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DOE SNF Packaging Demonstration Project: Worktable and Canister Loading Sleeve Design

February 2021

Daniel Albert Thomas

Changing the World's Energy Future

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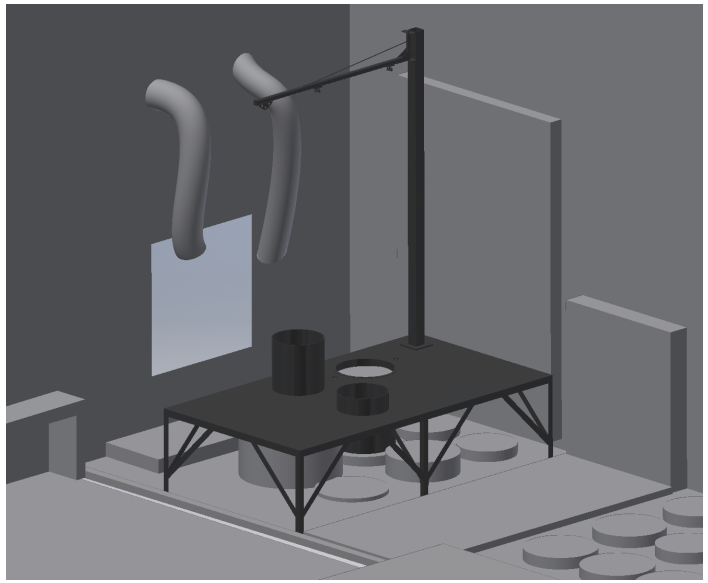
DOE SNF Packaging Demonstration Project:

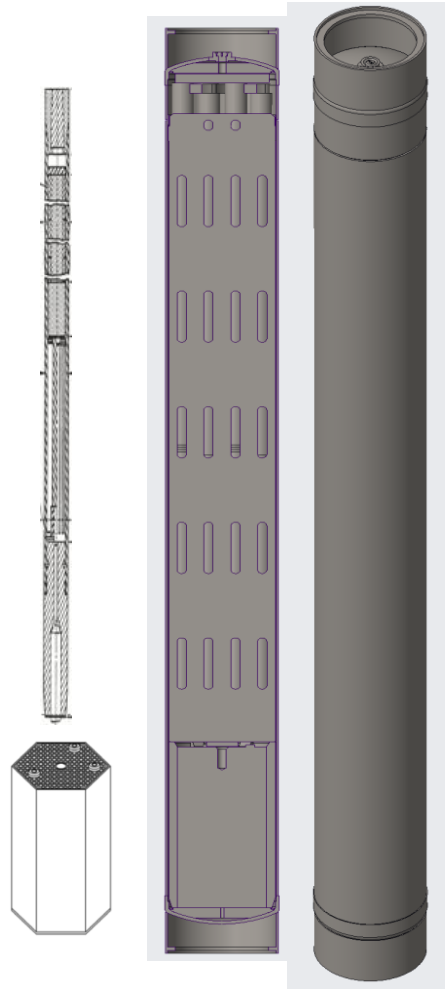
Worktable and Canister Loading Sleeve Design

Idaho National Laboratory

Overview

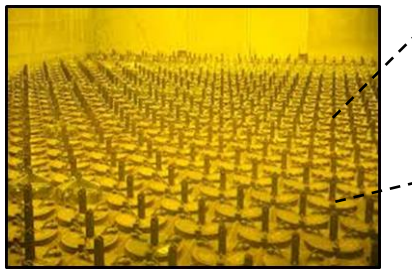
- Overview of the DOE SNF Packaging Demonstration Project
- DOE Standard Canisters
- CPP-603 Irradiated Fuel Storage Facility (IFSF) Fuel Handling Cave
- Worktable Design
- Canister Loading Sleeve Design



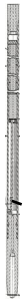


Overview of DOE SNF Packaging Demonstration Project

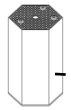
- The DOE SNF Packaging Demonstration Project is an effort to develop and demonstrate the designs, technology, processes, and regulatory framework for packaging DOE-managed spent nuclear fuel (SNF) for road ready dry storage (RRDS).
  - The project is to remotely load and seal two types of DOE-managed SNF from the CPP-603 facility into DOE Standard Canisters, place the sealed DOE Standard Canisters into commercial vendor over-canisters (equivalent to commercial MPCs), seal and place the over-canisters into commercial vendor storage overpacks, and place the storage system (over-canister and storage overpack) onto the CPP-2707 cask pad.



CPP-603 IFSF
(Irradiated Fuel Storage Facility)



