

Research Needs for Extended Storage of Used Nuclear Fuel: Container and Overpack

**Christine Stockman and David Enos
Sandia National Laboratories
Albuquerque, New Mexico**

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Introduction

- **Dry Storage of Used Nuclear Fuel is currently licensed for 20 years.**
- **Some 40 year extensions have been granted.**
- **Need to provide technical basis for extended storage.**



Focus for FY11

- **UO_x Light Water Reactor Fuels**
- **Impact of Normal and Off Normal Conditions**
- **Degradation that is influenced by extended storage times or higher burnup fuel**
- **Prioritization of New Research and Development**

Structures, Systems and Components (SSCs) of an Independent Spent Fuel Storage Installation (ISFSI)

- 1. UO_x Fuel**
- 2. Cladding**
- 3. Fuel Assembly Hardware**
- 4. Fuel Baskets**
- 5. Neutron Poisons**
- 6. Neutron Shields**
- 7. Container ***
- 8. Overpack or Storage Module ***
- 9. Pad**
- 10. Monitoring Systems**



Dry Cask Storage Systems:

Two Types:

- *Bolted, Direct Load Metal Casks*
 - Typically thick walled carbon or low alloy steel containers
 - Can be transportable if basket has neutron poisons

- *Welded Canisters with Overpacks*
 - More recent designs
 - Typically a stainless steel container within a reinforced concrete storage overpack
 - Can be transportable with another overpack if basket has neutron poisons



Dry Cask Storage Systems: Bolted Metal Casks

Common Features

- Multi layered Casks with Integral:
 - Fuel Baskets
 - **Optional Neutron Poisons**
 - Confinement Container
 - Metal Overpack
 - **Neutron Shields**
- Separate Cover for Seals and Bolts

170 in Use in 2011*

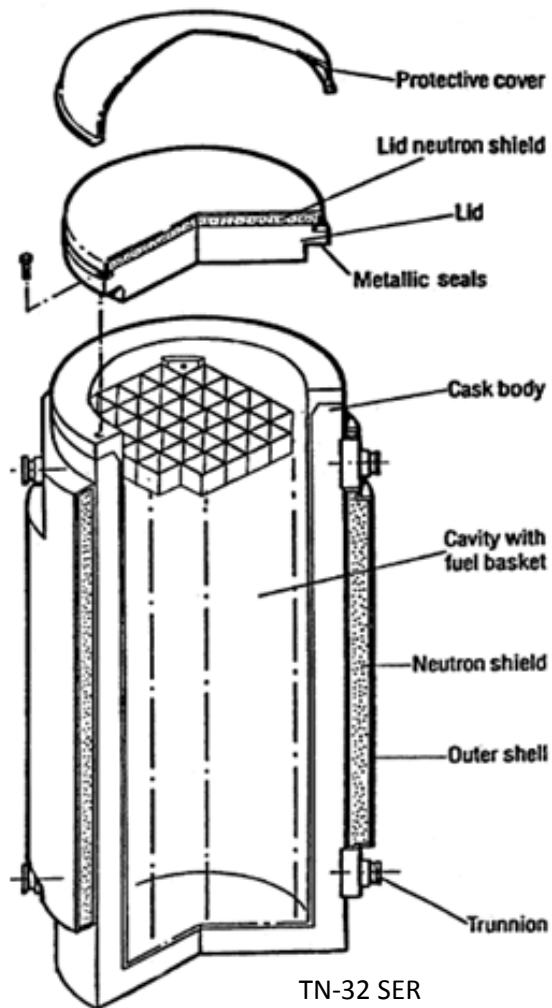
- 1 MC-10
- 2 NAC I28
- 26 Castor V21, X33
- **141** TN 32, **40**, **68**

