NCS design and evaluation of new high-density storage containers

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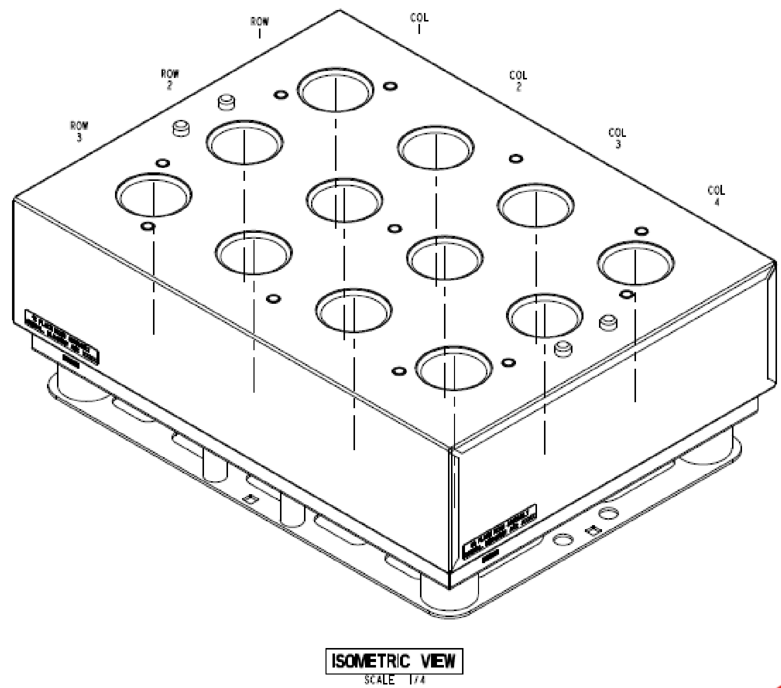
Presentation Summary

Overview of new container study

- Motivation for study
- Background – Existing RCSB Containers
- Changes in Mission
- NCS Evaluation of an Equivalent System
- Results
  - Varying Interstitial Water Density
  - Dehydrated BoroBond4™
- Conclusions and Future Work



Y-12 National Security Complex
Managed and Operated by Consolidated Nuclear Security, LLC

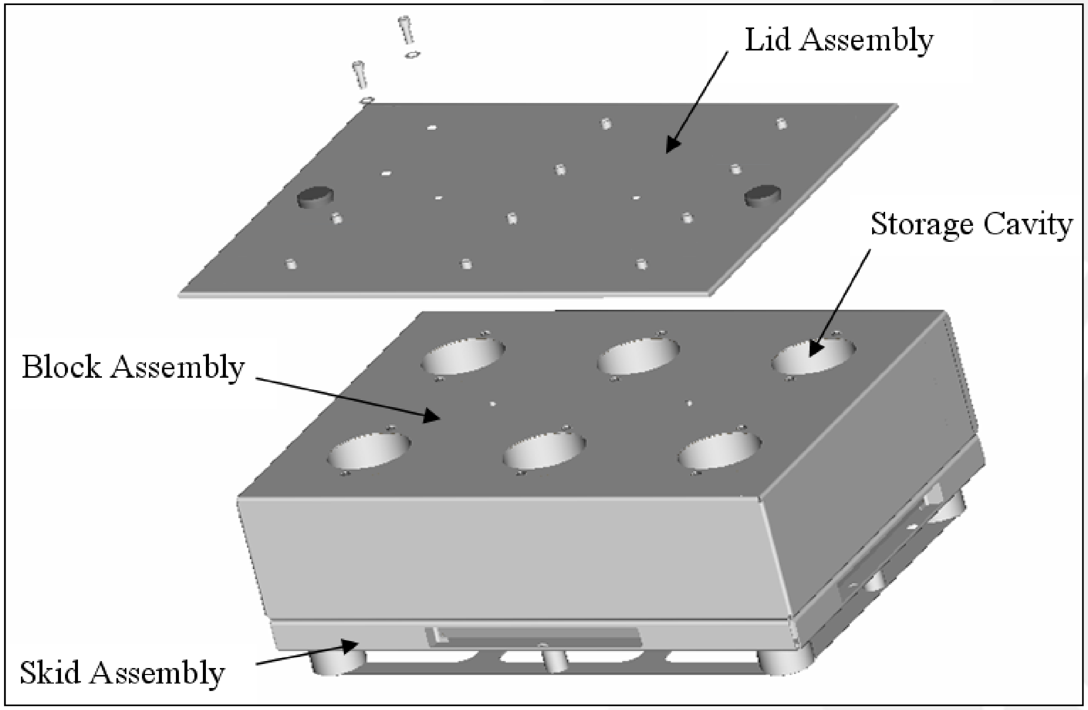
Motivation for Study

Highly Enriched Uranium Materials Facility (HEUMF)

