

# Cooling Multipurpose SNF Casks With Removable Liquid-Filled Fins

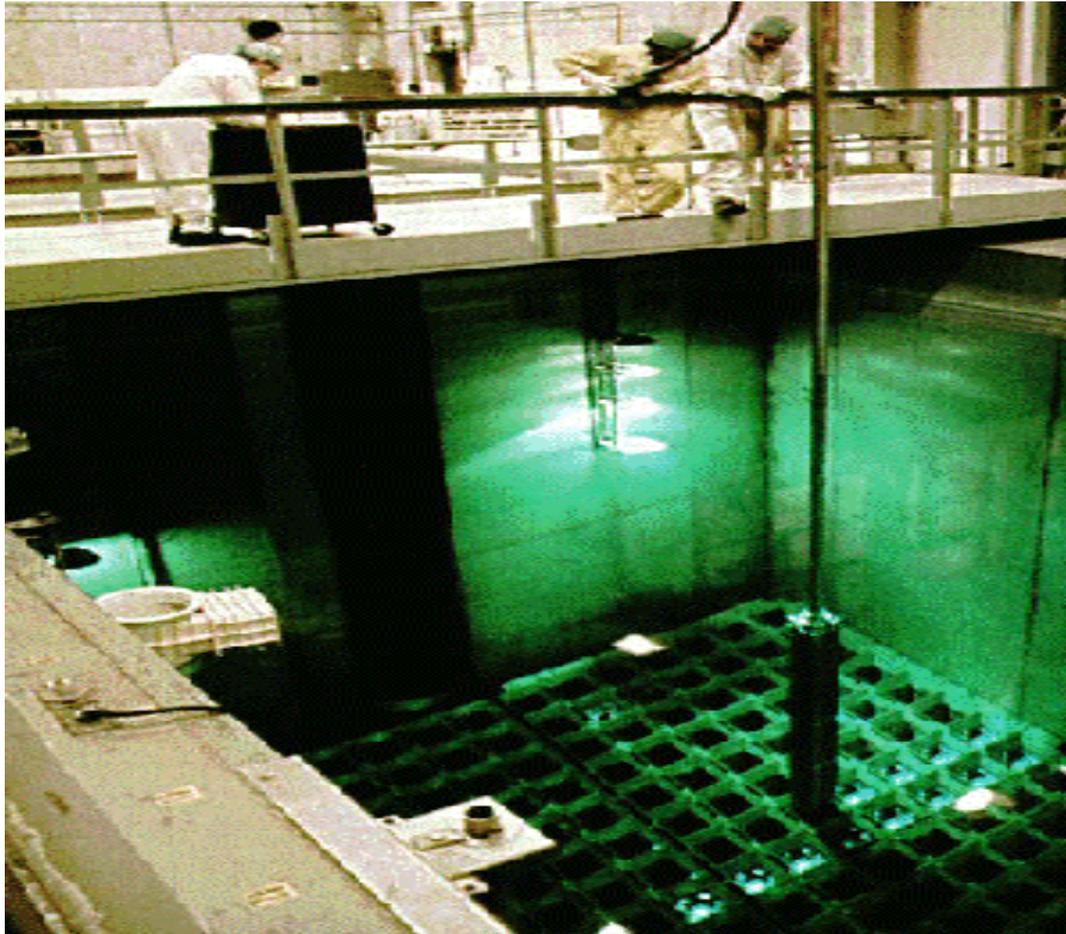
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**Session: Storage Systems and Components—I**  
**Room: Magnolia; Time: 10:00 am**  
**2003 International High-Level Radioactive Waste Management Conference**  
**American Nuclear Society**  
**Las Vegas, Nevada**  
**Tuesday April 1, 2003**

