Refueling Outage & Dry Cask Shielding Improvements at US Nuclear Plants

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Asian ISOE ALARA Symposium

Tokyo, Japan

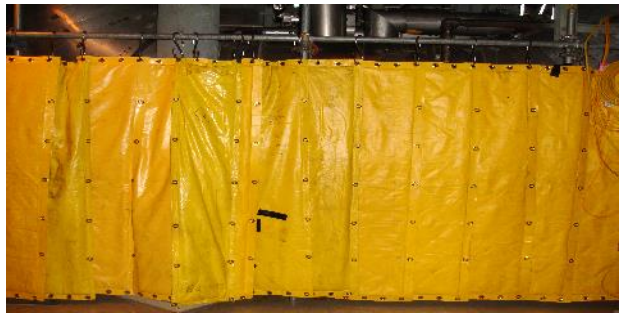
September 9, 10, 2015

NATC Shielding Studies to Reduce Occupational Dose

- NATC performed shielding studies at US PWRs in 2015.
- 5 senior nuclear engineers at University of Illinois developed shielding alternatives for their senior engineering design class in the spring semester, 2015
- The class examined high outage dose PWRs & low outage dose PWRs
- Gap analyses were performed to better understand the optimized use of temporary and permanent shielding at operating nuclear plants

Results of the US Shielding Study

- High dose PWRs can install up to 400,000 pounds of temporary lead shielding for refueling outages



- Low dose PWRs install 40,000 to 60,000 pounds of temporary lead shielding for refueling outages

- Low dose PWR are working with high dose PWRs this fall to examine ways to reduce their outage doses.

Cook 1,2 Shielding Initiatives

- Cook 1,2 is a low dose Westinghouse ice condenser PWR
- Five temporary shielding packages are no longer installed due to decreased dose rates
- Cook 1,2 has been working with NPO to eliminate high radiation areas in the Auxiliary Building using permanent shielding designs
- The objective of this initiative is to remove the radiological hazard
- Cook 1,2 is also employing new neutron and gamma shielding for the dry cask campaigns
- In 2012, Cook's dry cask worker dose per cask was 6 mSv
- In 2015, Cook's dry cask worker dose per cask achieved 0.87 mSv (85.5% reduction)
- NPO has assisted Cook RP Department in evaluating these initiatives
- The co-authored presentation will now describe some of the NPO shielding designs for US plants

Spent Fuel Storage Facts

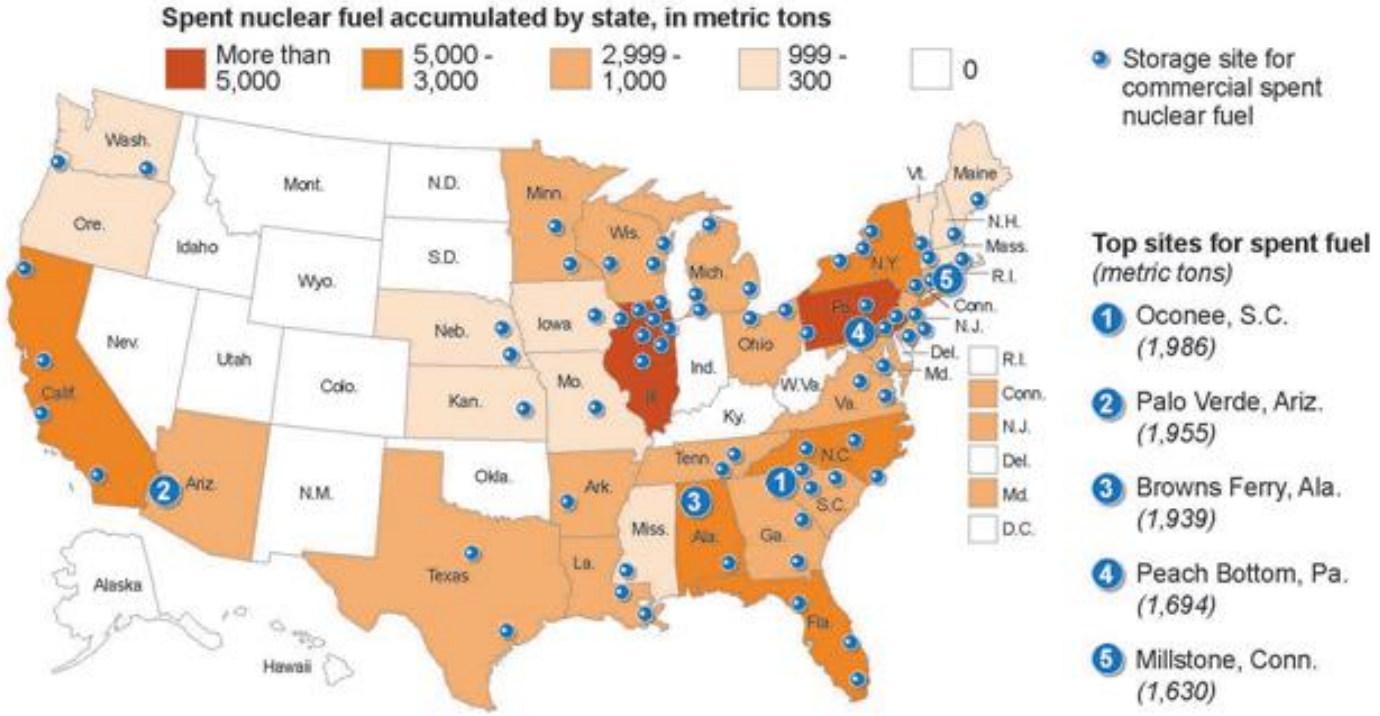
As of the end of 2009, 13,856 metric tons of commercial spent fuel – or about 22 percent – were stored in dry casks

