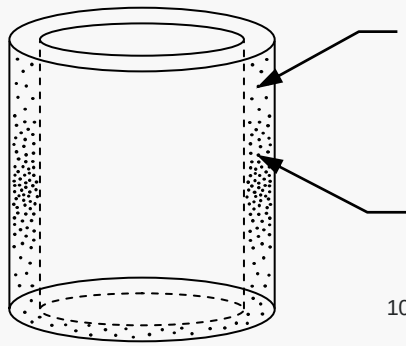
Cermet Cask Description

Basis for Cermet SNF Cask Performance

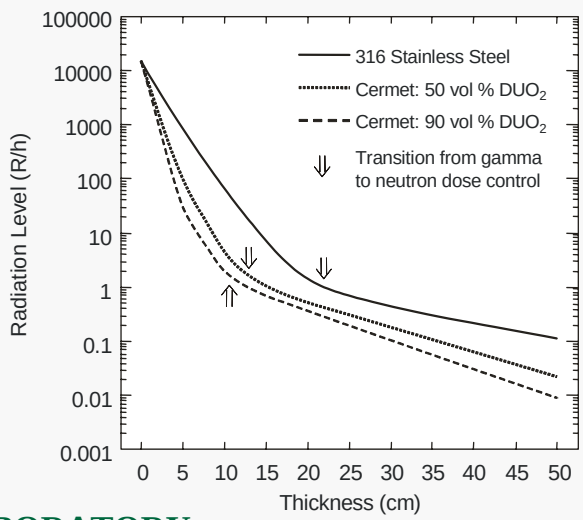
Higher Capacity Cask

(Increased capacity for a given cask weight)

Variable-Density Cask Wall

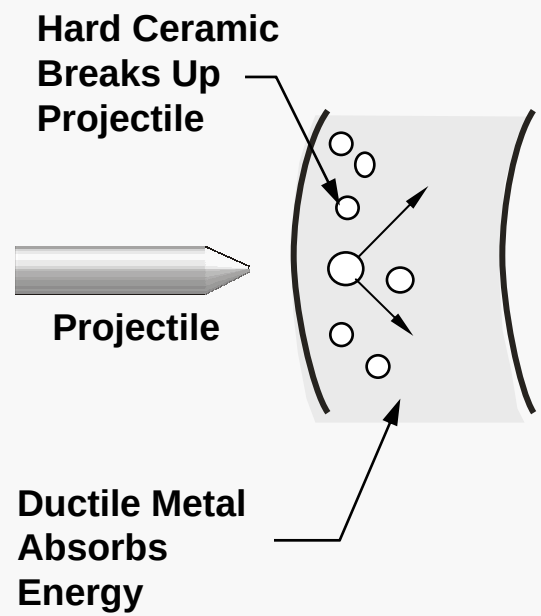


Superior Shielding
DUO_2 Particulates
Steel Matrix



Assault Resistance

(Traditional cermet application)



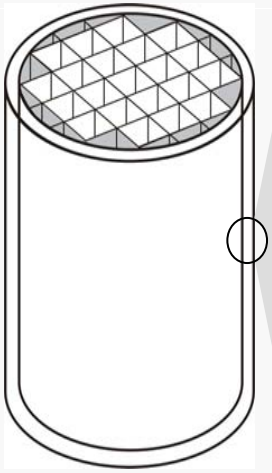
Because of Their Material Properties, Cermet SNF Cask Performance Exceeds That of Other Casks