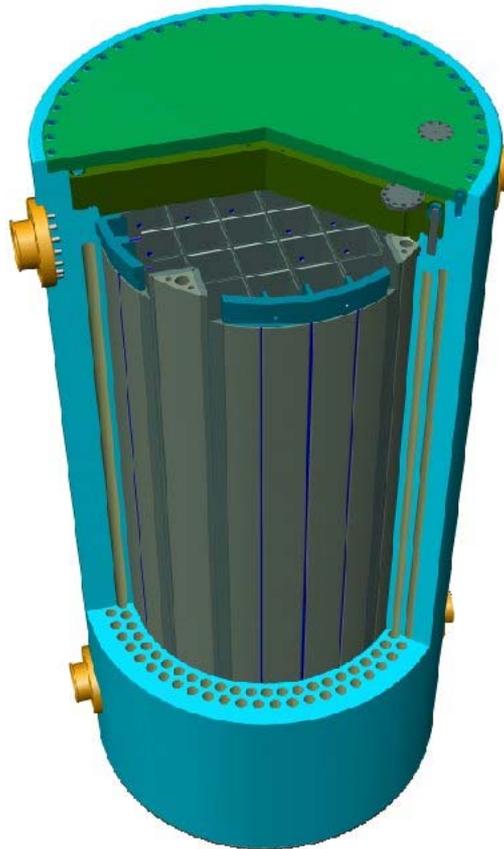
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# SNF Is Traditionally Stored in Reactor Pools (Pools Provide Cooling and Radiation Shielding)



# Space Limitations and Security Concerns Encourage SNF Transfer to Casks

(German GNS SNF Storage and Transport Cask:~100 tons)

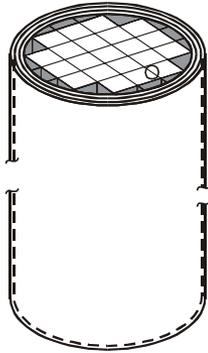


# GNS SNF Storage and Transport Cask on a Railcar



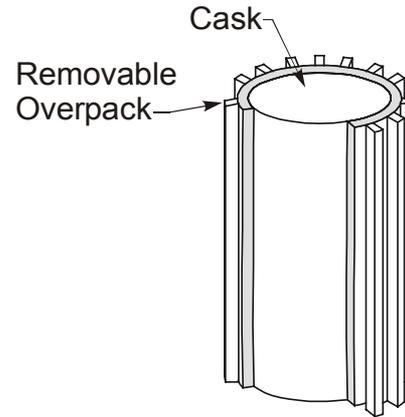
# Multipurpose Cask Systems Minimize SNF Handling But Need Over Packs To Address Variable Requirements

## Multipurpose Cask



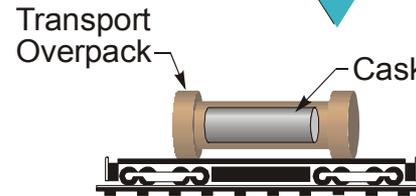
- Radiation Shielding
- Accident/Assault Protection: Multilayer Cermet
- Safeguards and Theft Resistance
- Decay Heat Removal

## Multipurpose Cask System

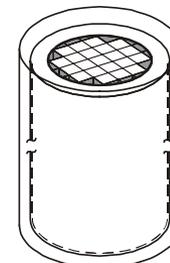


### Storage at Reactor

- Removable Overpack to Allow Disposal Overpack
- Augmented Cooling
  - Short Cooled SNF
  - Array Storage
- Augmented Shielding



### Transport



### Disposal

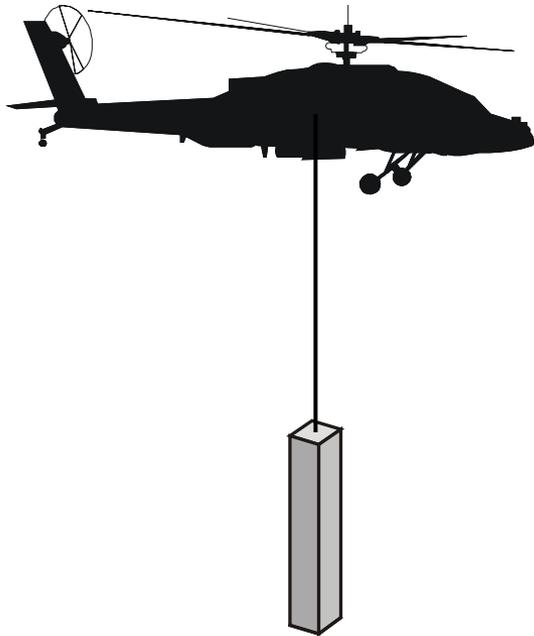
Corrosion Resistant Repository Overpack

# **Strong Incentives Exist for Storing Short-Cooled SNF in Large Casks**

- **Maximize pool space for maintenance**
- **Minimize SNF security issues (cask storage has superior performance)**
- **Reduce regulatory requirements at end-of-plant life by early emptying of SNF pools**
- **Cost competitive storage: large casks minimize capital and operating costs**