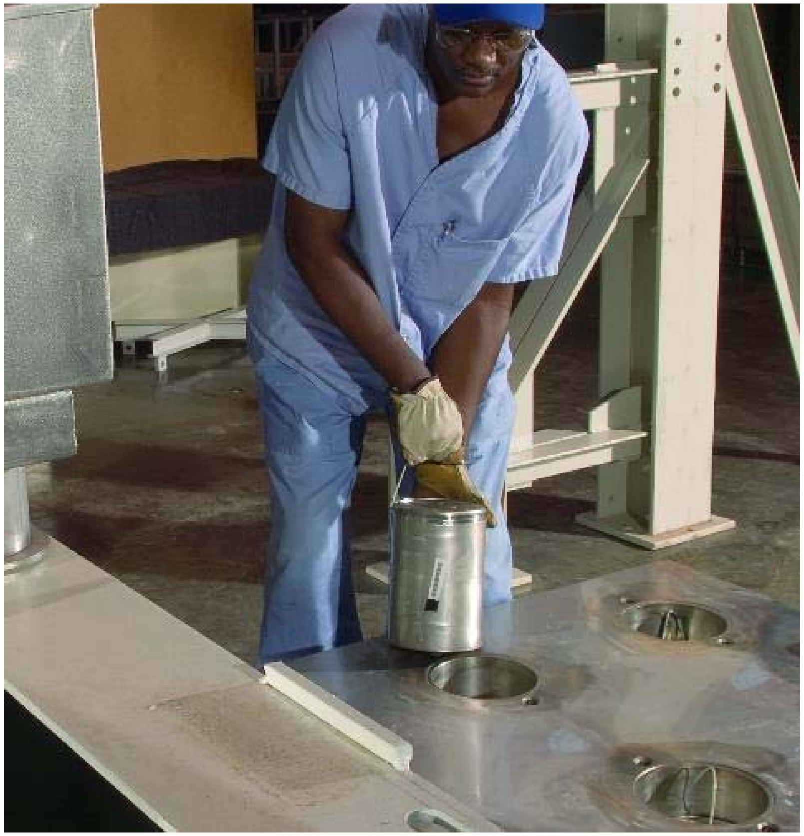
- Y-12 national repository for secure, efficient storage of highly enriched uranium
- Storage design – racks configured for both drums and Rackable Can Storage Boxes (RCSBs)
- Construction 2008, operational in 2010