* StoreFUEL March 2011

Red = recent

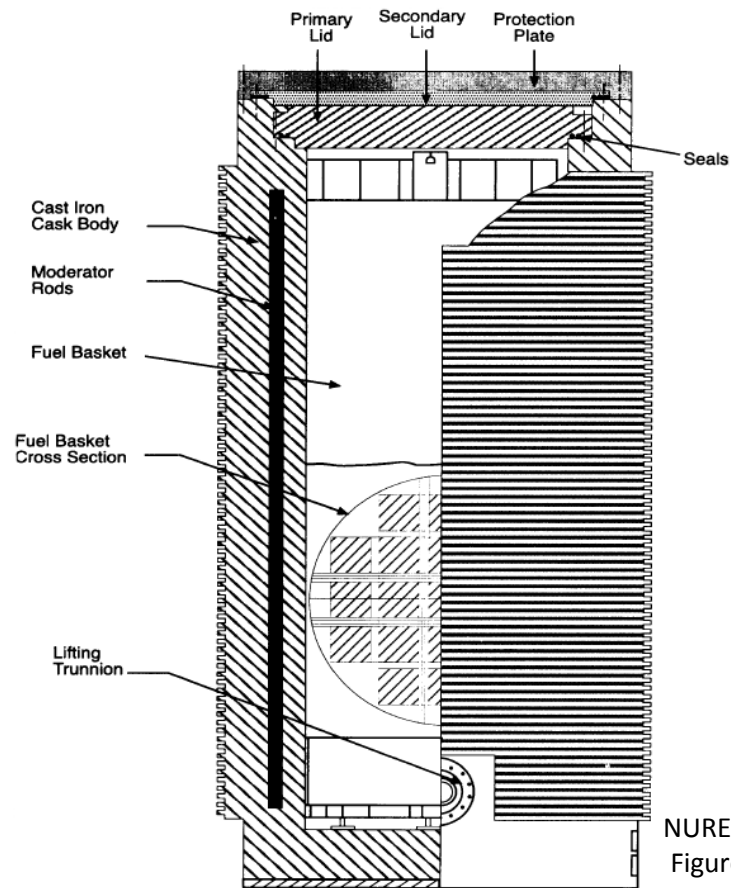
Dry Cask Storage Systems: Bolted Metal Casks

Transnuclear TN-32



TN-32 SER

Castor V/21



NUREG-1571
Figure 3.1-1

Dry Cask Storage Systems: Welded Metal Canisters with Overpacks

Common Features

- Multipurpose Canister with Integral:
 - Fuel baskets holding optional neutron poisons
 - Confinement Container
- Separate Transfer Cask and Overpack or Storage Module
 - Neutron Shielding