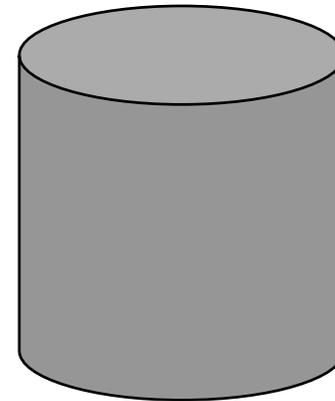
# The Characteristics of Multipurpose Casks Provide Protection Against Theft or Diversion

*Fuel Assembly*



**Low weight (~1/2 ton),  
small size**

*Multipurpose Cask*

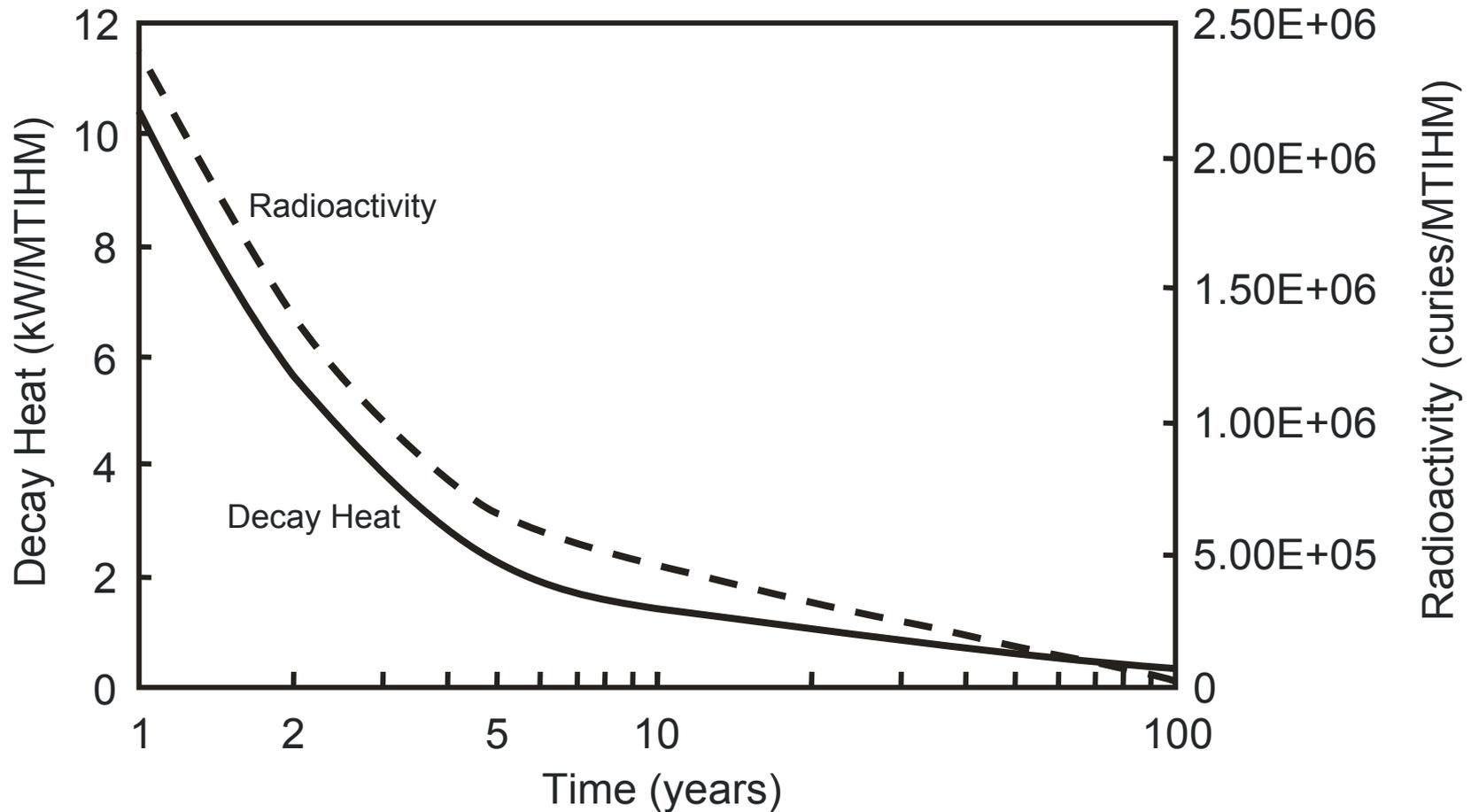


**Large weight (>70 tons),  
large size, detectable from  