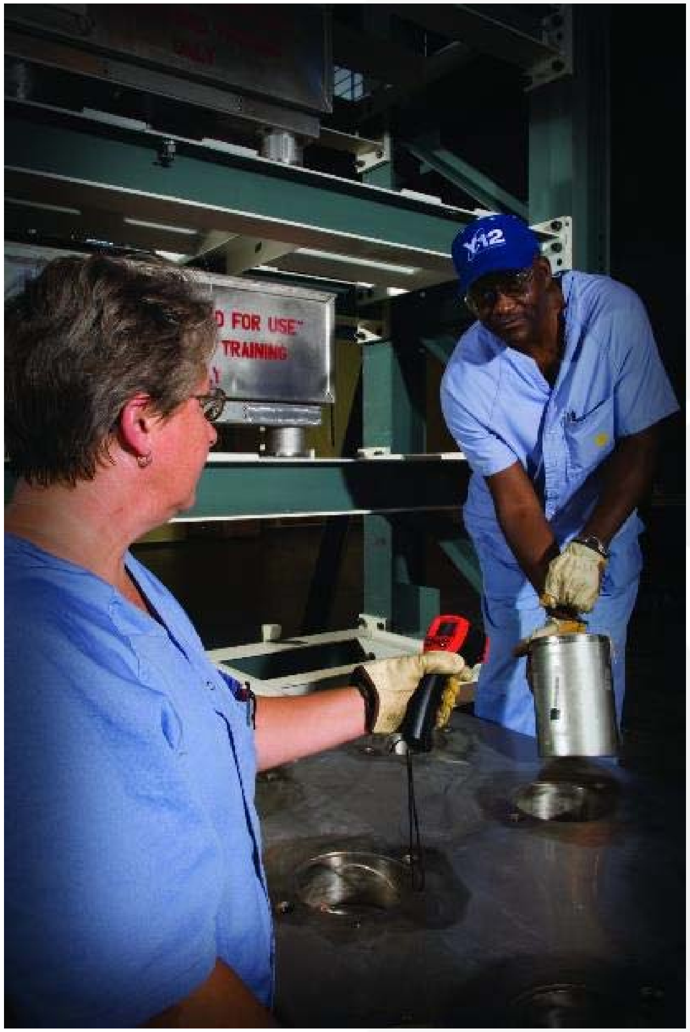
Background – Existing RCSB Containers

- 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



Background – Existing RCSB Containers





Changes in Mission

Storage utilization

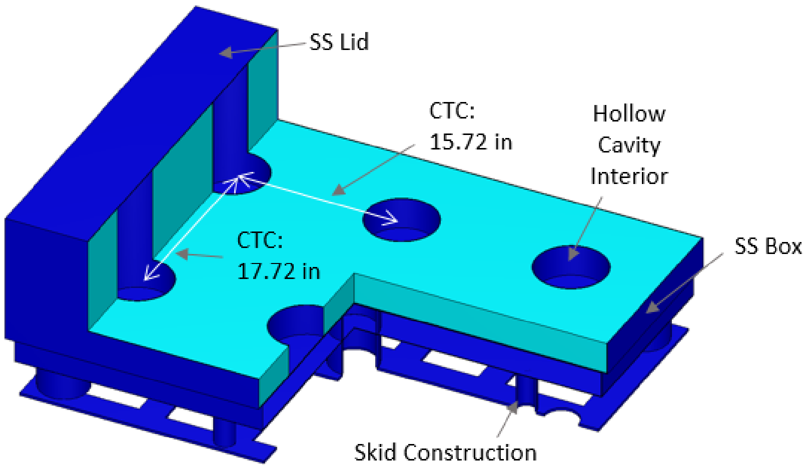
- Increased receipt of off-site shipments – facility designed for Y-12 materials
- Canisters from off-site shipments (< Ø 12.75 cm) typically received in ES-3100
- RCSB designed to receive large canisters (< Ø 15.70 cm)
  - Uranium metal or uranium oxide loadings up to 20kg
- Limited ability to consolidate material
- RCSB not used to full capacity

Proposal: design a neutronically and mechanically equivalent high density storage container capable of receiving lower masses in the same container footprint used by existing RCSBs

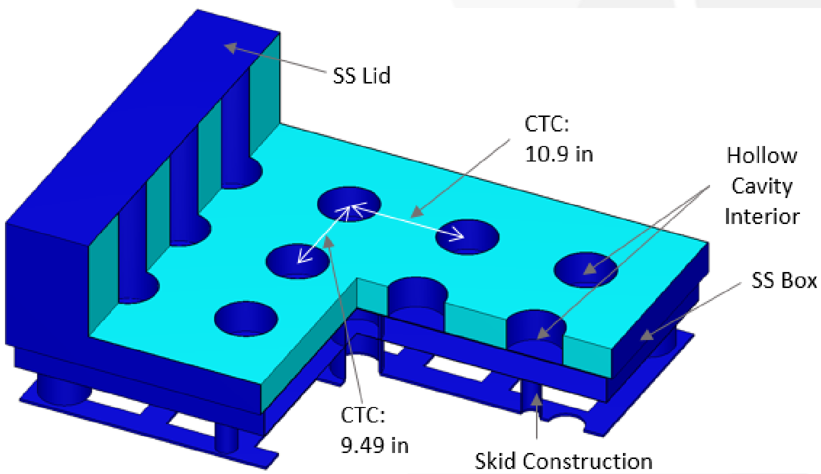
NCS Evaluation of an Equivalent System

Goal of study: provide proof of concept for test procurement

- SCALE 6.1.3 software perform KENO V.a Monte Carlo calculations
- Large array cases
- Worst case maximum 20kg loadings in RCSB compared to new maximum 10kg loading in new 12-Place design



