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PANTEX PLANT | Y-12 NATIONAL SECURITY COMPLEX

Update on the use of Neutron Absorbers for Storage Applications at Y-12

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2018 Joining Forces to Advance Nuclear

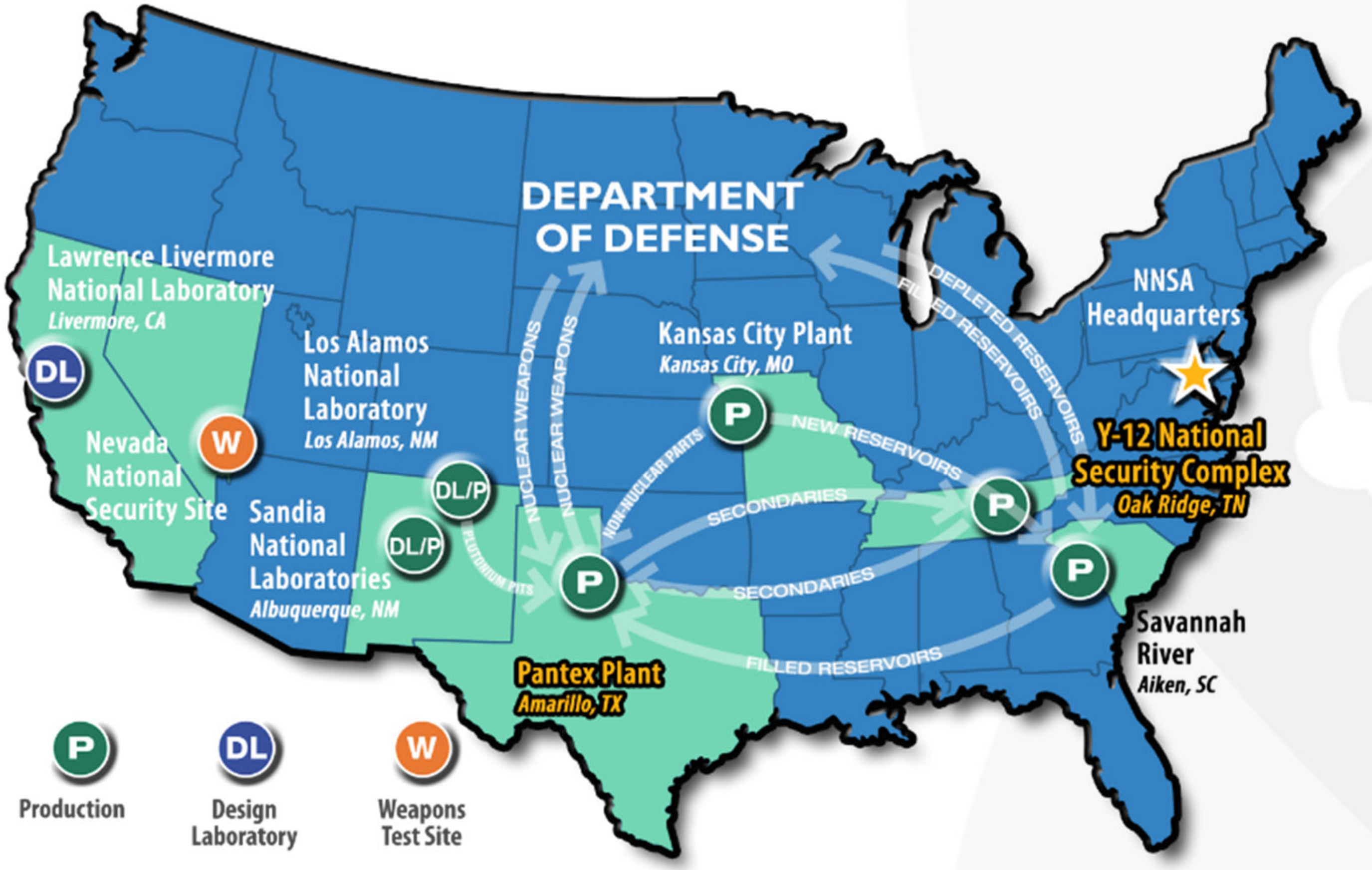
Outline

- Introduction to Y12 and its modern day storage mission
- Storage system used at Y12 and the RCSB
- Neutron absorber system characteristics
- Abnormal event testing and analysis
- Update on 10+ years of use
- Challenges encountered
- Future work

What is Y-12?