from orbit, option of  
transponder**

# German Rail Gun for Testing Casks: 1-ton Projectile at 300 m/s (Simulate Aircraft Jet-Engine Rotor)



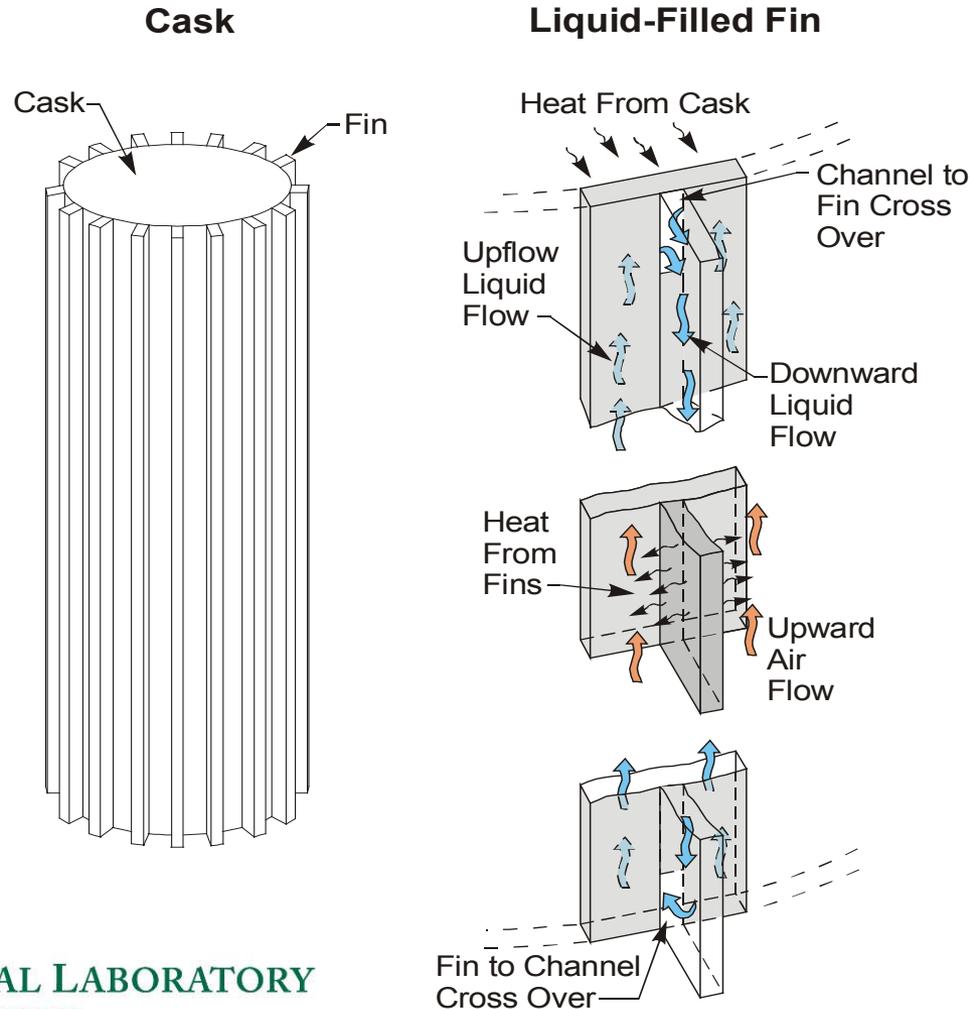
# The Problem: Decay Heat Controls the Design of SNF Cask Storage Systems at Short Times