Red = recent

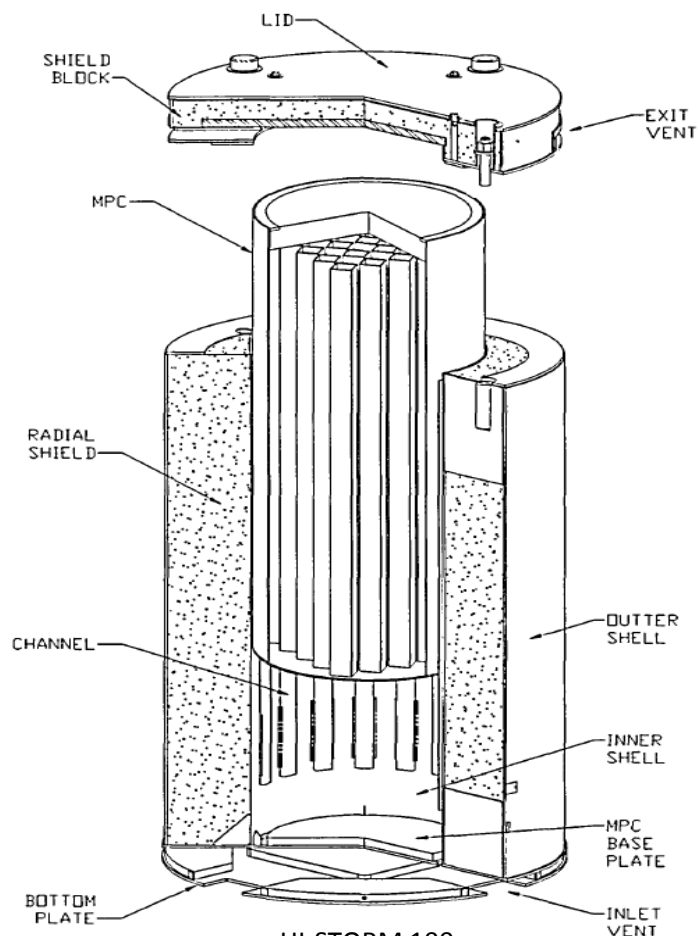
1234 in Use in 2011*

- 8 W150
- 12 HI-STAR
- 34 TranStor
- 58 VSC-24
- 246 NAC UMS-24,
MPC-26 and 36
- 347 HI-STORM
- 529 NUHOMS

* StoreFUEL March 2011

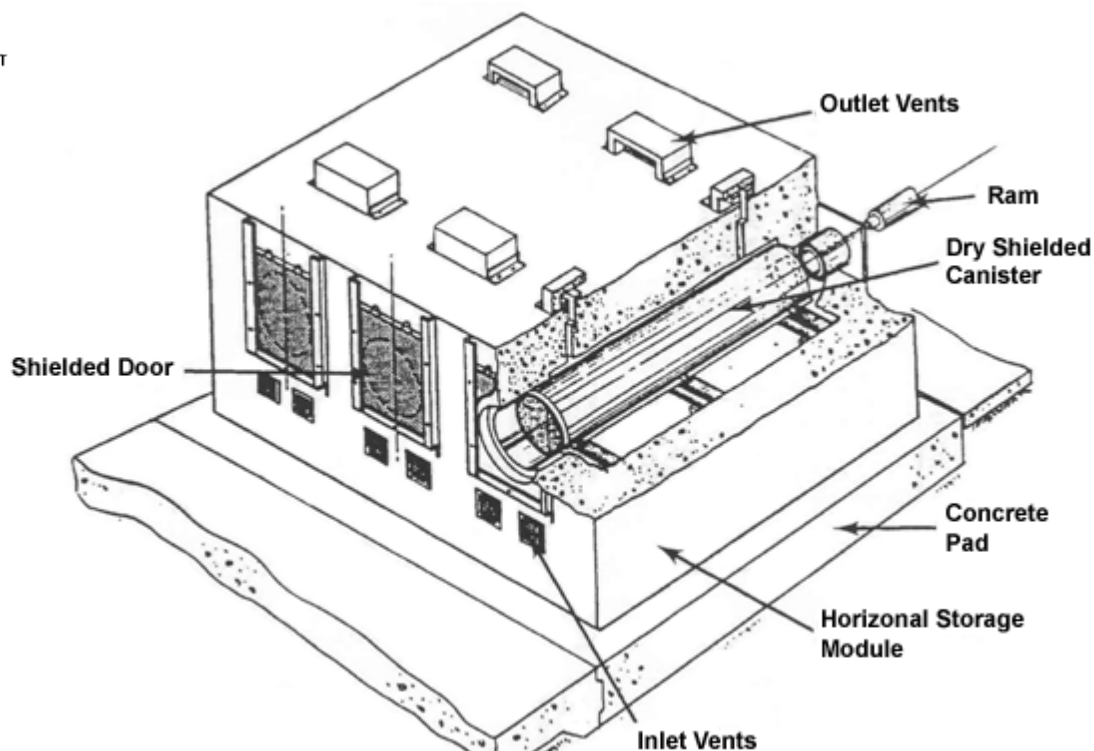
Dry Cask Storage Systems: Welded Metal Canisters with Overpacks

