United States Nuclear Regulatory Commission

NRC Perspectives on Spent Fuel Storage

Presented To
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Radioactive Waste Management

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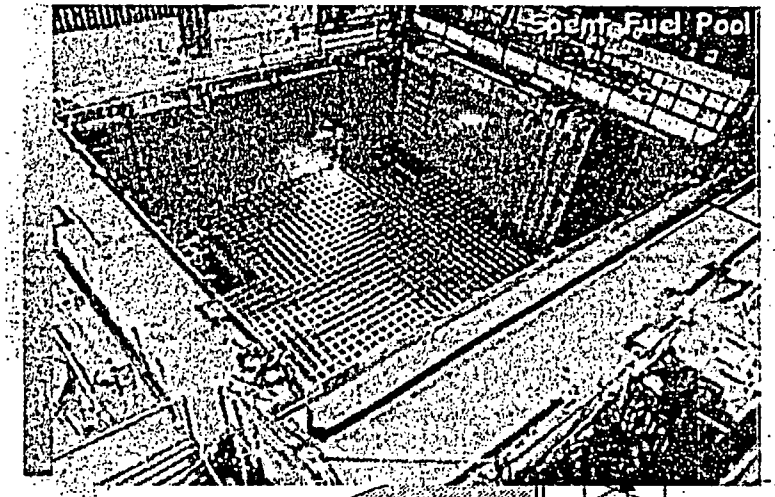
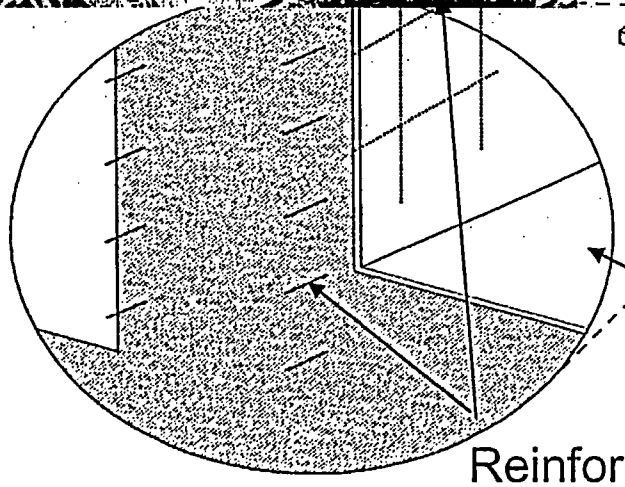
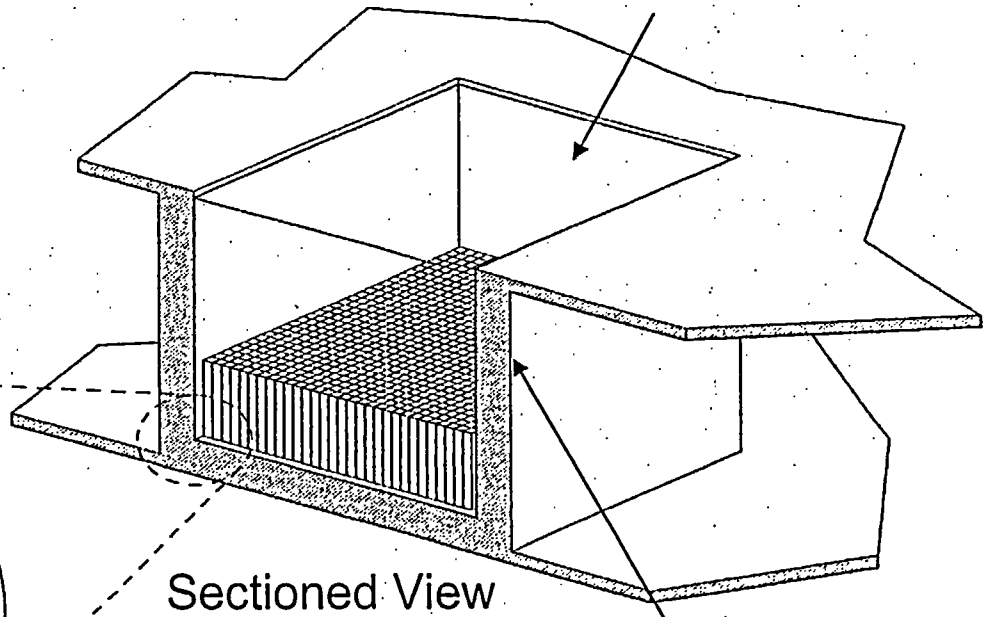
Spent Fuel Is Safe Under Either Wet or Dry Storage