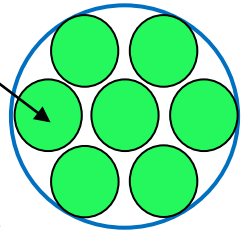
Peach Bottom
Core 2 Fuel

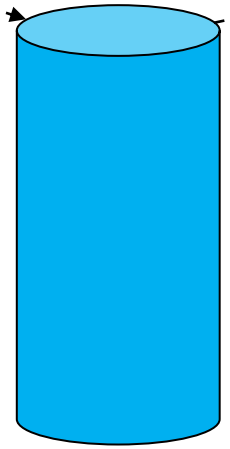


Fort Saint
Vrain Fuel

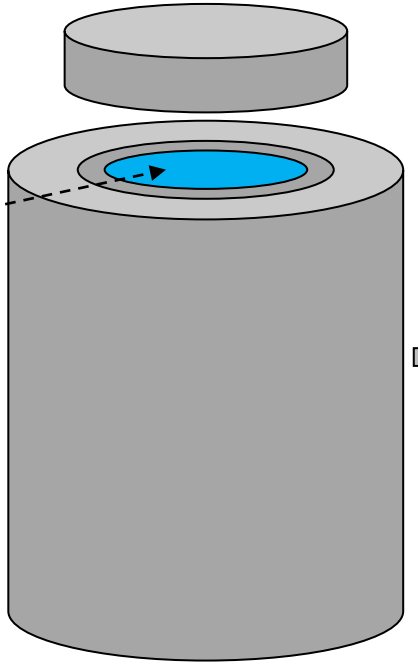
DOE SNF

Loaded
DOE
Standard
Canister





Over-Canister



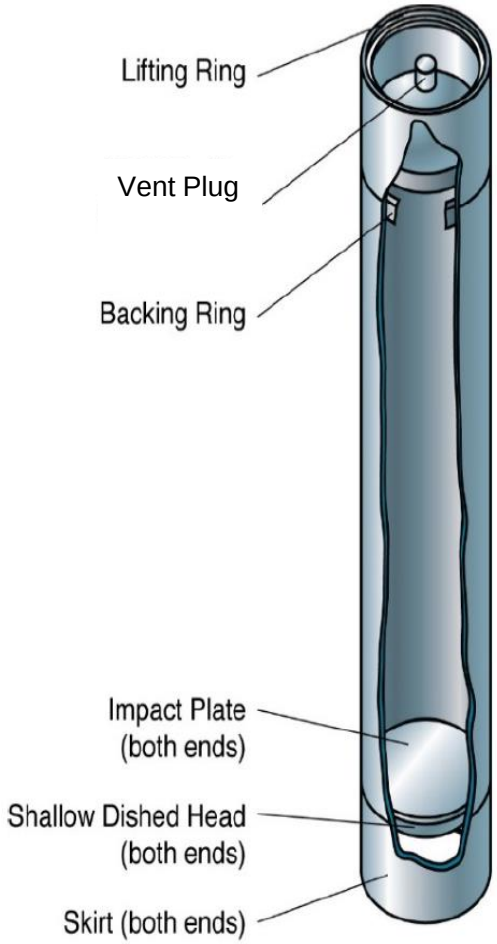
Storage Overpack

CPP-2707 Cask Pad

DOE Standard Canisters

- There are 4 configurations of DOE Standard Canisters, 2 diameters (18” and 24”) and 2 lengths (10’ and 15’).
- All are made of 316L stainless steel.
- The canisters have impact skirts at both ends.
- The canisters are lifted from a lifting ring attached to the impact skirt (a DOE Standard Canister without its lid assembly attached, will need to be lifted with a Canister Loading Sleeve, since there is no other lifting fixture on the canister that will allow it to be lifted upright). This ring is to support a minimum of 6,000 lb for the 18” outer diameter (OD) canister and 10,000 lb for the 24” OD canister.
- For the DOE SNF Packaging Demonstration, the 18” OD and 15’ long DOE Standard Canister will be used.
- The next couple slides have images/views of DOE Standard Canisters and the basket configurations for the DOE SNF Packaging Demonstration.

DOE Standard Canisters



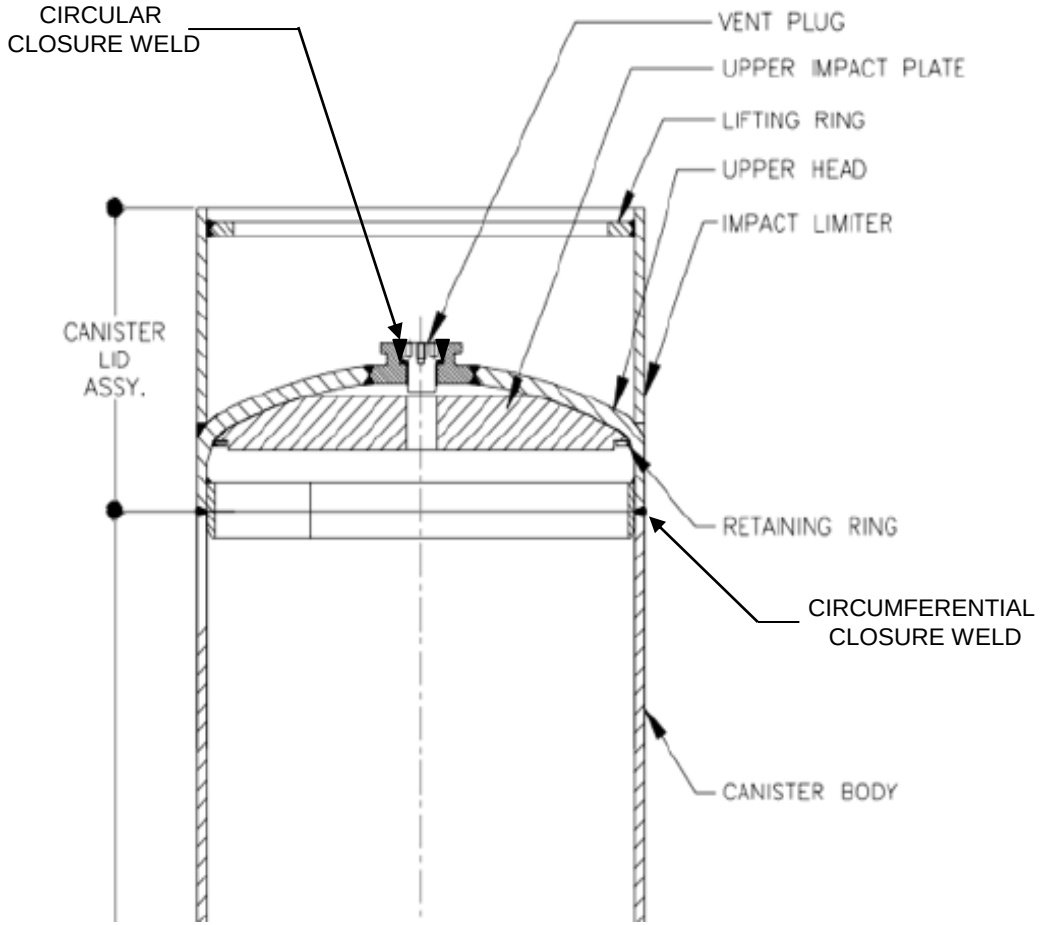
Nominal Outside Diameters:
18 in. and 24 in.