Cermets Are Used for Demanding Applications

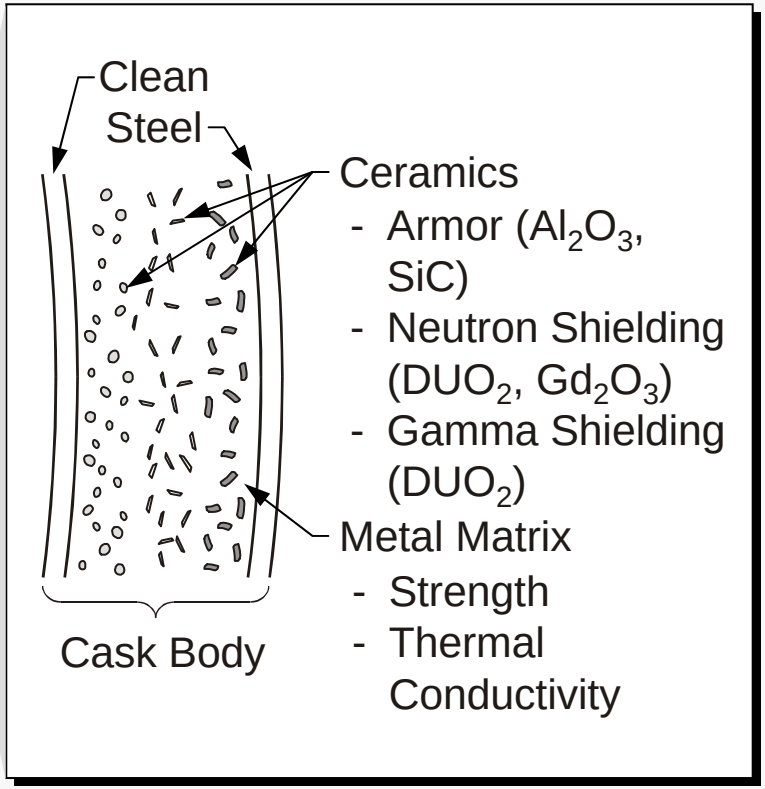
Brake Shoes

Main Battle Tank Armor

Cutting Tools



Cermet Body Cross Section

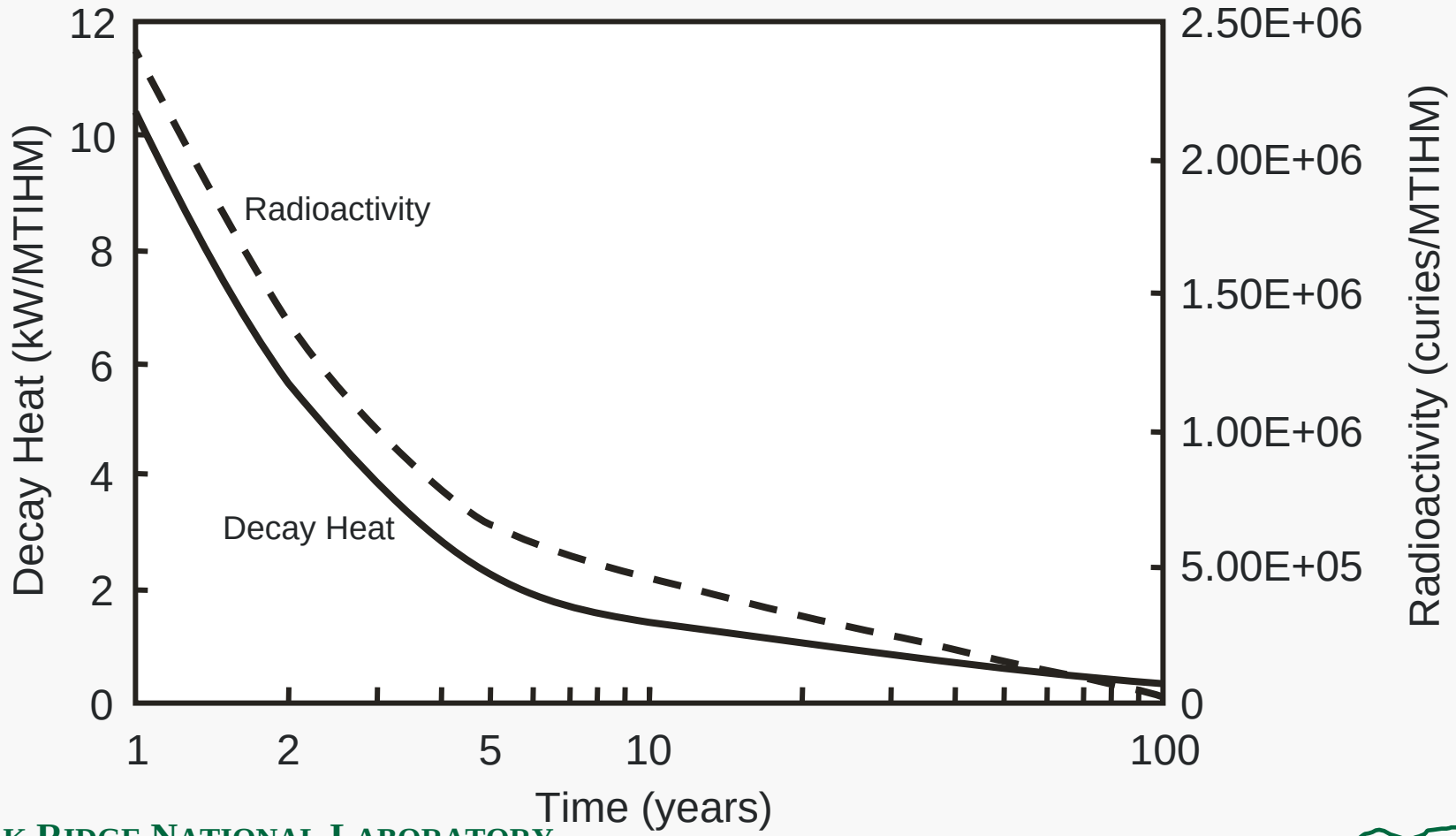