- WWII Manhattan Project site in Oak Ridge, TN.
- Original mission to enrich uranium for the first atomic weapon
- Later mission to perform lithium separation and provide key components for the thermonuclear weapons that helped end the Cold War.
- Ongoing mission to receive the uranium-based secondaries, which are then disassembled, refurbished and reassembled.
- Y12 has many legacy facilities and is undergoing a decades long transformation effort to consolidate capabilities into new facilities, and also responsibly maintain current facilities.

What is Y-12?



DEPARTMENT OF DEFENSE
Lawrence Livermore National Laboratory
Livermore, CA
Nevada National Security Site
Los Alamos National Laboratory
Los Alamos, NM
Sandia National Laboratories
Albuquerque, NM
Kansas City Plant
Kansas City, MO
NNSA Headquarters
Y-12 National Security Complex
Oak Ridge, TN
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Amarillo, TX
Savannah River
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NUCLEAR WEAPONS
NUCLEAR WEAPONS
NON-NUCLEAR PARTS
PLUTONIUM PITS
NEW RESERVOIRS
SECONDARIES
SECONDARIES
FILLED RESERVOIRS
DEPLETED RESERVOIRS
FILLED RESERVOIRS
DL
W
DL/P
DL/P
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P
Production
DL
Design Laboratory
W
Weapons Test Site

Pantex

- Weapons assembly and disassembly
- Life Extension Programs and surveillance for active weapons
- Plutonium pit surveillance
- High explosives components

Y-12

- Disassembly, refurbishment, and reassembly of canned subassemblies
- Safe, secure uranium storage
- Highly enriched uranium fuel for the United States Navy
- Specialized response training and material recovery to support nonproliferation

What is Y-12?

- Highly Enrich Uranium Materials Facility (HEUMF)
  - Secure, efficient storage of weapons-grade uranium
  - Larger than a football field – construction 2008, operational in 2010

- Uranium Processing Facility (UPF)
  - Under construction, operational in 2025
  - Sustains long-term uranium capabilities

ANSI/ANS-8.21 Overview

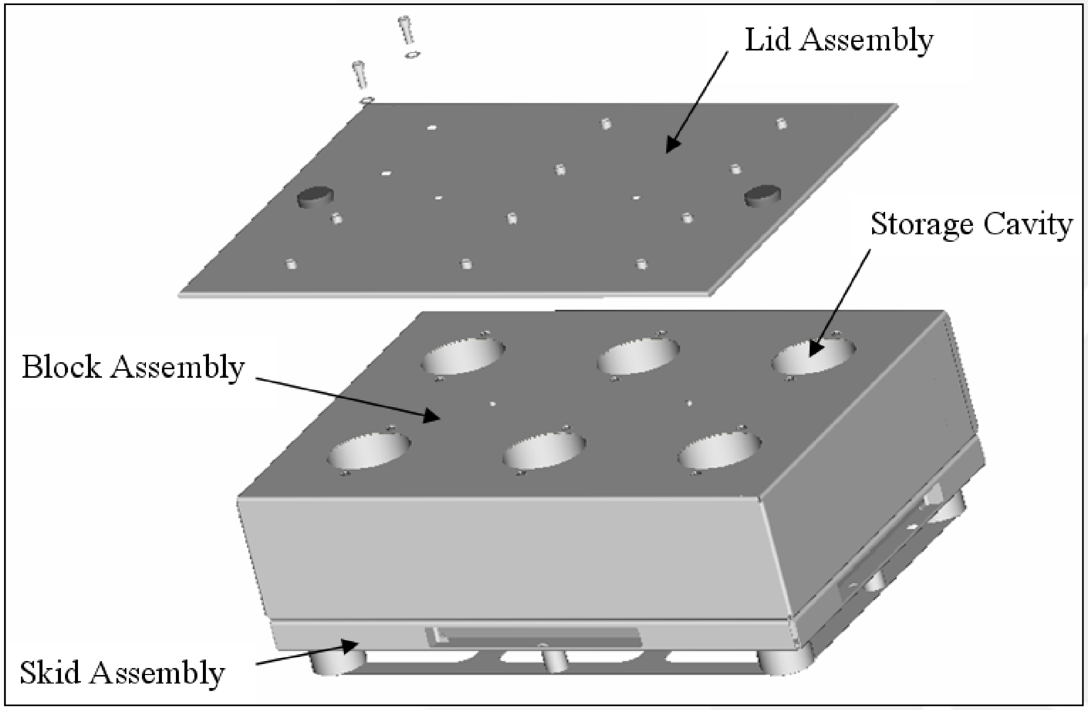
- ANSI/ANS-8.21 provides detailed Requirements and Guidance covering important aspects of neutron absorber reliability including:
  - Maintained presence and functionality of neutron absorber system
  - Material accessibility consideration
  - Impact of credible events such as fire, temperature variations, vibrations, mechanical impacts, corrosion, inadvertent removal, depletion, and flooding
  - Validation and modeling techniques
  - Testing and verification methods