Current RCSB model overview

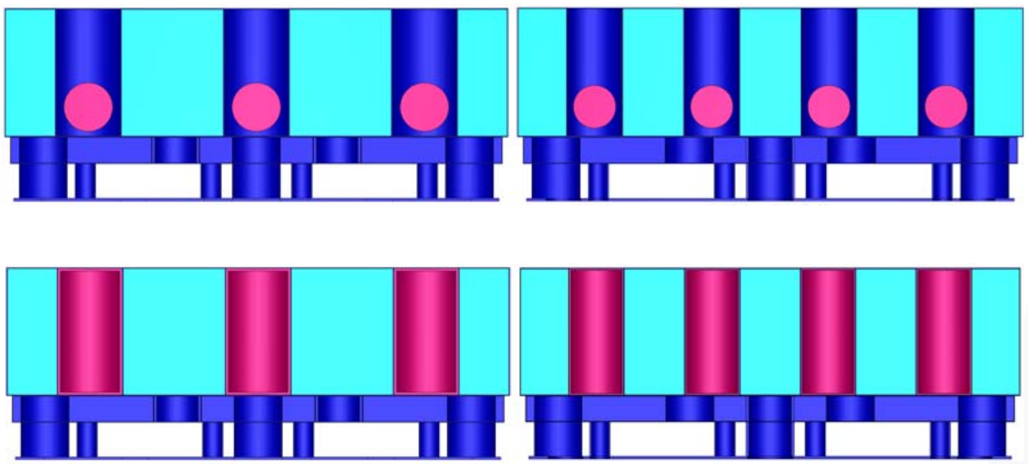


12-Place RCSB model overview

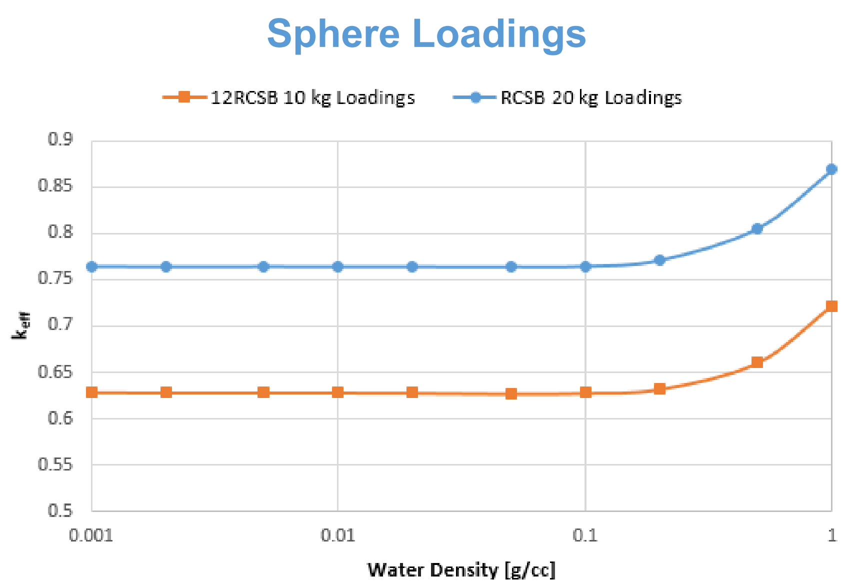
NCS Evaluation of an Equivalent System

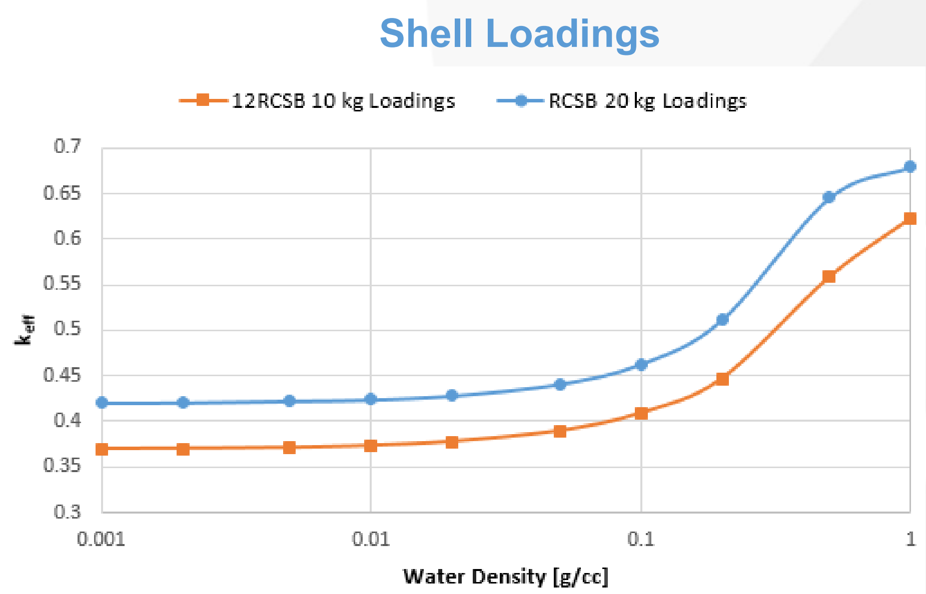
Studies use both sphere and shell models