# Ideal SNF Cask Cooling System

- **Efficient: Three sources of resistance to heat transfer to be minimized**
  - SNF to cask wall (grid structure)
  - Cask wall (smallest of the three)
  - Cask surface to air (subject of paper)
- **Low cost**
- **Cask surface-to-air heat transfer**
  - Removable fins after SNF cool down
  - High surface area fins are a source of contamination
  - Avoid oversized transport and disposal over packs

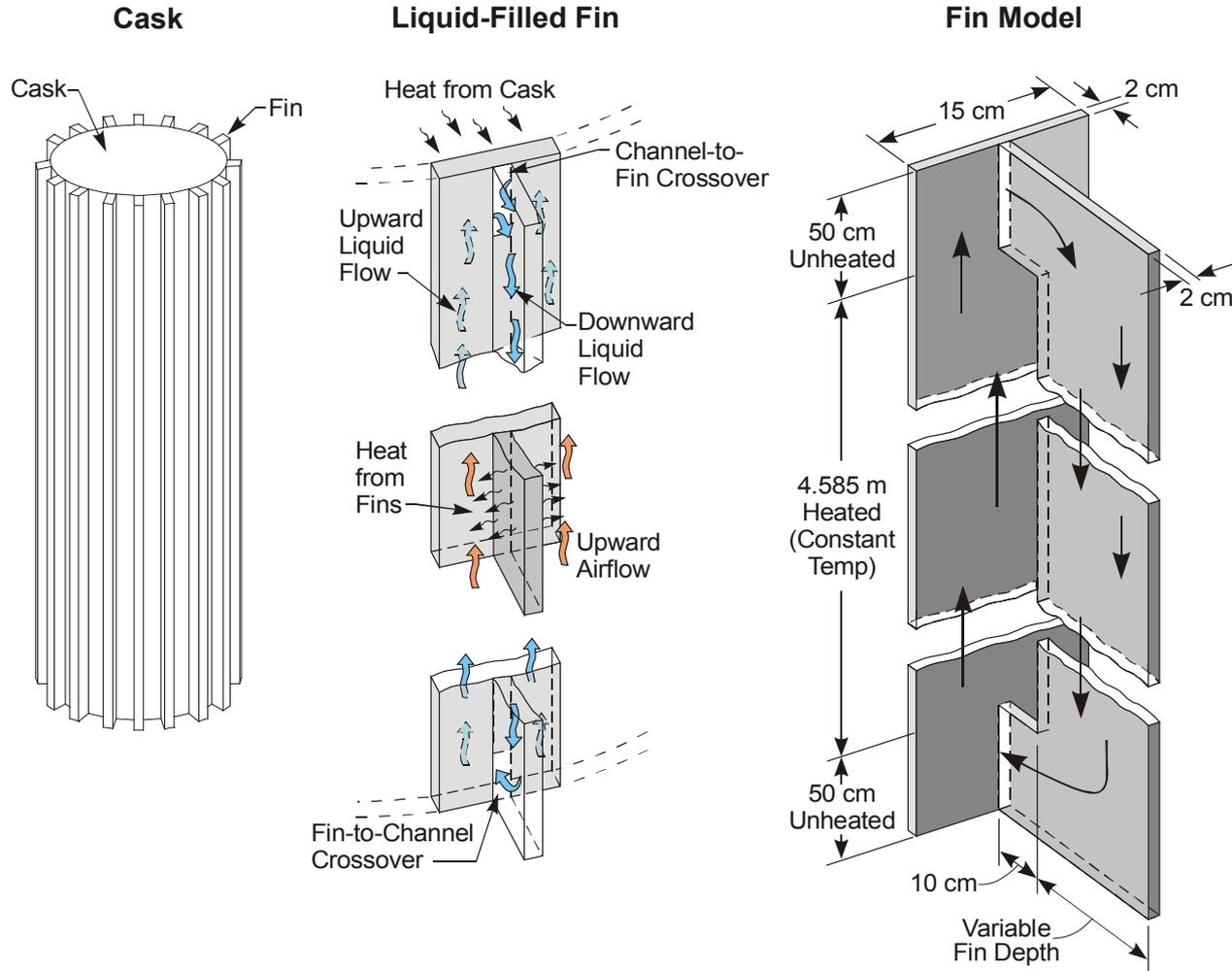
# SNF Cask Cooling Option: Removable Liquid-Fin Cooling Jackets