RCSB Development Timeline

- Conceptualized as early as 1999 to meet the nation's need to store large quantities of HEU—essentially a nearly infinite neutron system.
  - A.W. Krass, K.D. Lewis, J.J. Lichtenwalter, and D.A. Tollefson, **Comparison of Absorber Material for a Palletized Rack Storage System**, presented at the American Nuclear Society Winter Meeting, Reno, NV, November 11-15, 2001.
  - J.J. Lichtenwalter, D.A. Tollefson, L.E. Johnsen, A.W. Krass, and K.D. Lewis, **Palletized Rack Storage System Absorber Material Testing**, presented at the American Nuclear Society Winter Meeting, Reno, NV, November 11-15, 2001.
  - A.W. Krass, J.J. Lichtenwalter, D.A. Tollefson, and K.J. Carroll, **A Practical Application of a Fixed Neutron Poison for High Capacity HEU Storage**, presented at The American Nuclear Society Summer Meeting, Hollywood, Fl, June 9-13, 2002.
- Rackable Can Storage Box (RCSB) constructed and tested in 2001, and deployed as early as 2008.
- HEUMF complete and loaded with RCSBs in 2010.

RCSB Description

- 3’ x 4’ x 1’ block assembly on a 6” tall skid assembly
- Block has 567kg of solid ceramic material with 6 cavity positions, and 90 kg stainless steel body with 17 kg lid
- Skid is made of 72 kg stainless steel
- Positions are designed to receive one metal can each with up to 20kg loading
- Cans may have variable dimensions and must be loaded with material forms that are stable and suitable for long term storage



RCSB Description

RCSB Characteristics and Manufacture

- The solid ceramic material is a crystalline matrix of $MgKPO_4 \cdot 6H_20$ with distributions of:
  - $^{nat}B_4C$ to provide neutron absorption properties
  - Class F Fly-Ash added for set control and strength
- MgO (powder) + KH_2PO_4 (powder) + $5H_2O$ (liquid) $\rightarrow$ $MgKPO_4 \cdot 6H_2O$ (solid)
- The solution-slurry is poured into an inverted RCSB stainless steel body and allowed to harden
- The stoichiometric amount of H_2O necessary for full water saturation is used in the mix – however, excess water that escapes after solidification has been observed

RCSB Characteristics and Manufacture

Constituent	Proportion (wt%)
Water in liquid phase (H_2O)	21.1
Monopotassium Phosphate (KH_2PO_4)	31.9
Boric Acid (H_3BO_3)	1.0
Magnesium Oxide (MgO)	10.4
Fly Ash	31.1
Boron Carbide (B_4C)	4.5
Total	100.0