Wall Thickness:
3/8 in. for 18 in. Canister
1/2 in. for 24 in. Canister

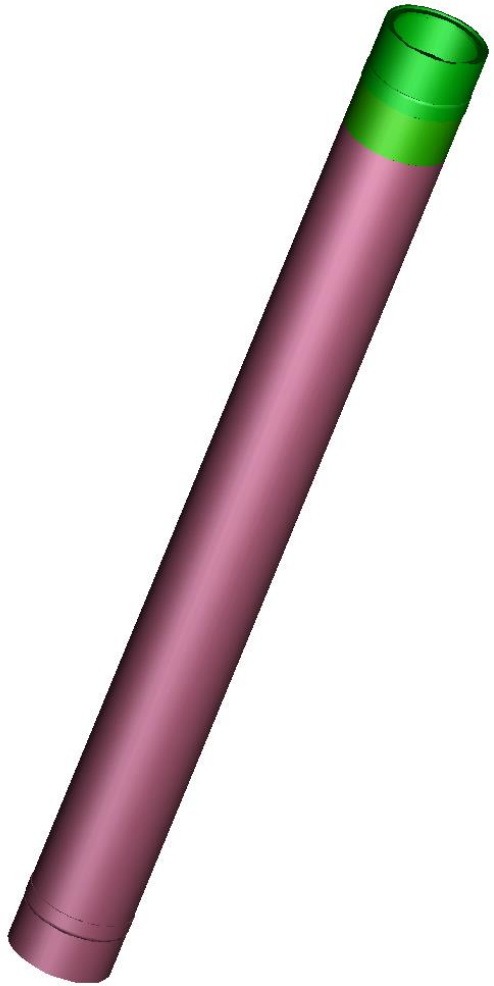
Maximum Weight with Fuel:
18 in. x 10 ft: 5,005 lb
18 in. x 15 ft: 6,000 lb
24 in. x 10 ft: 8,996 lb
24 in. x 15 ft: 10,000 lb