The total increases by 2,000 to 2,400 tons annually

Spent Fuel Storage Facts

Spent Nuclear Fuel Awaits Permanent Home

The U.S. has about 70,000 metric tons of spent nuclear fuel stored at 75 active and decommissioned reactor sites in 33 states.



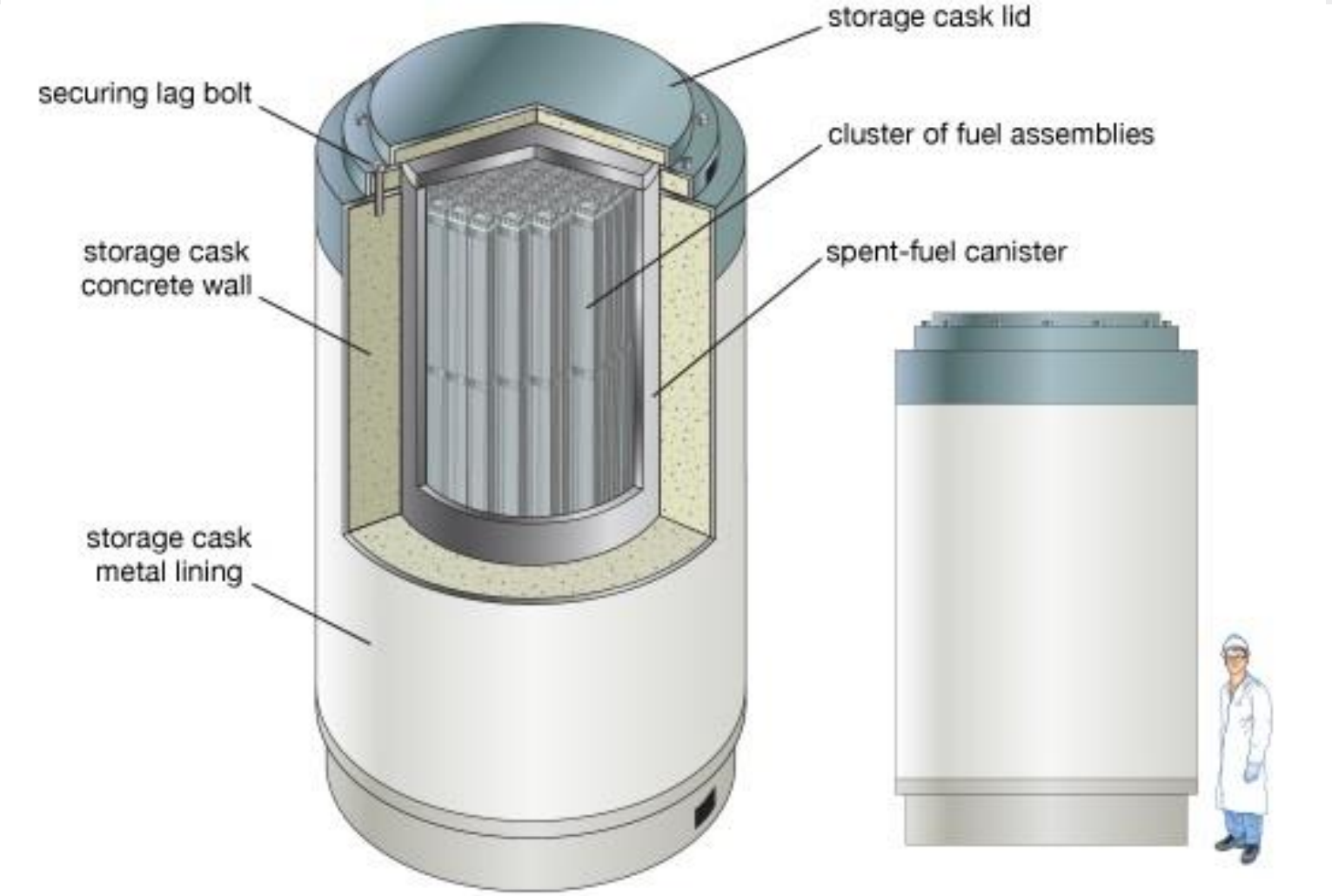
Note: Does not include about 13,000 metric tons of nuclear waste, primarily from U.S. weapons programs, that the Department of Energy manages in several states.