RCSB Characteristics and Manufacture

RCSB Characteristics and Manufacture

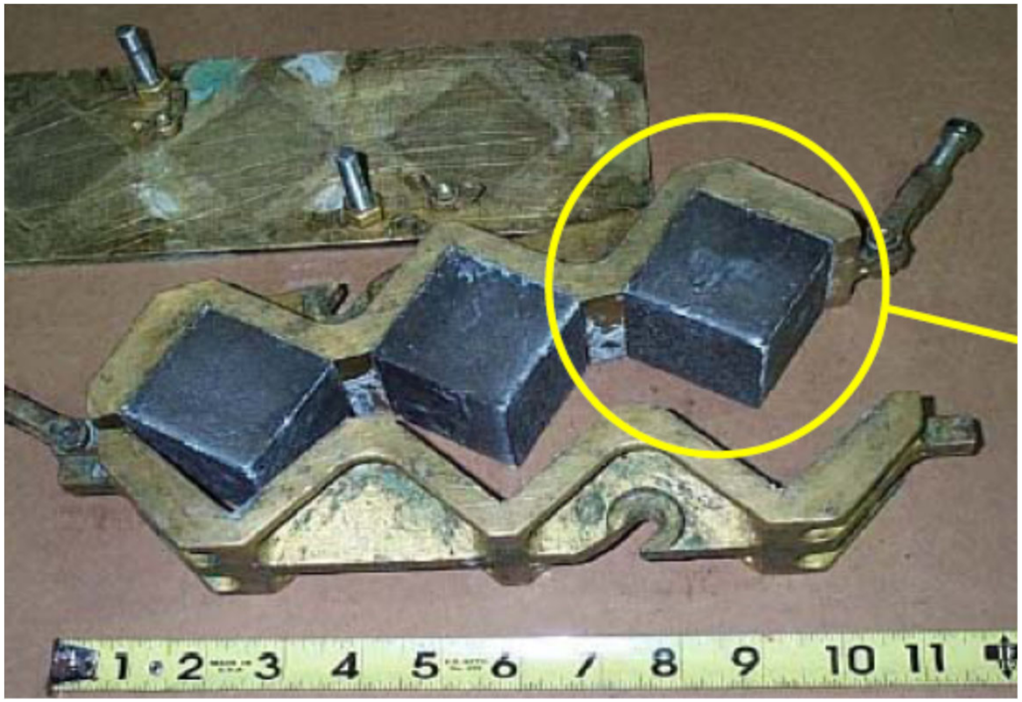
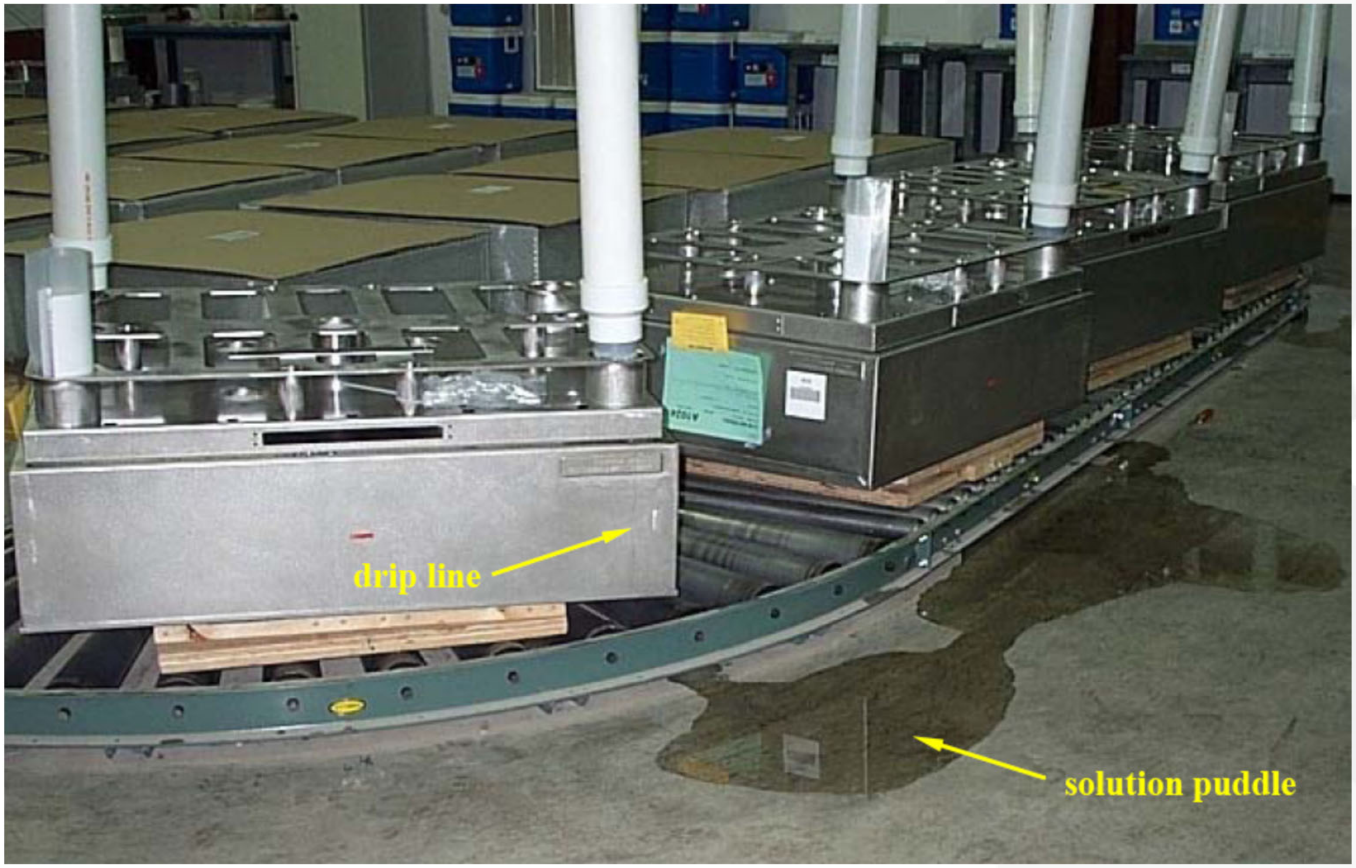