- RCSB 3x2 cavity arrangement
- 12-Place RCSB 4x3 cavity arrangement
- BoroBond4™ (teal) fissile region (magenta).



Results – Varying Interstitial Water Density



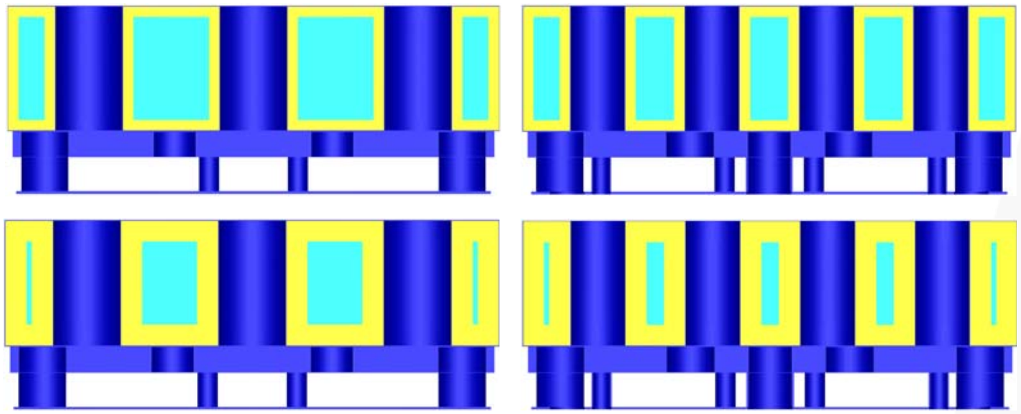


Anticipated behavior: – All cases in 12-place RCSB produce lower k_{eff}
- Reactivity increases at higher water densities

Results – Dehydrated BoroBond4™

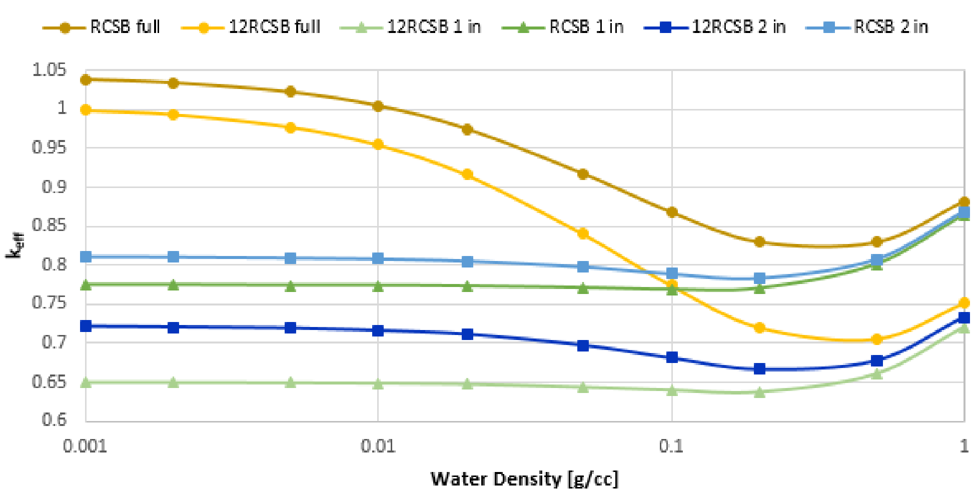
Fire scenario subject to extreme heat

- BoroBond4™ consists of ordinary Class F Fly-Ash and B_4C powder distributed throughout the solid crystalline matrix of MgKPO4·6H20.
- Dehydrated BoroBond4™ assumes no hydrogen and half the number of oxygen atoms are present
- Depths of 2.54 cm, 5.08 cm, and full dehydration
- Previous computational thermal analysis support potential for 5.08 cm of dehydration under design basis fire scenario (two powered industrial trucks collide in storage bay)