HI-STORM



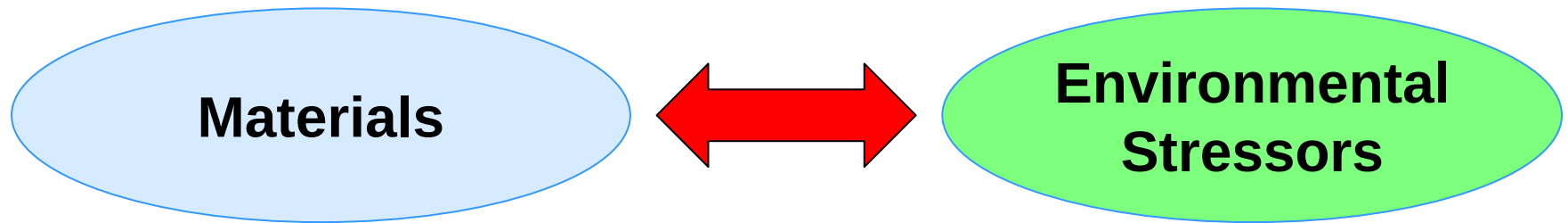
HI-STORM 100
FSAR Rev2.

NUHOMS



EPRI-NP-6941, PNL-7327

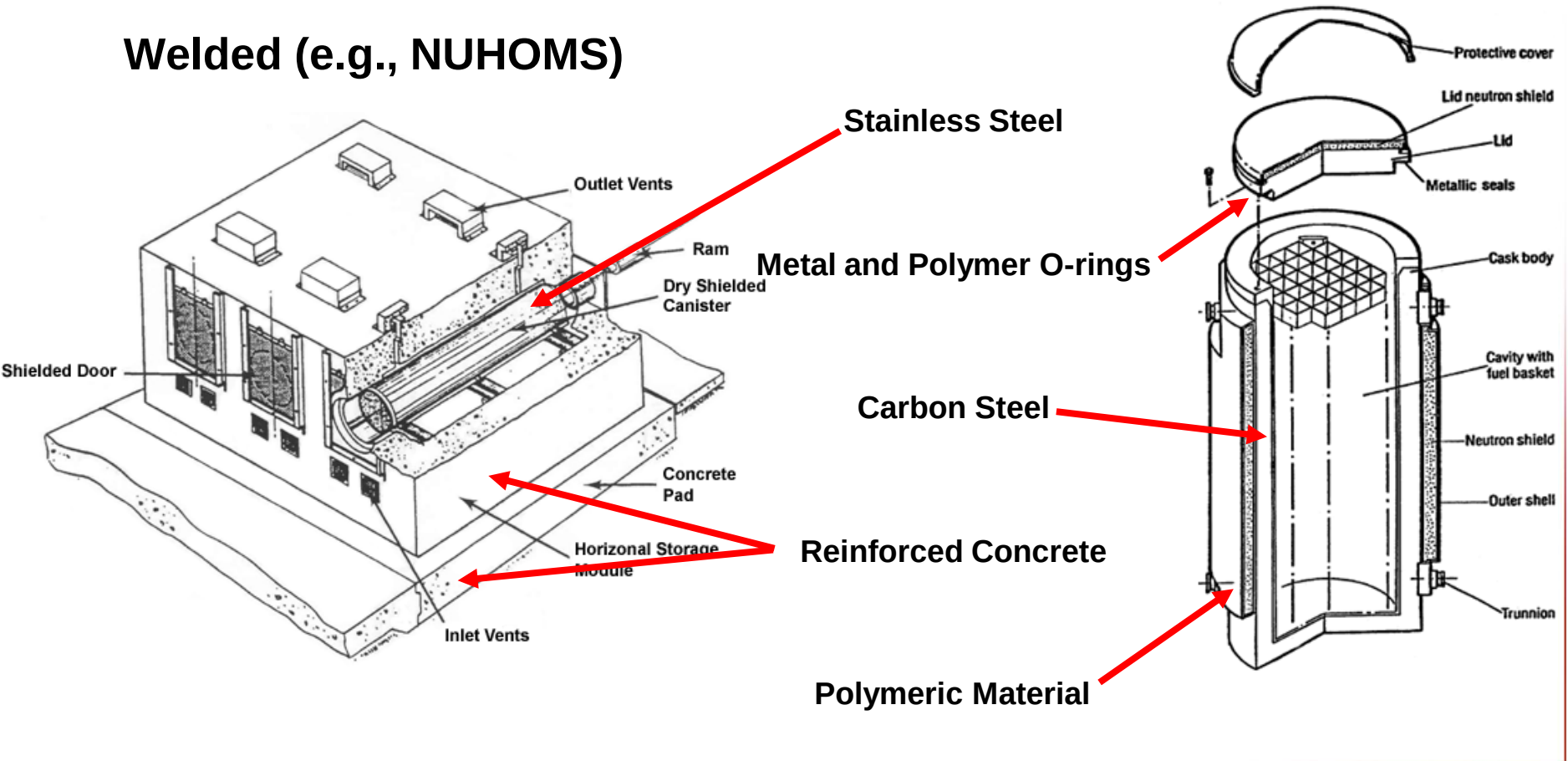