Photo curtesy of Ceradyne, Inc.

RCSB Characteristics and Manufacture

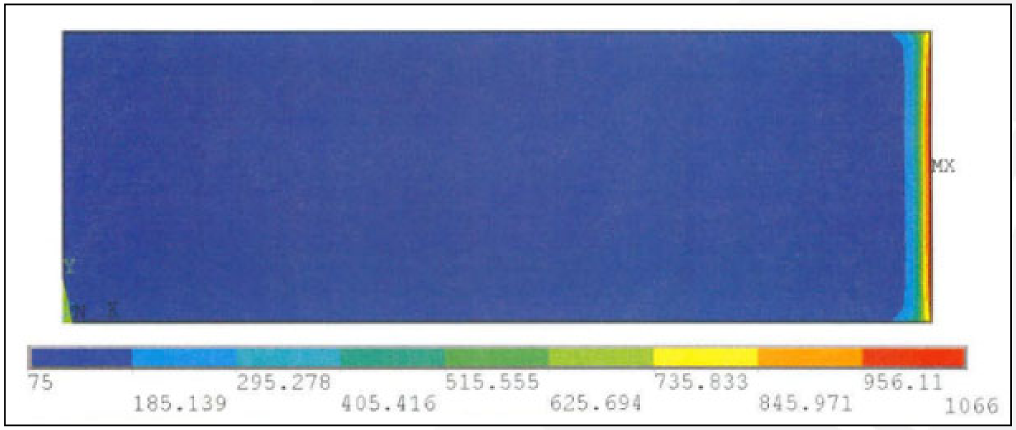
- Samples are generated from the same batch of solution slurry and undergo testing
  - Density
  - Compression
  - Neutron absorption
- The boron additives with chemically bound water in solid ceramic material provide a robust fixed medium that can be credited for its neutron absorbing properties
- Loss of water is a concern
  - Yearly surveillance performed to ensure no more than 50lb gross weight loss
  - No significant water loss has been measured