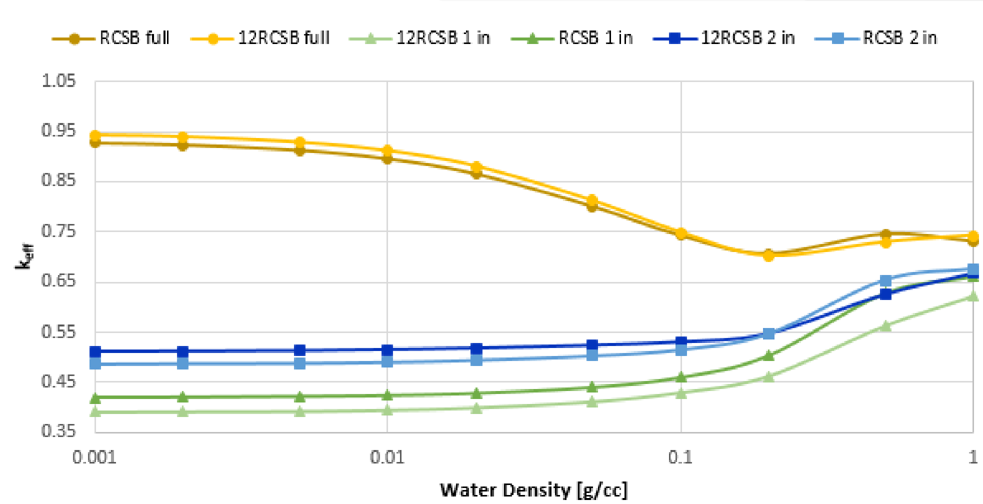


Results – Dehydrated BoroBond4™

Sphere Loadings



Shell Loadings



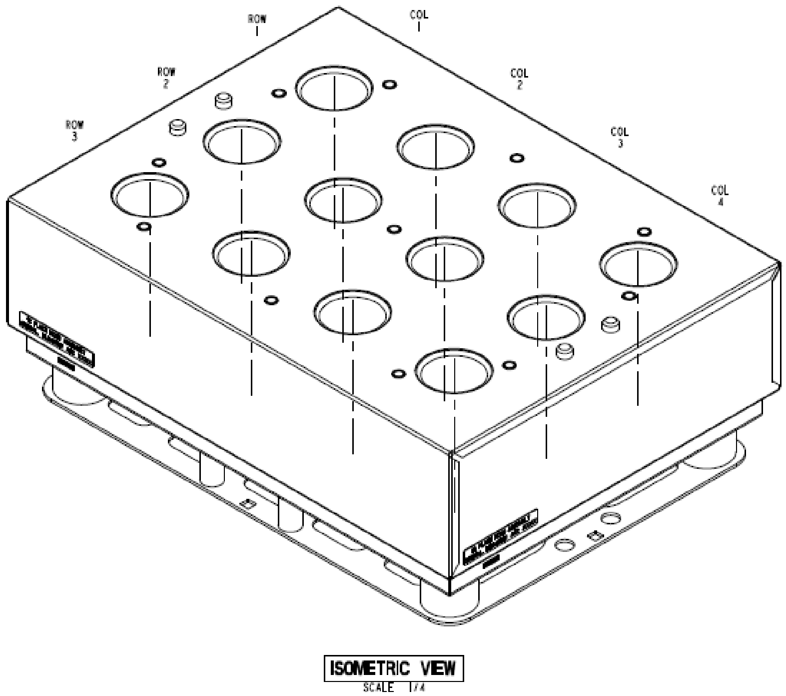
- Anticipated behavior with exception full dehydration: 12-place RCSB produce lower k_{eff} until interaction effects begin to dominate
- Only cases exceeding USL (0.96) are full dehydration

- Interaction effects dominate immediately due to increased surface area (shell) and limited BoroBond4™, RCSB lower k_{eff}
- Little difference between container types

Conclusions and Future Work

12-Place RCSB conclusions

- Lower or similar k-eff values produced in most cases – safer or similar level of safety as existing boxes
- Less mass within individual cavities –> increases fissile material surface area in close proximity of poison, aids in absorption ability
- Although cavities are closer together, increased neutron interaction effects are not observable until substantial dehydration occurs



Future Work

- Over mass loadings – largest credible over mass
- Homogenous U-water mixture loadings
- Results of packaging thermal and drop tests (DOE 420.1c) will inform CSE and additional calculations

Questions?

DISCLAIMER