Sources: U.S. Government Accountability Office, Nuclear Energy Institute, Union of Concerned Scientists

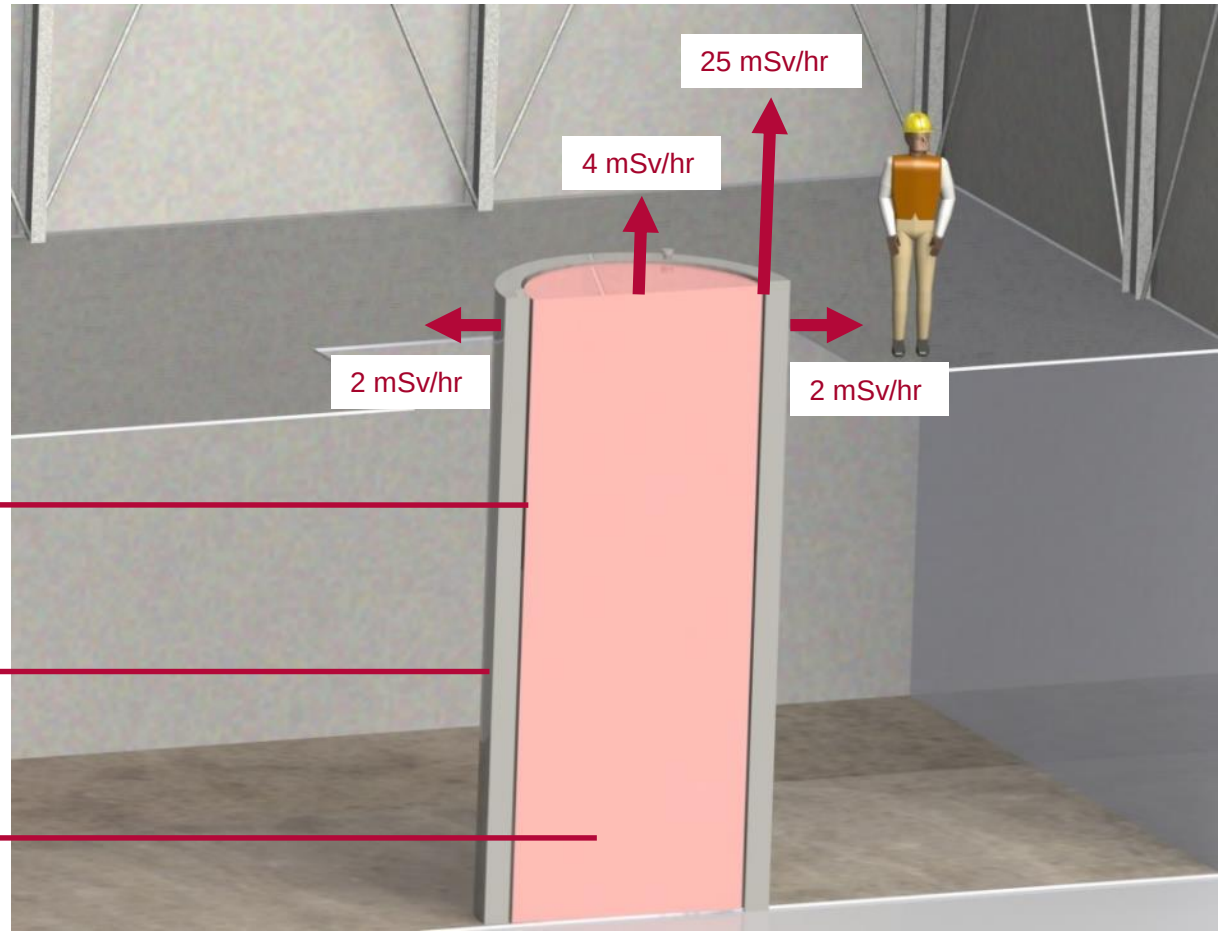
Graphic: Dave Merrill
BGOVgraphics@bloomberg.com