RCSB Characteristics and Manufacture

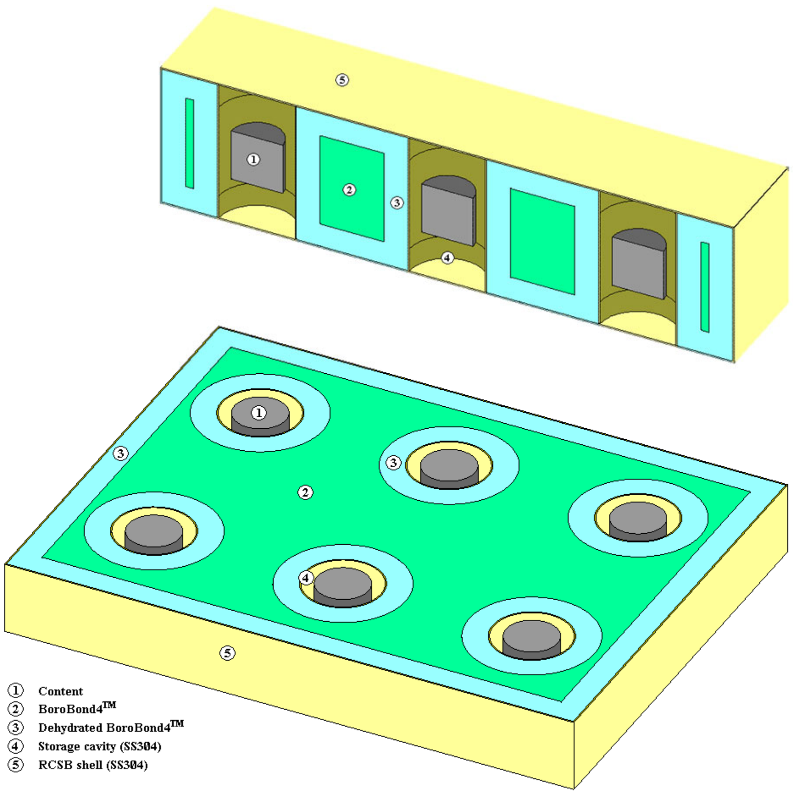


Fire Scenario involving RCSBs

- Thermal analysis of RCSB using two dimensional finite element model
- Design basis fire at HEUMF
  - 47 min, max temp of 1491ºF
- Examine temperature penetration profile
- Results show that at deeper than 2 inches, temperatures remain below 212ºF



Fire Scenario involving RCSBs

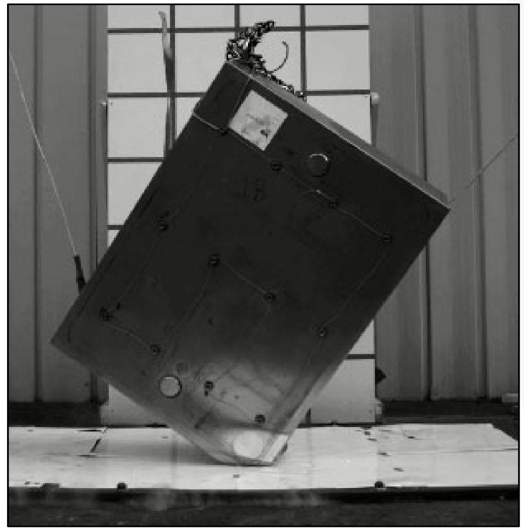


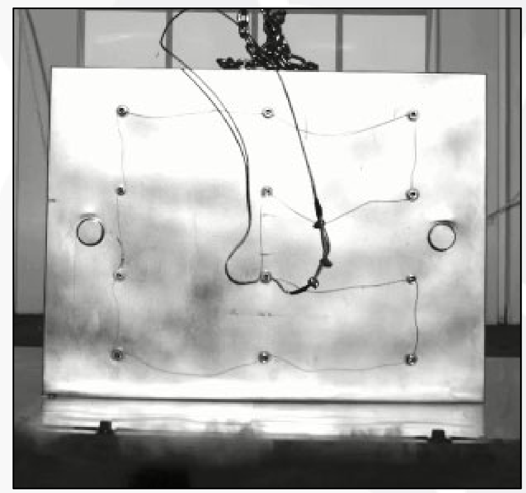
- NCS models with up to 2" of "dehydrated" ceramic on sides and cavities