Material:
Canister Body: SS 316L

06-GA50003-59

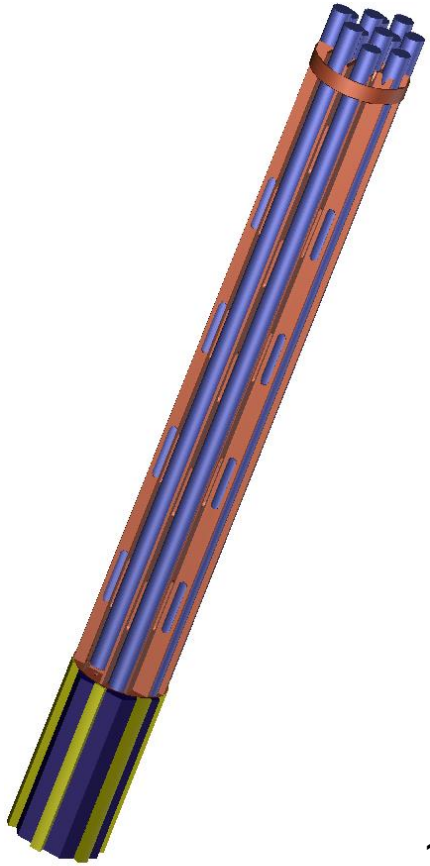


Views of the DOE Standard Canister and 12PB2+1FSV Baskets

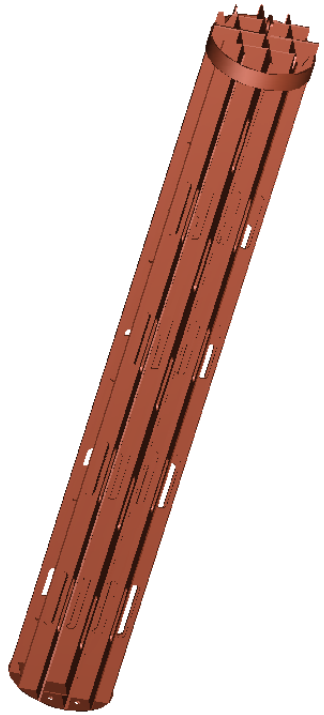


Sealed Canister

Canister Lid Removed



Baskets and Fuel Elements



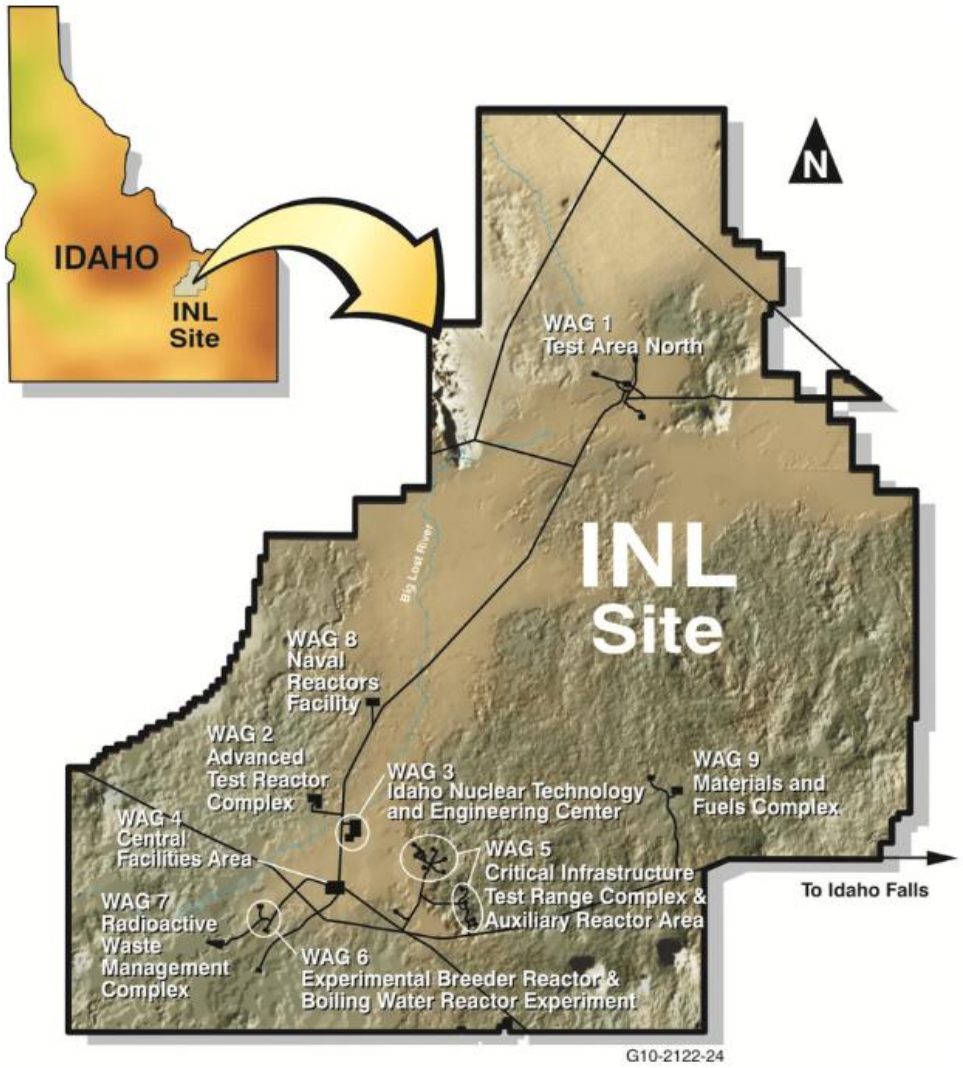
12PB2 Basket

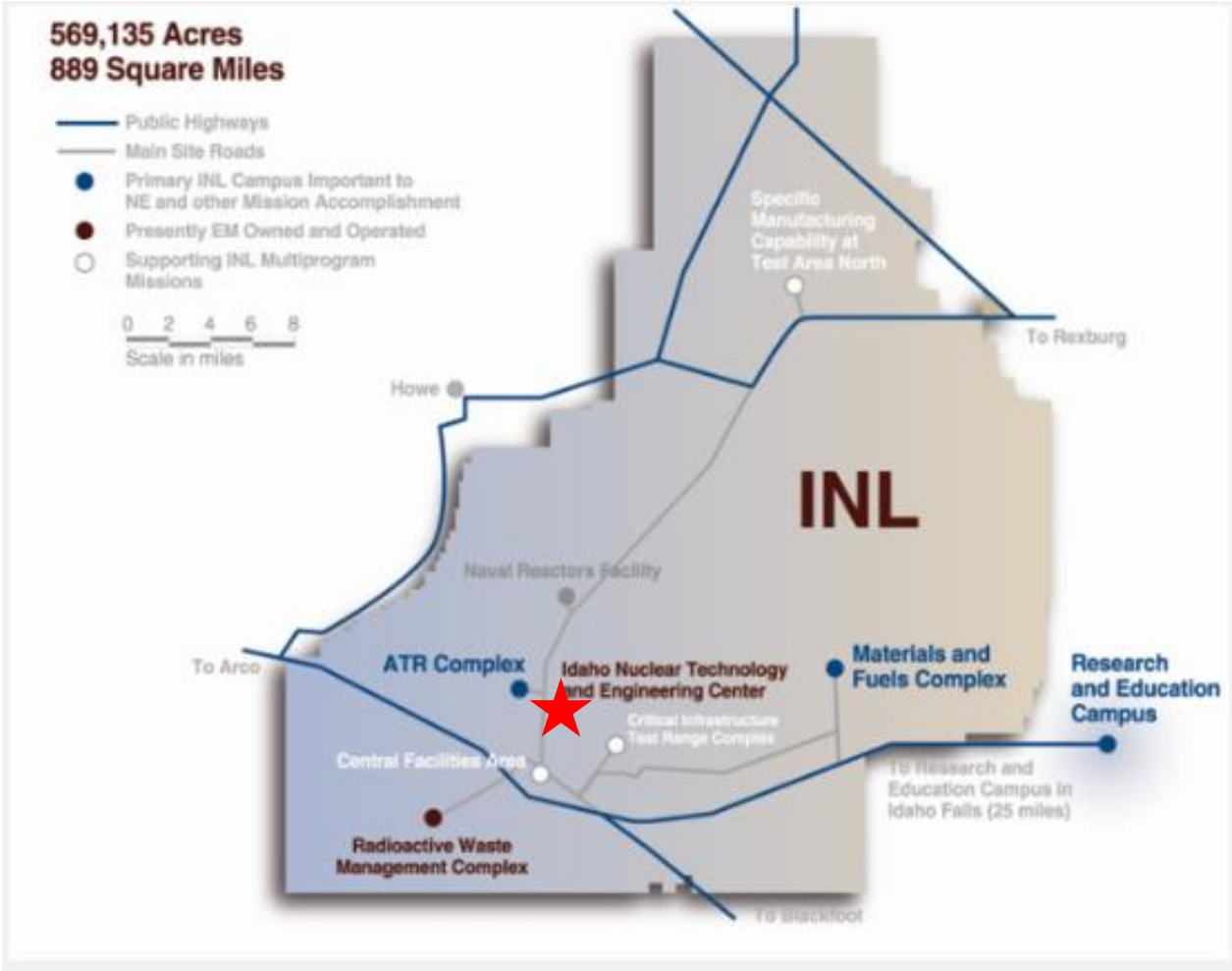
1FSV Basket

Location of Operations

- All loading (fuel, baskets, inserts, spacers, and shims) and closure (weld, non-destructive examination (NDE), repair, stress relief/coating) operations with DOE Standard Canisters for the DOE SNF Packaging Demonstration are to occur in the Fuel Handling Cave (FHC) of the CPP-603 Irradiated Fuel Storage Facility (IFSF) in the Idaho Nuclear Technology and Engineering Center (INTEC) area of the Idaho National Laboratory (INL) Site.
- The FHC is a contaminated zone (beta and gamma, mostly Sr-90 and Cs) and moderator exclusion/control area (hydrogenous material entry highly restricted).
- There is no manned entry into the FHC while SNF is present. All operations within the FHC will need to be fully remote (telemanipulator, programmable crane with electromechanical arm, etc.).