Degradation Mechanisms



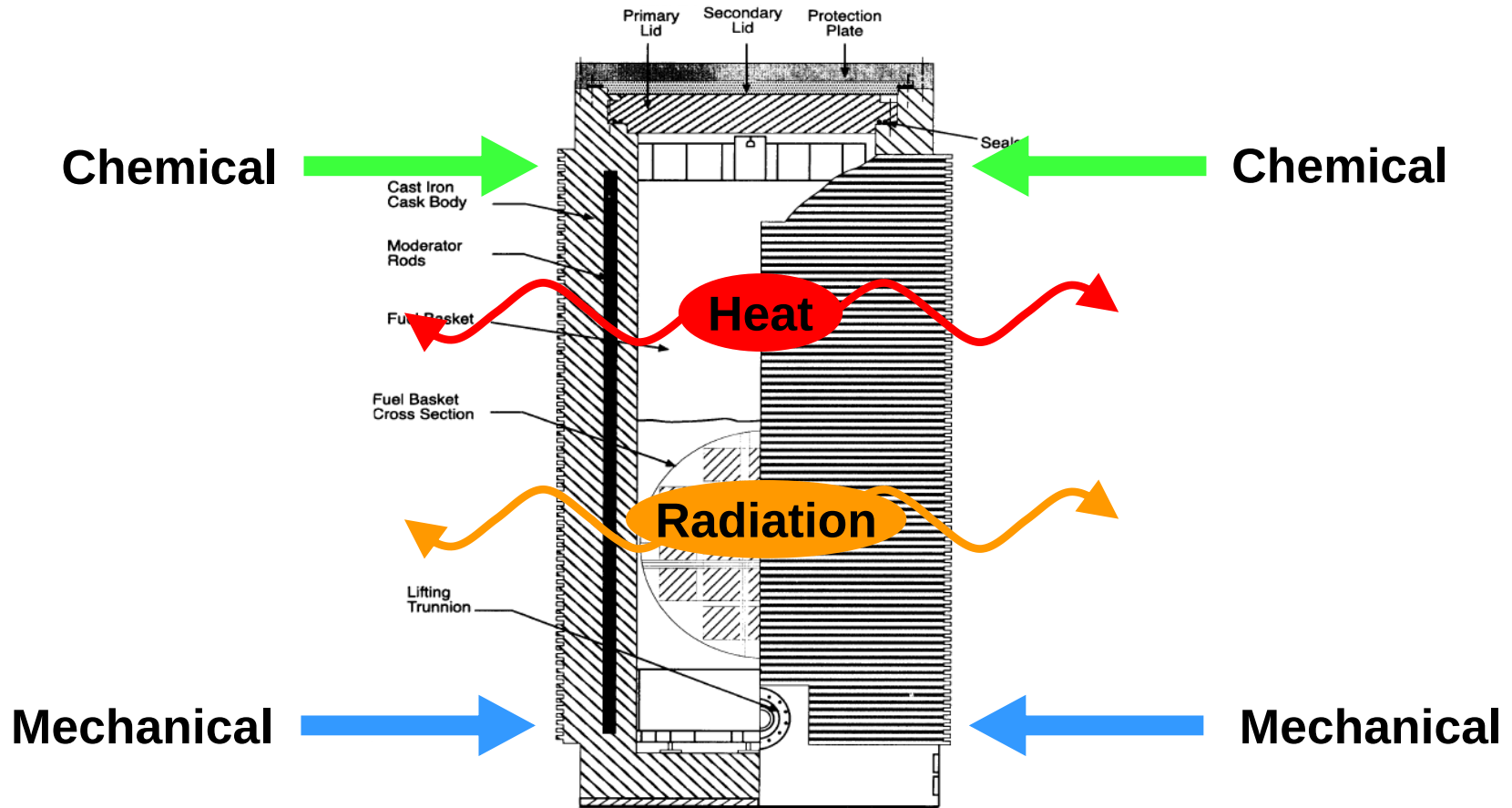
Typical Materials of Construction

Bolted (e.g., TN-32)