Bloomberg GOVERNMENT

Typical Dry Cask



Typical Dry Cask Dose Rates



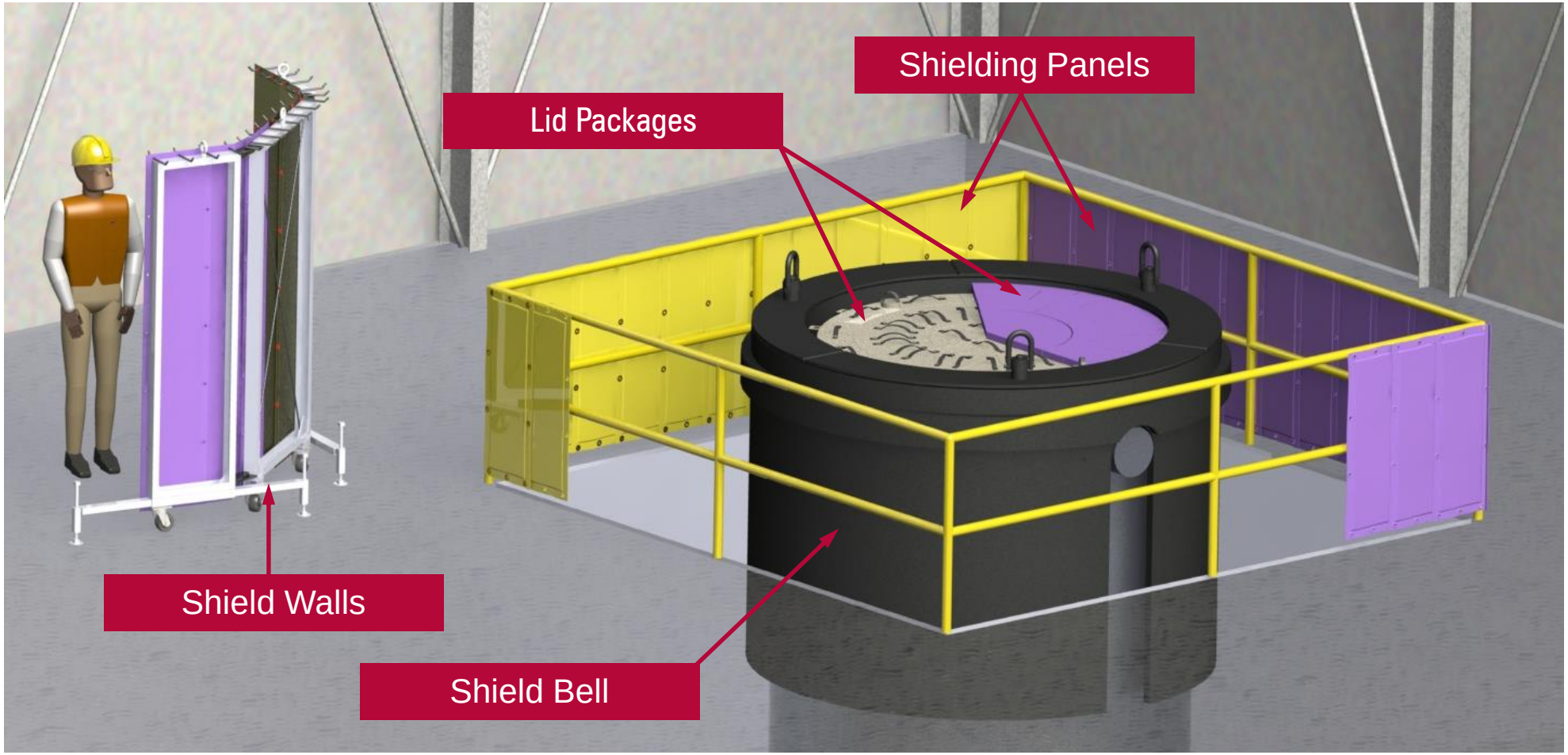
Gamma and Neutron Shielding Materials

NEUTRON
Borated Polyethylene (BPE)

GAMMA
Lead, Steel

BOTH
T-Flex, Water, Concrete

Dry Cask Storage



Lid Shield – Lead Wool

Dry Cask Lead Shield

The ultra high-density lead shielding is optimally sized for fit, coverage and ergonomics, and includes a high-temperature alpha maritex cover. The 700lb. (approx.) dry cask provides an approx. gamma reduction at Co-60 of 65%. Modular pieces allow for removal only in the required areas to maximize dose reduction.