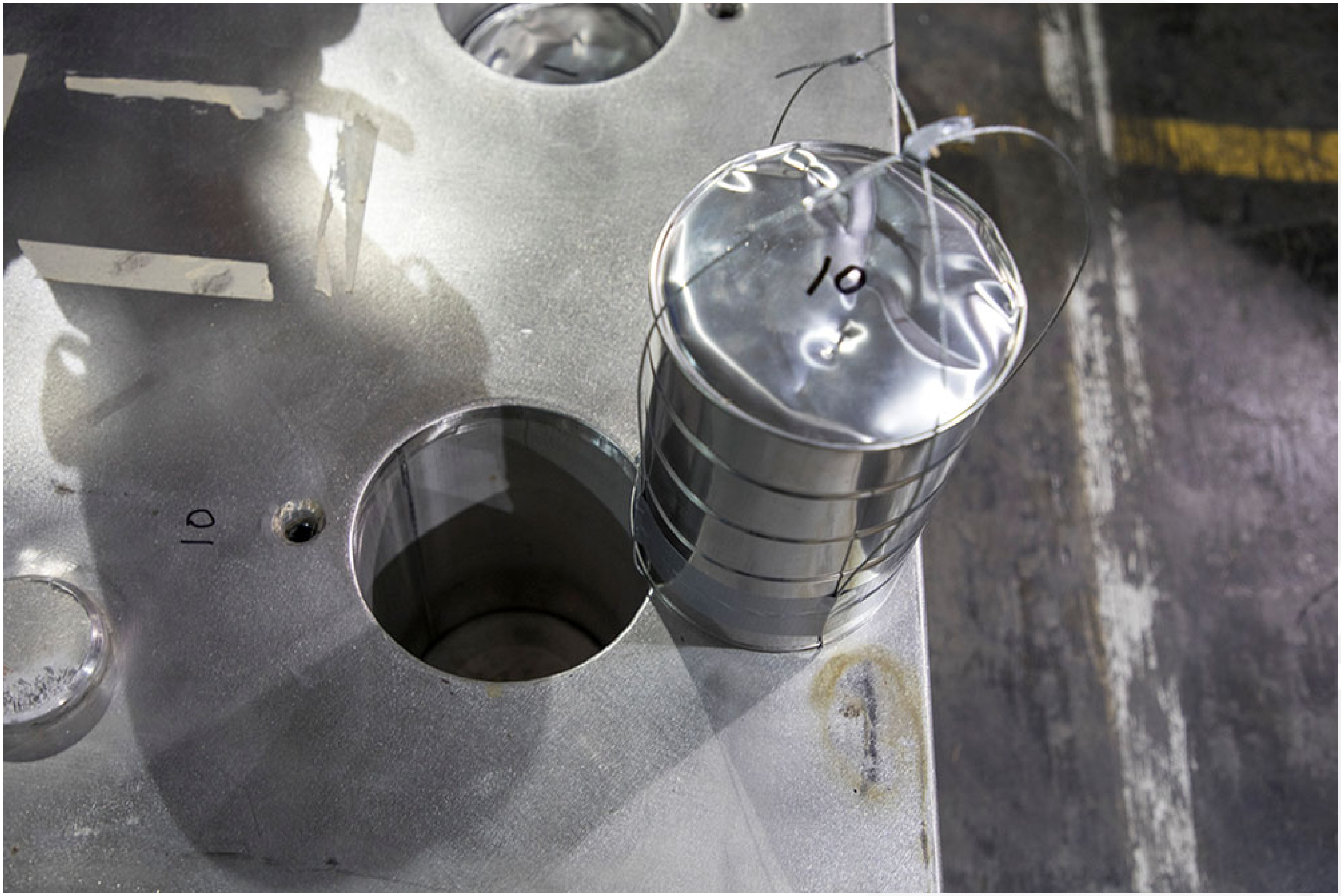
Description	Single Unit K_{eff}	Large Array K_{eff}
20 kg metal 0" dehydrated	0.80611	0.86382
20 kg metal 1" dehydrated	0.79689	0.86701
20 kg metal 2" dehydrated	0.79443	0.89262
20 kg metal full dehydrated	0.79893	1.09493

Vibrations and Mechanical Impacts

- Recent drop test of RCSBs pulled from the field completed, continues to perform well and retain its loading.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13

Update on 10+ Years of RCSBs

- The loaded RCSBs in place at HEUMF have rested in static storage for many years with very little excitement, successfully meeting the long term storage mission
- The use of RCSBs has changed substantially at Y-12 from the original storage of high-equity materials
  - Loading of cans into RCSBs directly at a processing facility
  - Transport of loaded RCSBs on the Special Nuclear Material Vehicles
  - Intermediate storage of empty and loaded RCSBs outside of the HEUMF
  - Receipt of material from other DOE sites, and even across the world, that is loaded into RCSBs
  - Storage of low equity Y-12 materials.