Welded (e.g., NUHOMS)



Environmental Stressors





Container and Overpack: Priority of New Research and Development

➤ Do we have sufficient data?

- Large amount of data on steels and concretes
- ISFSI Safety analysis Reports (SARs) discuss environment for 20 years
- Thermal history needed for long term storage

➤ Probability of degradation mechanism occurring?

- Depends on material and environment
- Probability of loss of safety functions is low in license period

➤ Consequence of degradation?

- Container breach – Release of Radionuclides
- Concrete degradation – Temporary loss of protection for container

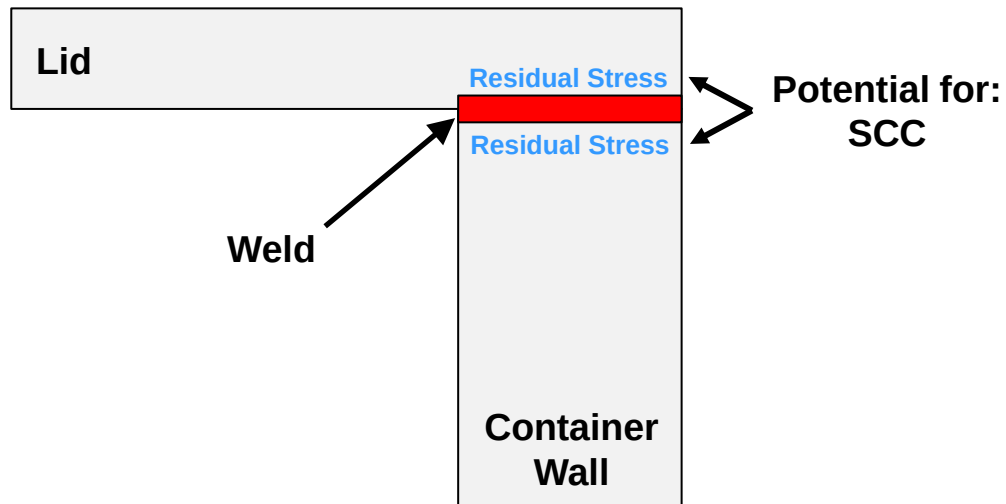
➤ Aging management program?

- Difficult for internal components such as seals, and canisters
- Easier for external components such as overpacks or storage modules

Degradation of Closures

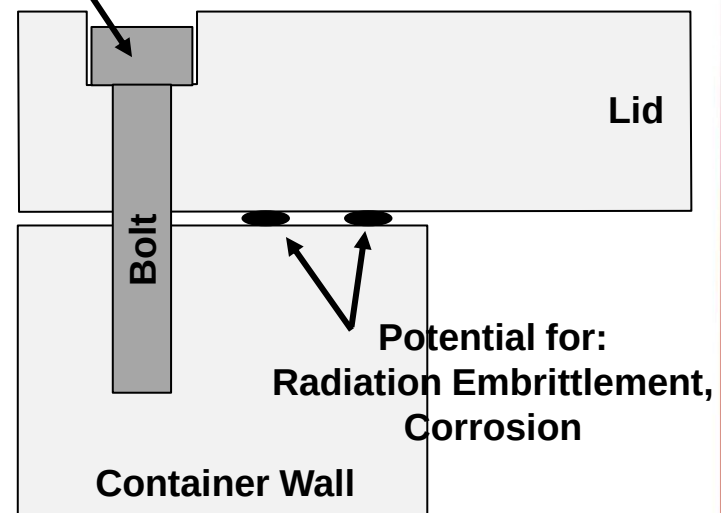
- Maintaining waste confinement is required
- The closure system is generally the weakest link
- Must protect from corrosive environment