- Standardized for each cask manufacturer and robotic welding system
- Install dry cask lead shield in less than 5 minutes.
- Reduce dose by 65%.
- Eliminate streaming with dry cask lead shield's optimal size.

Lid Shield - Composite

Holtec Dry Cask Neutron-Gamma shield consists of Borated Poly and T-Flex Tungsten

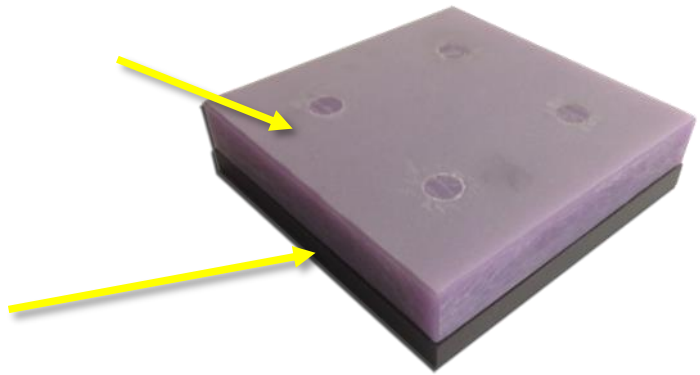
Designed to shield neutron and gamma sources with dry cask operations.

2″ Borated poly provides:

43% neutron reduction
20% gamma reduction.

1″ T-Flex provides:

62% gamma reduction
20% neutron reduction

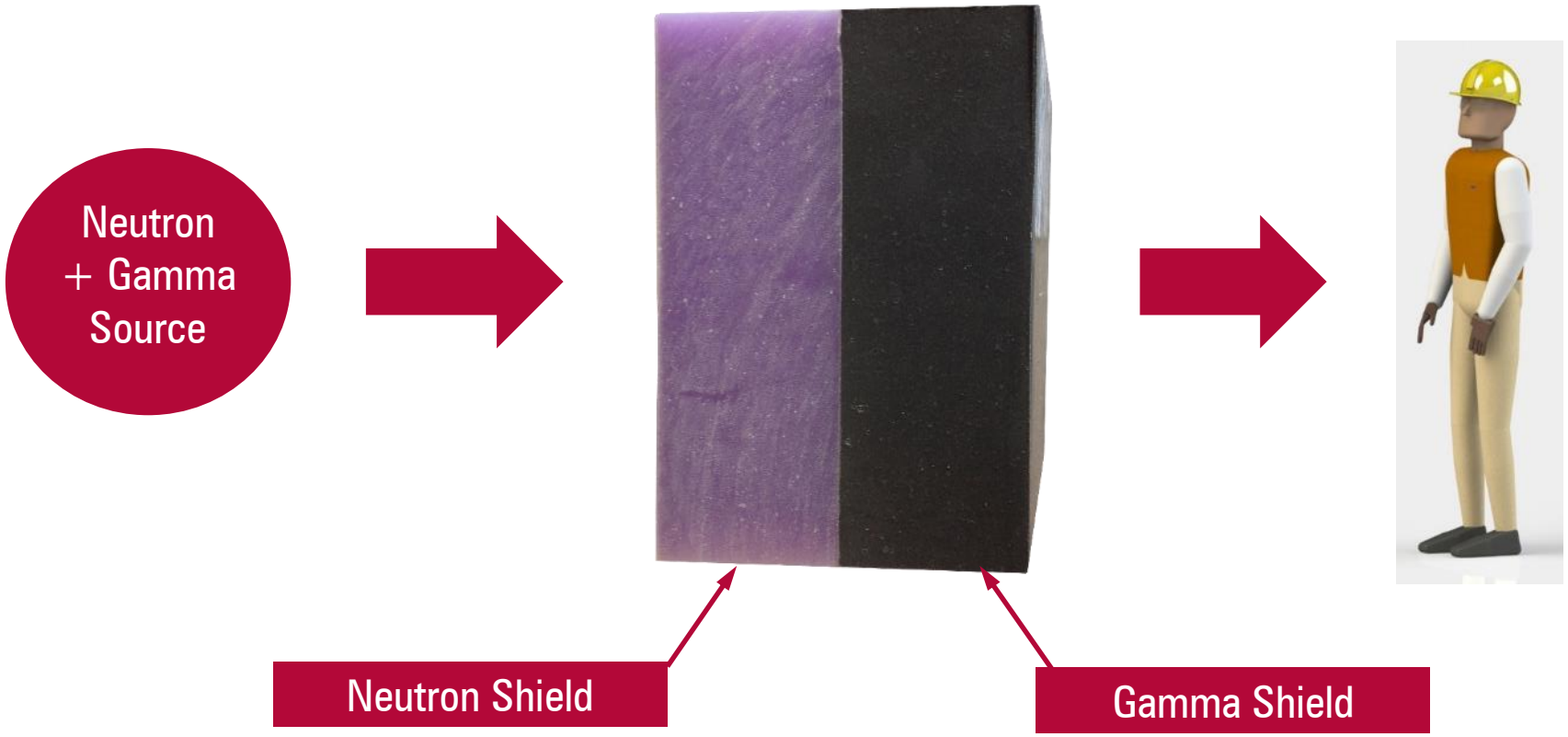


Lid Shield - Composite

- Pieces are designed around the manufacture's lid
- This lid shield is for the Holtec MPC-37 with the radial breaks specified by Holtec Engineers
- Each piece weighs less than 50 lb and is easily added or moved
- Able to withstand the surface temperatures of the lid

Dry Cask Storage – Shielding Placement

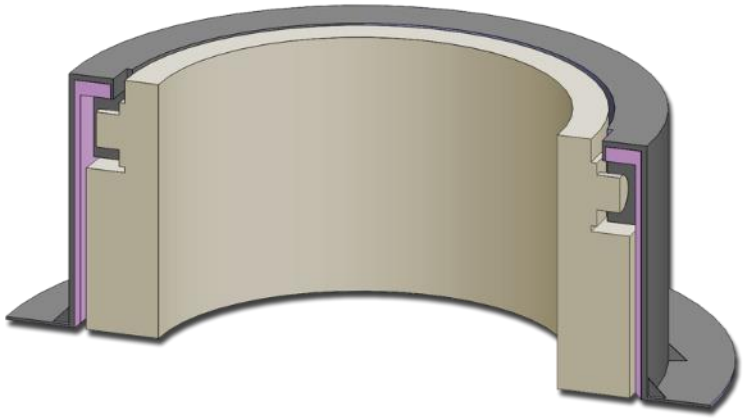
- Put Neutron Shielding between Source and Gamma Shield to prevent ACTIVATION of Gamma Shielding **when possible**



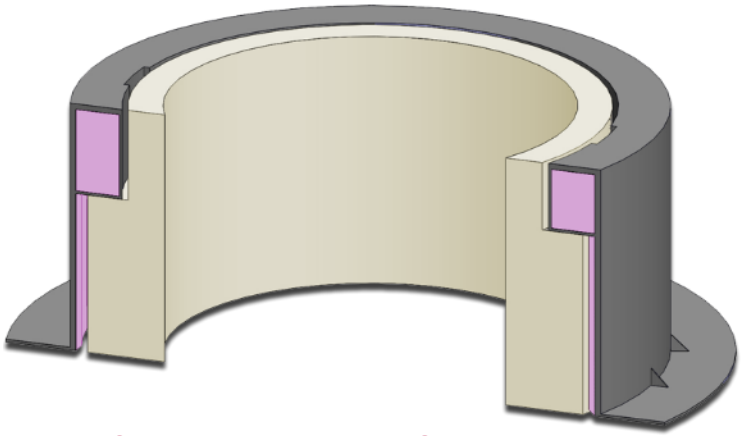
Dry Cask – Shield Bell

- A thick carbon steel cylinder provides gamma shielding and multiple layers of a high density 5% borated polyethylene that provides neutron shielding.
- 4 swiveling hoist rings for overhead lifting
- Openings for accessing drains, valves, ports or any other purpose can be added
- Coated inside and out with two-part epoxy finish.
- Approximate gamma attenuation is 67% and approximate neutron attenuation is 90% for the shield shown