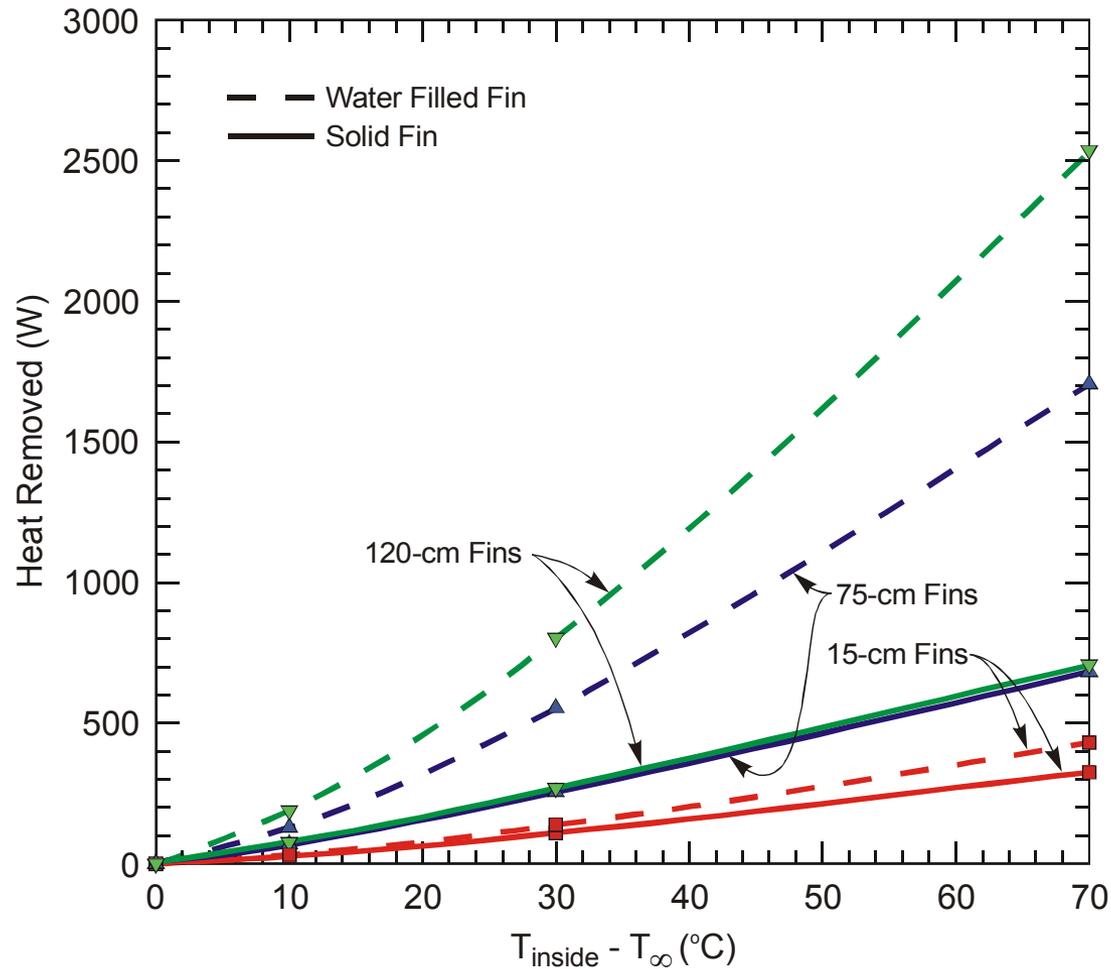
# The Technology Is Not New: Electrical Transformers With Liquid-Filled Fin Cooling Systems