New cermet manufacturing method for low-cost production

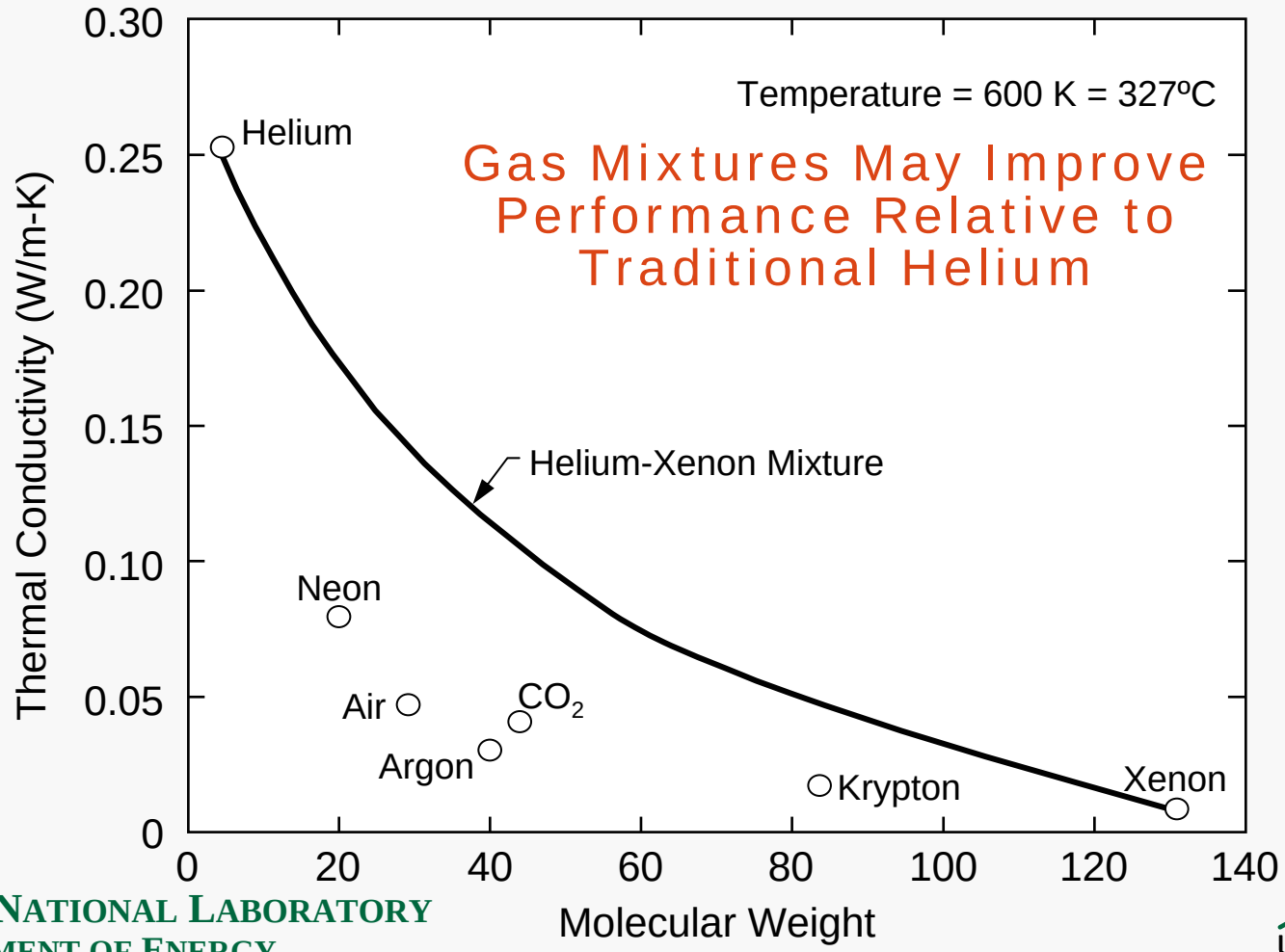
Cask Decay Heat Removal

The Other Constraint in Cask Design

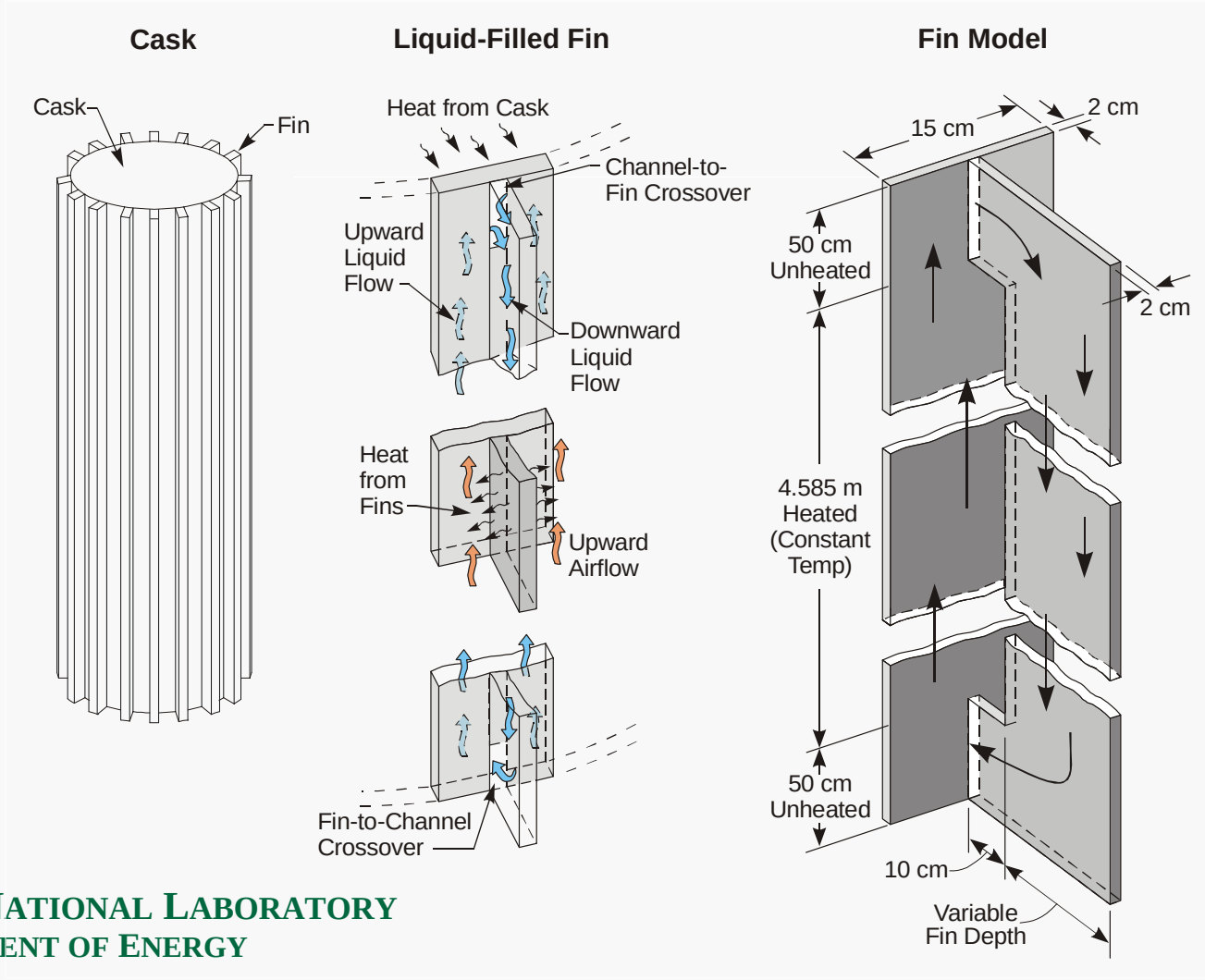