- Robust Structures Constructed of Very Thick Concrete Walls With Stainless Steel Liner (Spent Fuel Pool)
- Many of The Spent Fuel Pools Located Below Grade or Shielded By Other Structures
  - Would Obstruct An Aircraft's or Other Vehicle's Impact
- Spent Fuel Pools Have Low Heat Content
- Additional Security Measures Implemented Since 9/11/2001
- Notwithstanding The Above, Insight From New Analyses Show That Radioactive Release Would Be Much Smaller And Would Begin Later Than Previously Estimated Resulting in Reduced Health Effects and Land Contamination
- Strategies For Loading Spent Fuel In Pools Can Substantially Reduce Cooling Time of Freshly Discharged Fuel

Spent Fuel Pools Are Robust Structures







Spent Fuel Pool

Water level

Sectioned View

5-6 ft thick concrete walls

1/4 inch-thick steel liner

Reinforcement

Physical Location Of Fuel In Pools Make Them Highly Resistant to Terrorist Attack

- Design of Pools With Fuel Located Below Grade or Shielded By Other Structures
  - Make Them Highly Resistant to Damage
- New NRC Enhanced Physical Security Measures to Defend Against and Mitigate Other Threats

Spent Fuel Pools Have Low Heat Content And Are Easily Cooled

- The Fuel in the Spent Fuel Pool Generates Small Fraction of the Heat in the Reactor
  - Fuel in Spent Fuel Pool Which Is Relatively Full (e.g., Containing 4 Reactor Cores) Generates Heat at a Rate Which Is 10 to 40 Times Lower Than That of Fuel in Reactor When Reactor Is Shutdown
  - Lower Heat Generating Capacity of Spent Fuel Means Heat Removal Is Simple, Even Under Adverse Conditions
- Most of the Heat Generated by Fuel in the Spent Fuel Pool
  - Comes From the Fuel Most Recently Offloaded From the Reactor
  - Not From the Old Fuel Which May Be Loaded in Casks

How About NUREG-1738, SNL And BNL Studies?

- Previous NRC Studies Were Based on More Conservative Assumptions And Analytical Models Than Current Analysis,
  - Limited to "Early Phase" Heat-Up Calculations
    - → Bounding Pool Configurations
  - No Integrated Severe Accident Analysis
  - Potential For Zirc Fire Using "Ignition Temperature" Criteria
  - Up to 100% of The Cesium Was Released to The Atmosphere
  - No Credit For The Likely Intervention By Operators To Prevent Uncovering The Fuel; Although a Very Long Time Is Available for a Loss of Cooling Event
- These Assumptions Are Neither Realistic Nor Appropriate For Assessment of Security Issues Where Realism Is Needed

New Analysis

- Current Analyses Are Using More Sophisticated Models And Techniques (MELCOR Severe Accident Code + Detailed Computational Fluid Dynamics--Thermal Hydraulic Calculation)
- MELCOR Has Mechanistic Melt Progression Models
  - Damage Propagation
  - Oxidant Depletion
  - Fission Product Release And Transport
  - Heat Transfer
  - Flow Mixing
- Building Upon Results of More Than Twenty Years of Research And Experience
  - Thermal Hydraulics
  - Severe Accidents
  - Probabilistic Risk Assessments