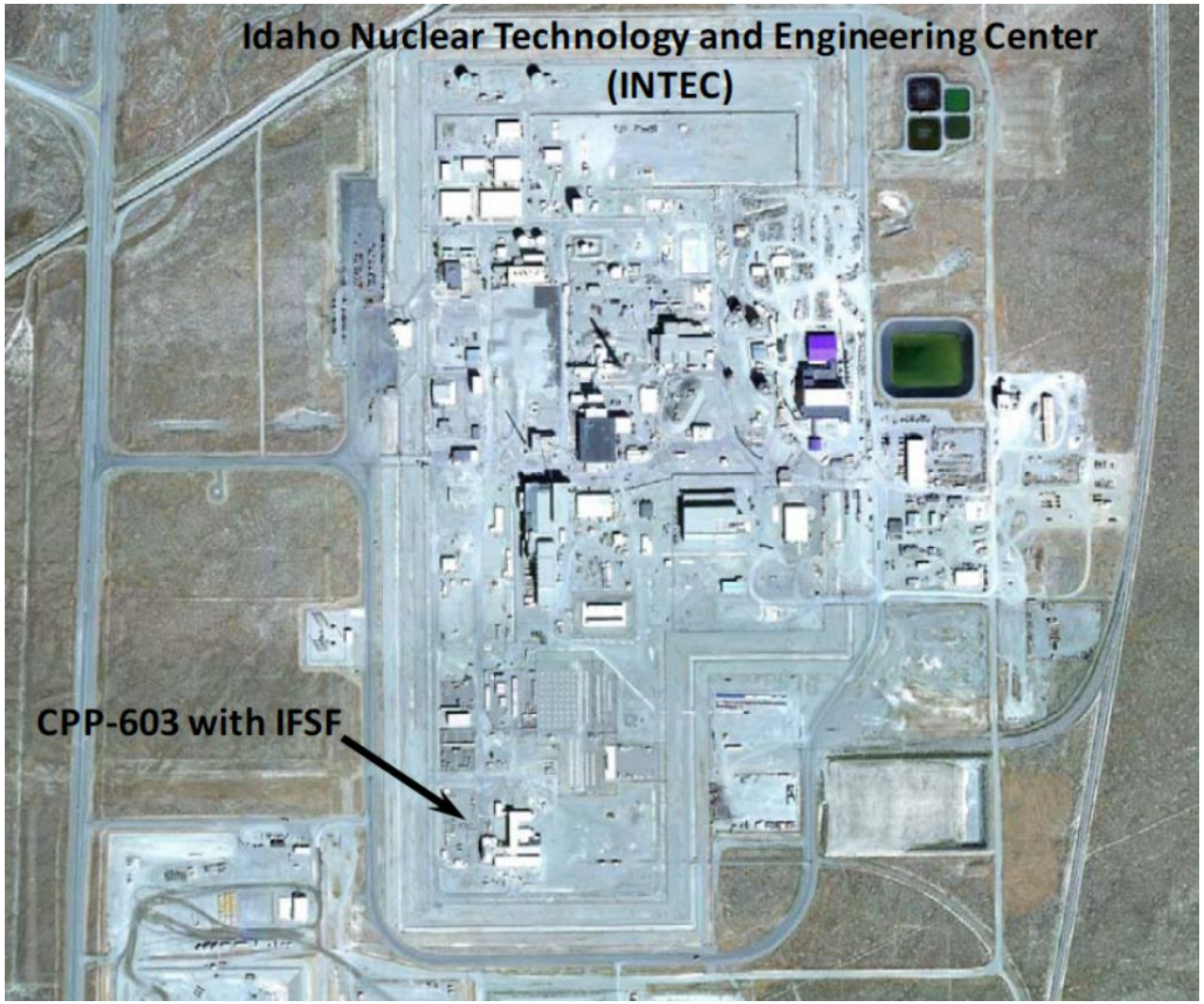
INL Site


IDAHO
INL Site
N
WAG 1
Test Area North
INL
Site
Big Lost River
WAG 8
Naval
Reactors
Facility
WAG 2
Advanced
Test Reactor
Complex
WAG 3
Idaho Nuclear Technology
and Engineering Center
WAG 9
Materials and
Fuels Complex
WAG 4
Central
Facilities Area
WAG 5
Critical Infrastructure
Test Range Complex &
Auxiliary Reactor Area
To Idaho Falls
WAG 7
Radioactive
Waste
Management
Complex
WAG 6
Experimental Breeder Reactor &
Boiling Water Reactor Experiment
G10-2122-24


569,135 Acres
889 Square Miles
Public Highways
Main Site Roads
Primary INL Campus Important to
NE and other Mission Accomplishment
Presently EM Owned and Operated
Supporting INL Multiprogram
Missions
0 2 4 6 8
Scale in miles
Specific
Manufacturing
Capability at
Test Area North
To Rexburg
Howe
INL
Naval Reactors Facility
To Arco
ATR Complex
Idaho Nuclear Technology
and Engineering Center
Materials and
Fuels Complex
Research
and Education
Campus
Central Facilities Area
To Research and
Education Campus in
Idaho Falls (25 miles)
Radioactive Waste
Management Complex
To Blackfoot

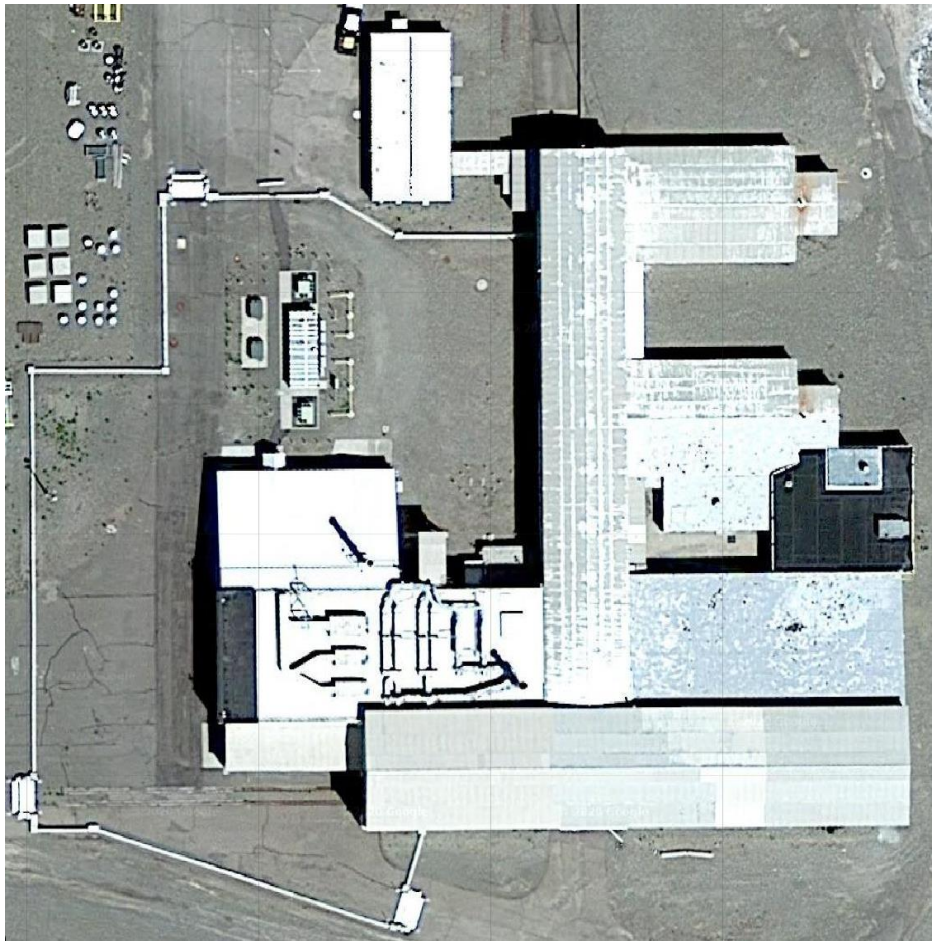
INTEC

- Overhead view of INTEC with CPP-603 identified.