Challenges encountered

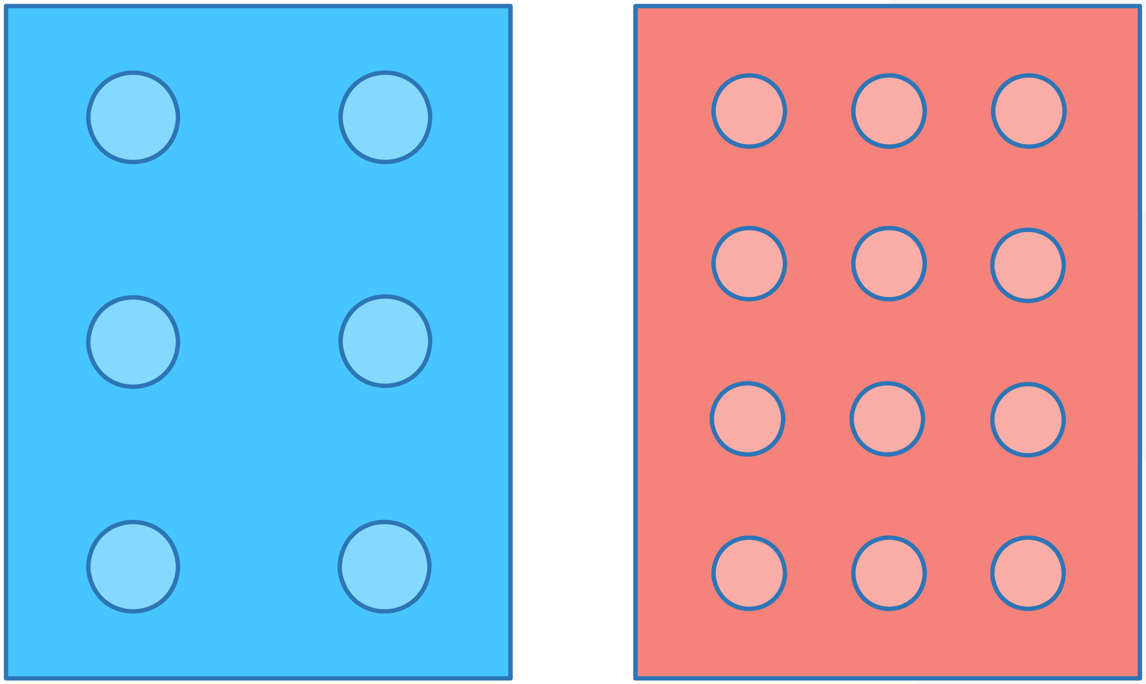
- The nature of verifying and qualifying each RCSB makes for a laborious quality assurance process, and procuring additional RCSBs takes substantial resources
- The direct-to-storage approach of many offsite shipment receipts has made for limited RCSB utilization
- Unreacted water from the solid ceramic material has been observed to have leaked from RCSBs over time
- Some fissile materials that have been loaded in RCSBs have raised concerns over certain material properties, like ignitability or expandability
- The ability of the RCSB to resist heat from reaching the cavities is largely unknown

Future work

- Further testing of the RCSB may be beneficial by demonstrating its performance in certain scenarios of interest.
  - Furnace Testing and/or additional thermal modeling
  - Additional Drop Testing
- Minor design changes may be beneficial to reduce the amount or impact of unreacted water or water loss
  - Use less water in the manufacturing process
  - Lids and bolts could be improved with seals to resist water entry from external sources
- A new design for larger loadings to support UPF missions

Future work

- A new design with more cavities, but a smaller diameter, that would allow for more cans that have lower fissile loadings



Questions?

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