Insights From New Analysis
Reduced Health Effects and Land Contamination

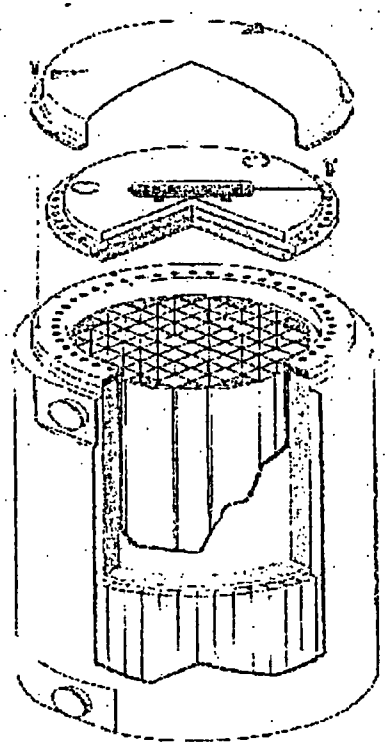
- Vulnerability Assessment to Date Indicates That Pools are Robust and Well Protected
- Nevertheless, We Performed Spent Fuel Pool Transient Analyses
  - Based on Actual Pool Conditions, Fuel Inventory and Loading Pattern
- Analyses Indicate That:
  - Fuel in the Spent Fuel Pool Is More Easily Cooled Than Predicted in Earlier Conservative Studies
  - Even If Cooling Is Lost More Time Is Available to Restore Cooling and Prevent Fuel Damage
  - Even If Fuel Is Damaged Consequences Will Be Less Severe Than Calculated in Past Studies
    - → Previous Estimate of Fission Products Released Are Likely Conservative By At Least An Order of Magnitude

Dry Cask Storage Experience

- First Cask Placed in Service July 1986
- 30 Operating Spent Fuel Storage Facilities
- No Spent Fuel Storage Cask Release or Safety Problems