Welded



Bolted

Potential for:
Stress Relaxation,
Corrosion





Corrosion of Closure Welds, Bolts, and Seals

➤ Atmospheric Corrosion

- High humidity plus aggressive contamination (gaseous or solid phase)
- SCC could initiate at closure welds and bolts since no stress mitigation is performed
- Due to potential impact of SCC, research priority is high

➤ Aqueous Corrosion

- Protective cover may leak
- Once fuel has cooled, condensation may form on container surface – this combined with aggressive contamination could potentially lead to corrosion initiation on container.
- Primarily an issue for non-stainless steel containers
- Due to potential impact of general corrosion on carbon steel container designs, research priority is high

Container Degradation Mechanisms

Base Metal, Welds, Bolts, and Seals

Stressor	Degradation Mechanism	Influenced by VLTS or Higher Burnup	Additional Data Needed	Priority of R&D
Thermal and Mechanical	Embrittlement of elastomer seals	Yes	Yes	Low
	Thermomechanical fatigue of seals and bolts	Yes	Yes	Medium
Radiation	Embrittlement of elastomer seals	Yes	Yes	Low
Chemical	Atmospheric Corrosion (Including Marine Environment)	Yes	Yes	High
	Aqueous Corrosion: general, localized (pitting, crevice), SCC, galvanic	Yes	Yes	High

Concrete Overpack Degradation Mechanisms

Stressor	Degradation Mechanism	Influenced by VLTS or Higher Burnup	Additional Data Needed	Priority of R&D
Thermal	Dry Out	Yes	Yes	Low
	Freeze Thaw	Yes	Yes	Low
Radiation	Aggregate Growth	Yes	Yes	Low
	Decomposition of Water	Yes	Yes	Low
Chemical	Calcium leaching	Yes	Yes	Low
	Chemical Attack	Yes	Yes	Low
	Chemical Reaction with Aggregate	Yes	Yes	Low
	Corrosion of Embedded Steel	Yes	Yes	Low
Mechanical	Creep	Yes	No	Low



Concluding Remarks

Defining New Research and Development

➤ Near Term Research

- Evaluation of long term environment for canisters
- Longer-term aging management programs

➤ Testing and Evaluation Facility (TEF)

- Monitor Container and Overpack for any form of degradation that may jeopardize their ability to perform their safety functions



BACKUP SLIDES



Container Degradation Mechanisms: Bolted Canisters

- **Thermal/mechanical, and radiation stressors may impact seal integrity**
- **Thermal and mechanical stressors**
 - Thermal exposure for extended periods of time may embrittle elastomeric seals
 - As these are secondary seals, research priority is low
 - Thermal cycling may result in fatigue of bolts used to secure lids
 - Due to potential impact to casks, research priority is medium
- **Radiation exposure**
 - Prolonged exposure to radiation fields may result in the embrittlement of elastomeric seals.
 - As these are always secondary seals, research priority is low



Degradation Mechanisms: Overpack

- **The integrity of the overpack does not directly impact containment, and degradation may be identified and repaired, priority of new research is low**
- **Thermal effects**
 - Exposure to temperatures above 150F results in dehydration of concrete, lowering strength
 - Freeze-Thaw exposure can result in a mechanical stress sufficient to crack concrete
- **Radiation effects**
 - Exposure to high levels of neutrons can result in aggregate growth, the decomposition of water within the pore structure of the concrete, and thermal warming of the concrete.
 - Reactions can result in a loss of strength of the concrete
- **Chemical effects**
 - Corrosion of the reinforcement can result in strength loss and cracking
 - Aggregate within the concrete can react with alkali species within the concrete (alkali-silica reaction, cement-aggregate reaction, alkali-carbonate reaction), potentially causing significant cracking/structural damage.
 - Calcium hydroxide may be leached from the concrete, reducing the pore water pH, and potentially causing corrosion of the reinforcing steel