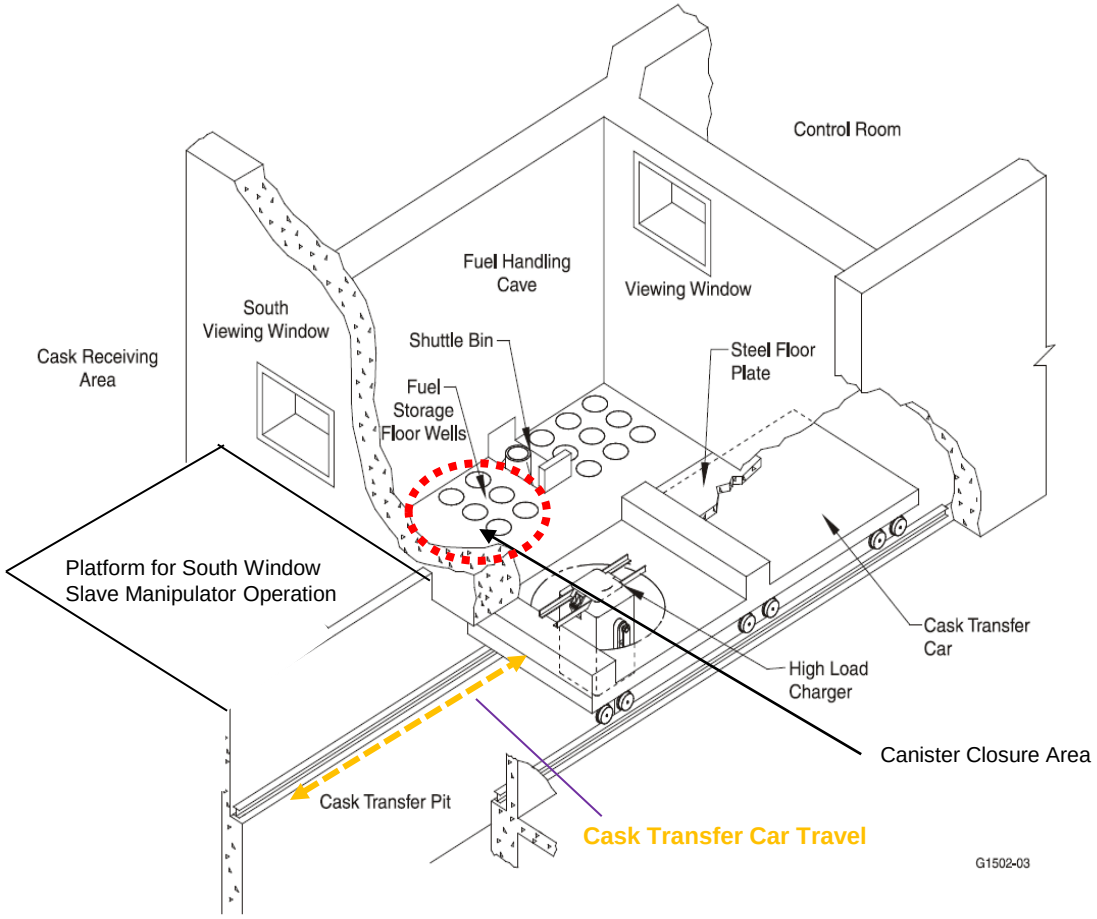


CPP-603 Irradiated Fuel Storage Facility (IFSF)

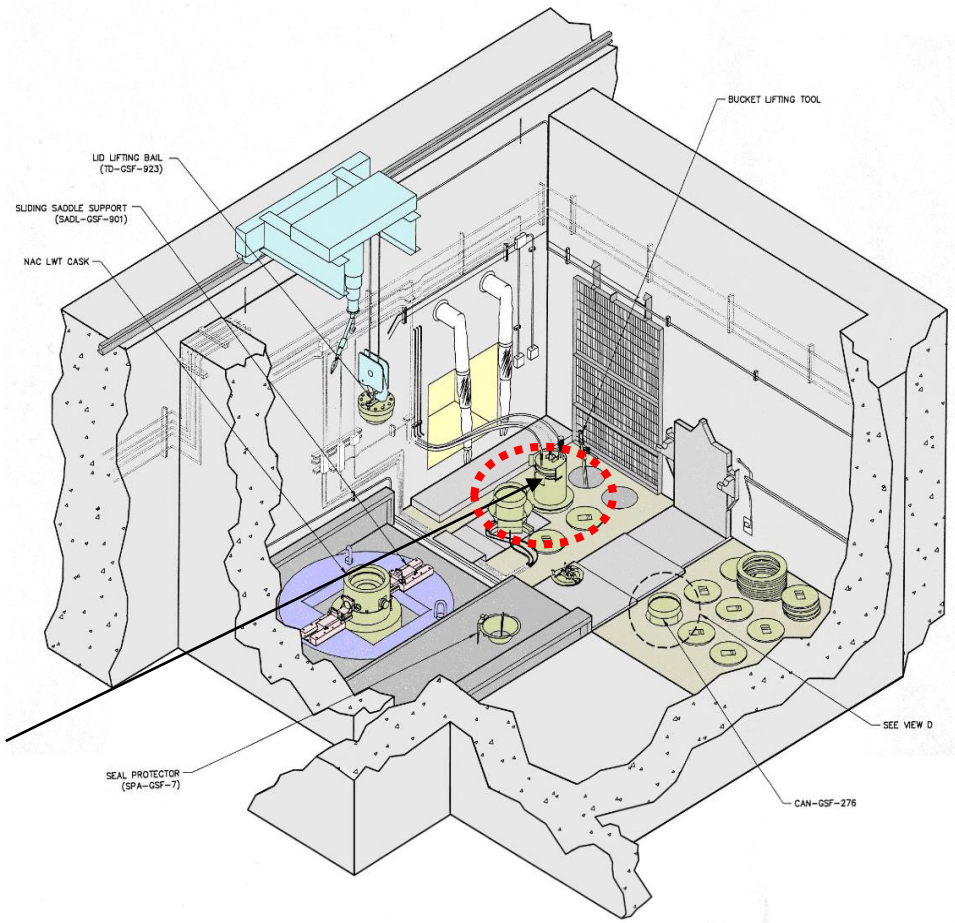
- Formerly Graphite-Fuel Storage Facility (GSF)
- South end of INTEC