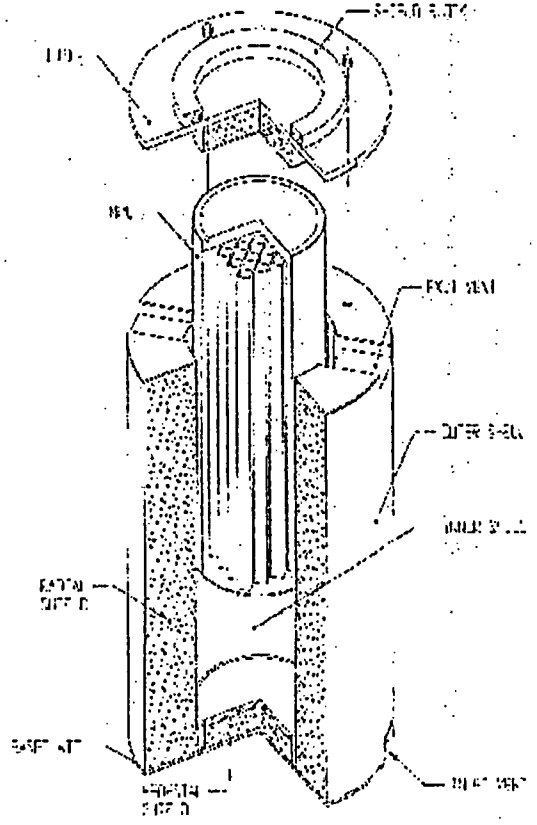
Example Storage Cask Diagrams

Bolted-Closure Design



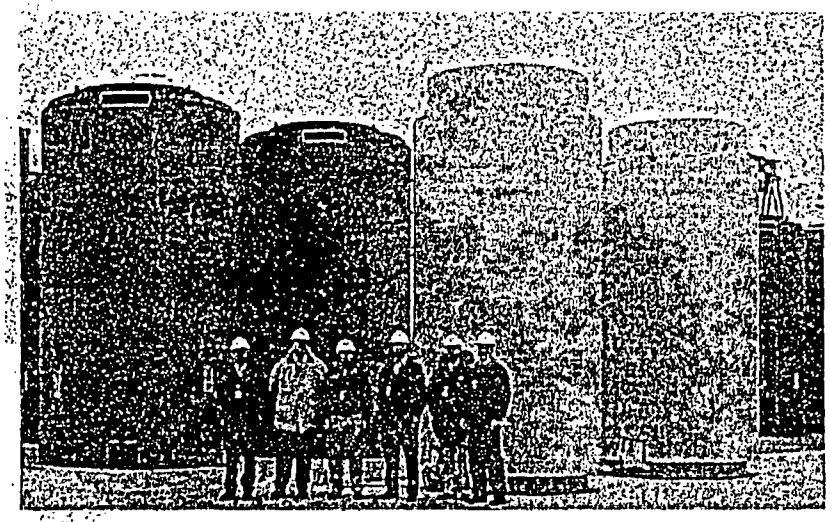
Transnuclear TN-68

Welded Closure Design



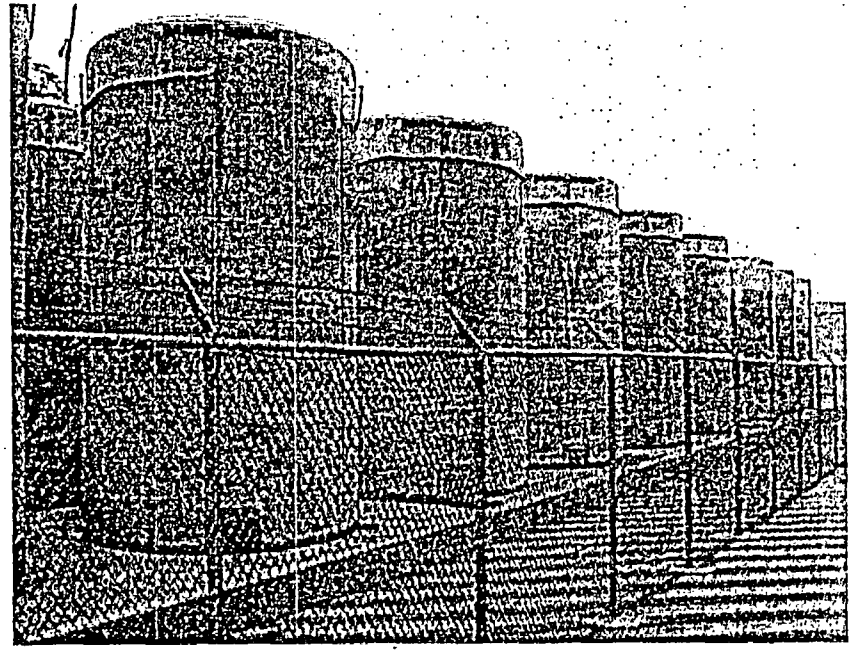
Holtec International HI-STORM 100

Storage Casks



Loaded Concrete–Steel casks (left)

Steel Casks (right)



Concrete Storage Casks

Spent Fuel Casks Are Robust Structures

- Structural Integrity to Confine Spent Nuclear Fuel Inside Cask
- Protection to Prevent Accidental Criticality
- Shielding to Minimize Radiation Dose
- Heat Dissipation to Minimize Fuel Temperatures
- NRC Has Implemented Enhanced Physical Security Measures to Defend Against and Mitigate New Threat Environment

Concluding Remarks

- Staff Concludes That Public Health and Safety Is Protected With Spent Fuel Stored in Pools or Dry Casks
  - Spent Fuel Pools Are Robust Structures
  - Further Protection Is Provided By
    - Surrounding Structures
    - Below Grade Fuel Location
  - Dry Casks Are Robust Structures
    - The Significant Amount of Physical Mass Used for Shielding and Confinement Inherently Provides Protection Against Significant Threats
- The Use of Previous NRC Studies Provides Overly Conservative And Misleading Results When Assessing Mitigative Strategies For Potential Spent Fuel Pool Vulnerabilities
- The Recommendation for An Accelerated Program of Complex and Costly Measures to Place All Spent Fuel (More Than Five Years Old) in Dry Casks Does Not Have a Sound Technical Basis

Concluding Remarks

- When Past Studies Are Taken Out of Original Context, Where Applied to Very Low Probability Events, the Predicted Behavior Including Consequences Are Not Appropriate
  - One Must Consider Both The Probability and Consequences
- There Are Other Measures, Other Than Removal of The Fuel And Lower Density Racking
  - Both The Federal Government And Utilities Are Addressing The Likelihood of Threats And Mitigation Strategies
    - → The Federal Government Has Taken Numerous Actions to Prevent Terrorist Use of Large Air Craft, Thereby Reducing the Likelihood of An Attack on All Critical Infrastructure from Such Threats
  - Measures Have Been Taken Since September 11, 2001, to Protect Nuclear Facilities, Including Spent Fuel Pools
    - → Enhanced Protection of Spent Fuel Pools to Address Land Attack