Shield Bell in use at Kewaunee



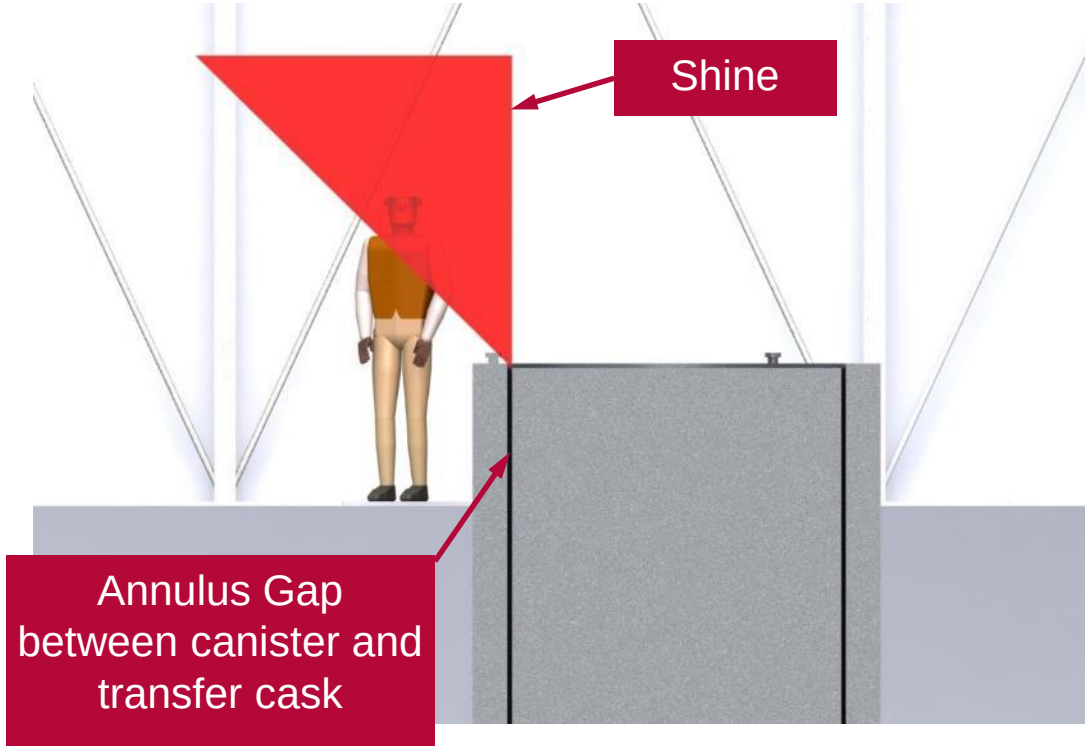
Cut Away: Trunions

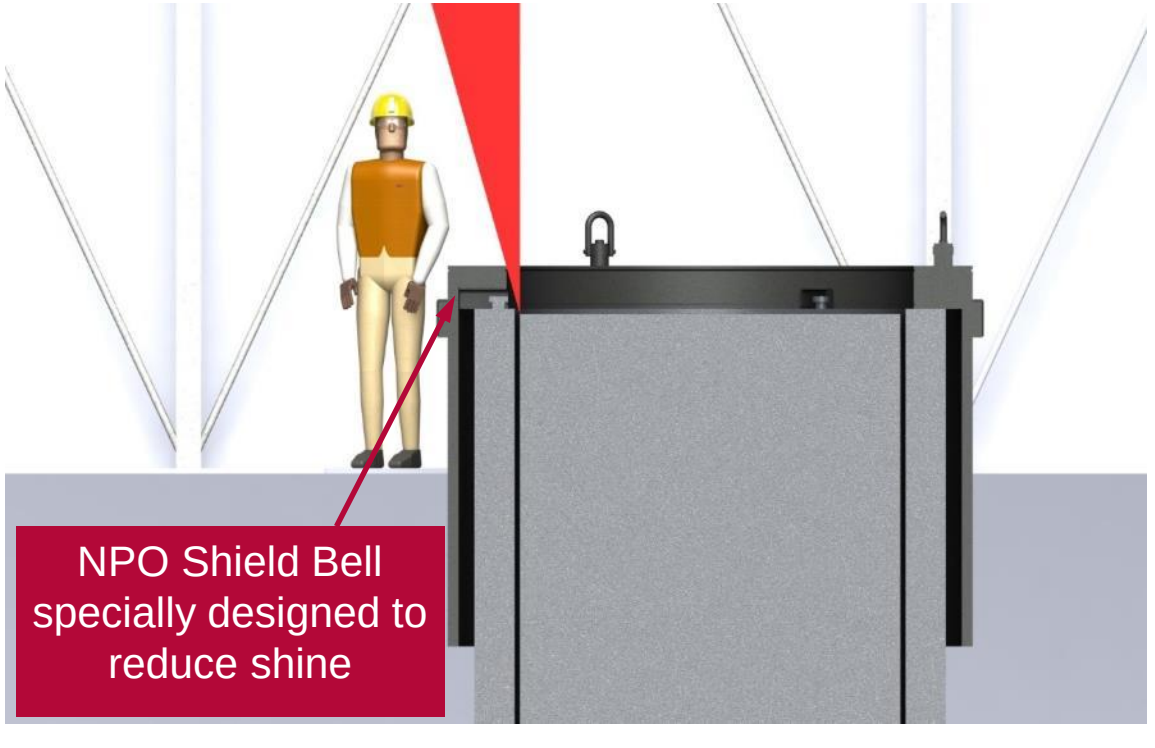


Cut Away: Main Section

Dry Cask - Shielding Placement

- Consider Line of Sight for Sources and Shielding Placement