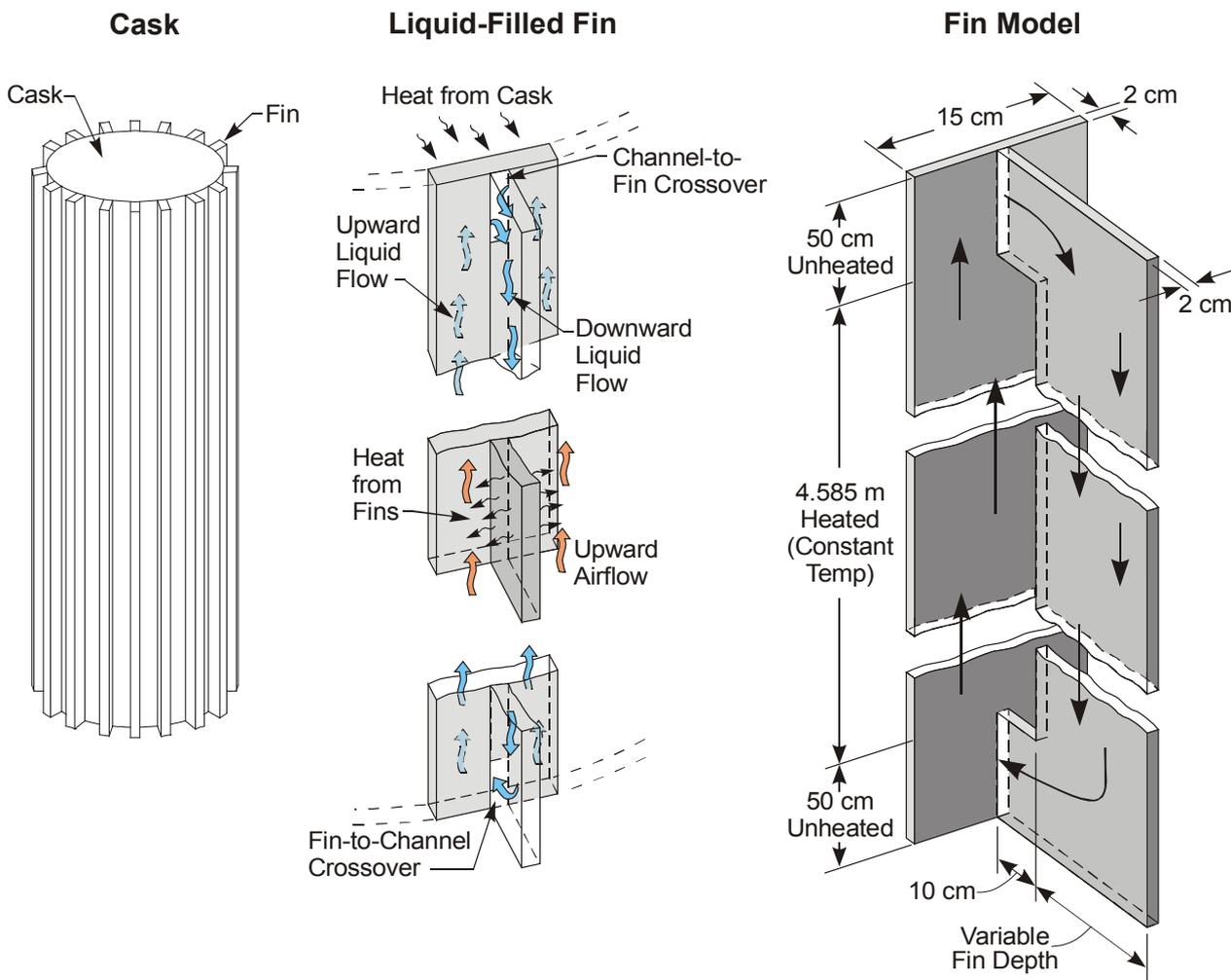
# Removable Liquid-Fin Cooling Jackets Were Modeled to Determine Performance



# Heat Rejection Per Fin Versus Temperature For Different Fin Depths (Solid and Water-Filled Fins)



# The High Efficiency of Liquid-Fins Is a Consequence of Natural Circulation of Liquids



# Other Considerations

- **Each fin is a separate cooling system**
  - Redundancy
  - Liquid boil off (automobile type radiator cap) provides cooling under fire conditions
  - Infrared camera for inspections
- **Cooling water contains antifreeze and corrosion inhibitors**

# Conclusions

- **Strong incentives to move short-cooled SNF to dry cask storage**
- **Decay heat from short-cooled SNF limits the capacity of large SNF casks**
- **Liquid-cooled fins provide superior performance compared to solid fins**
- **Base technology used for electrical equipment**
- **New application of an old technology**