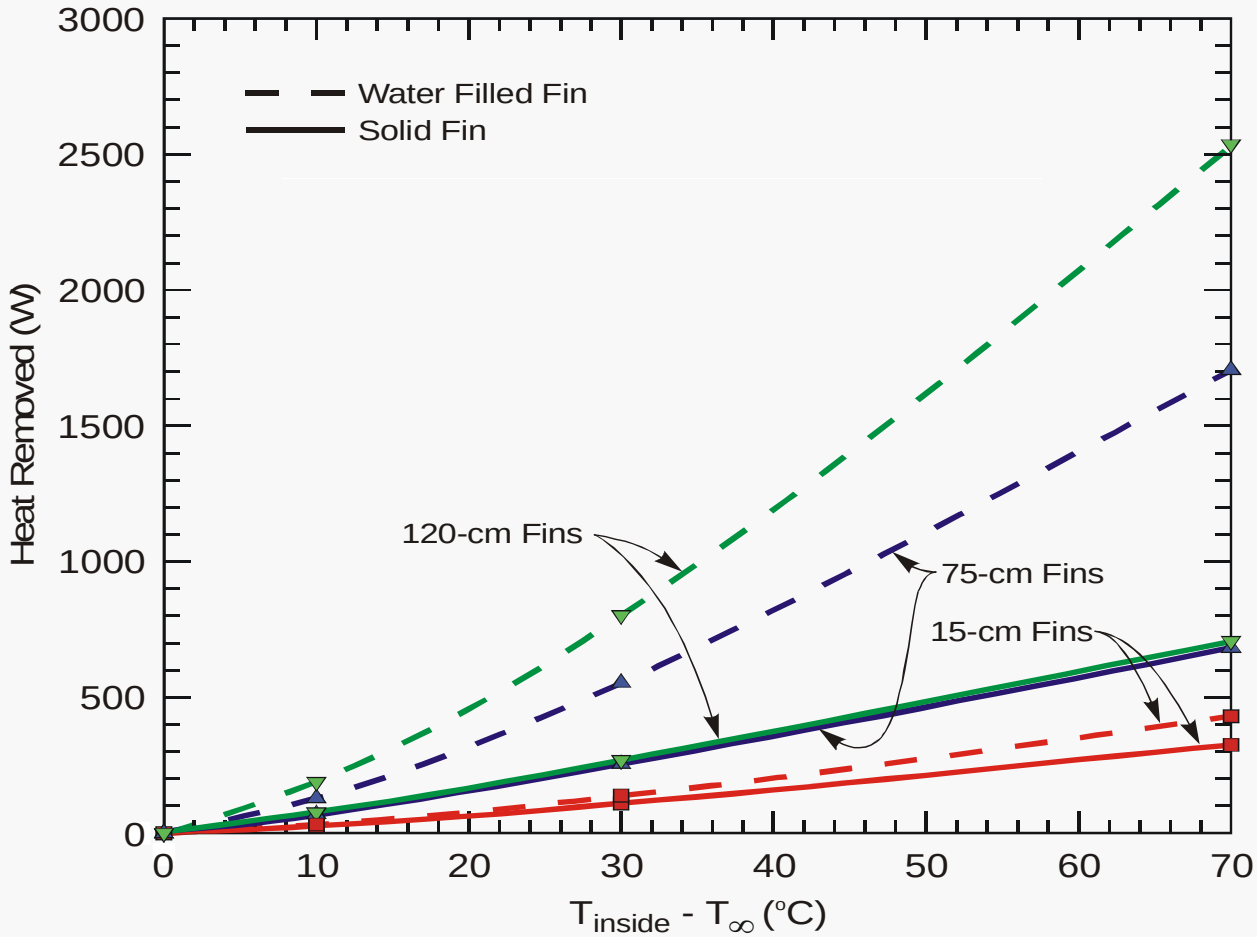
Decay Heat Controls the Design of SNF Cask Systems for Large Casks and Short-Cooled SNF



Convective Heat Transport is Maximized with a High Thermal Conductivity for Heat Transfer (e.g. He) and a High Density for Convection (e.g. Xe) Gas



Decay Heat Removal can be Increased by Using Fins with Natural Circulation of Liquids



Heat Rejection from Solid and Water-Filled Fins Versus Temperature and Fin Depth