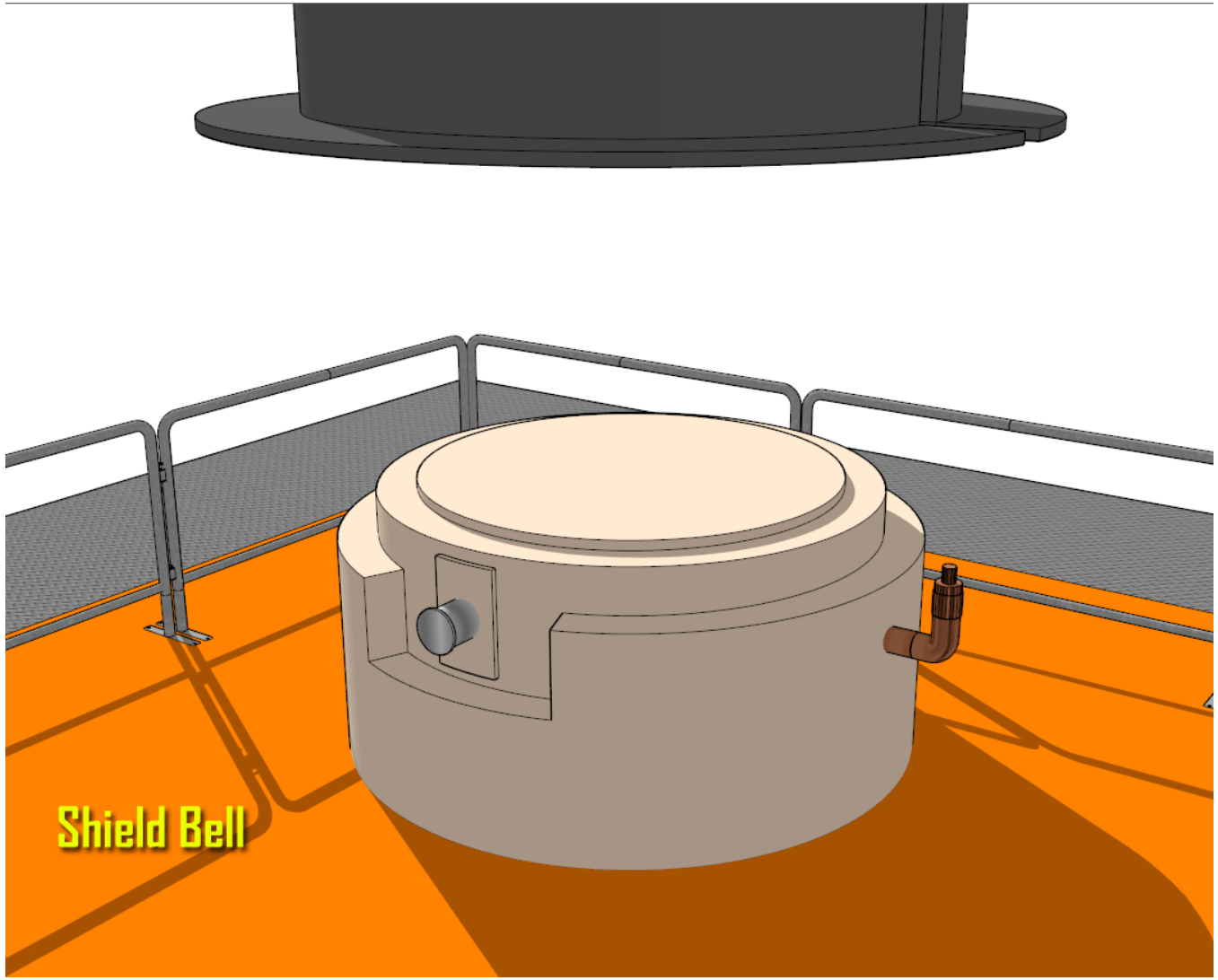




Kewaunee Success Story

Kewaunee achieved an industry best canister load 46 mRem with the use of an NPO shield bell

Dry Cask Shielding – All Shielding



Thank You