CPP-603 IFSF Fuel Handling Cave (FHC)

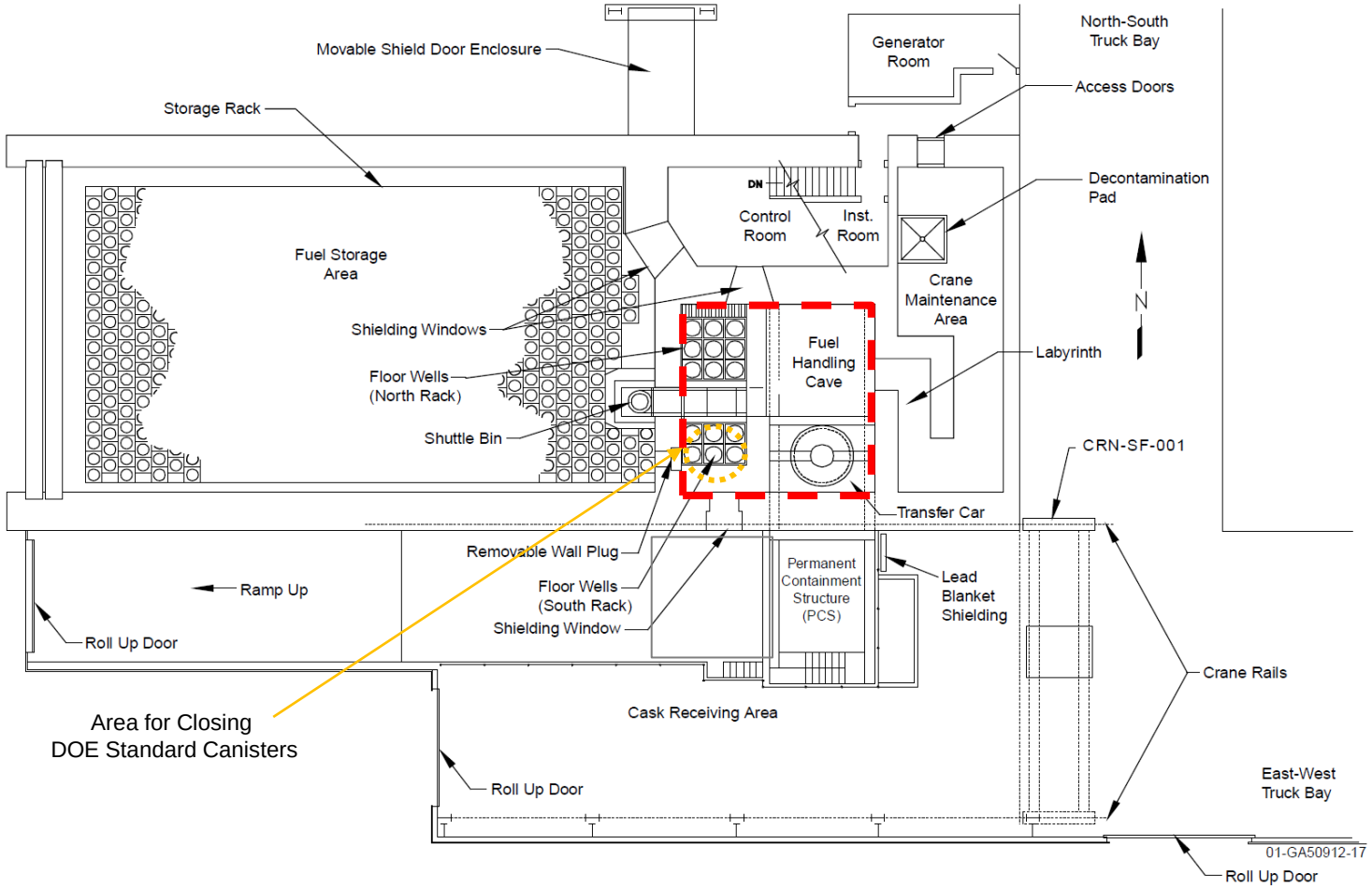


View North-West



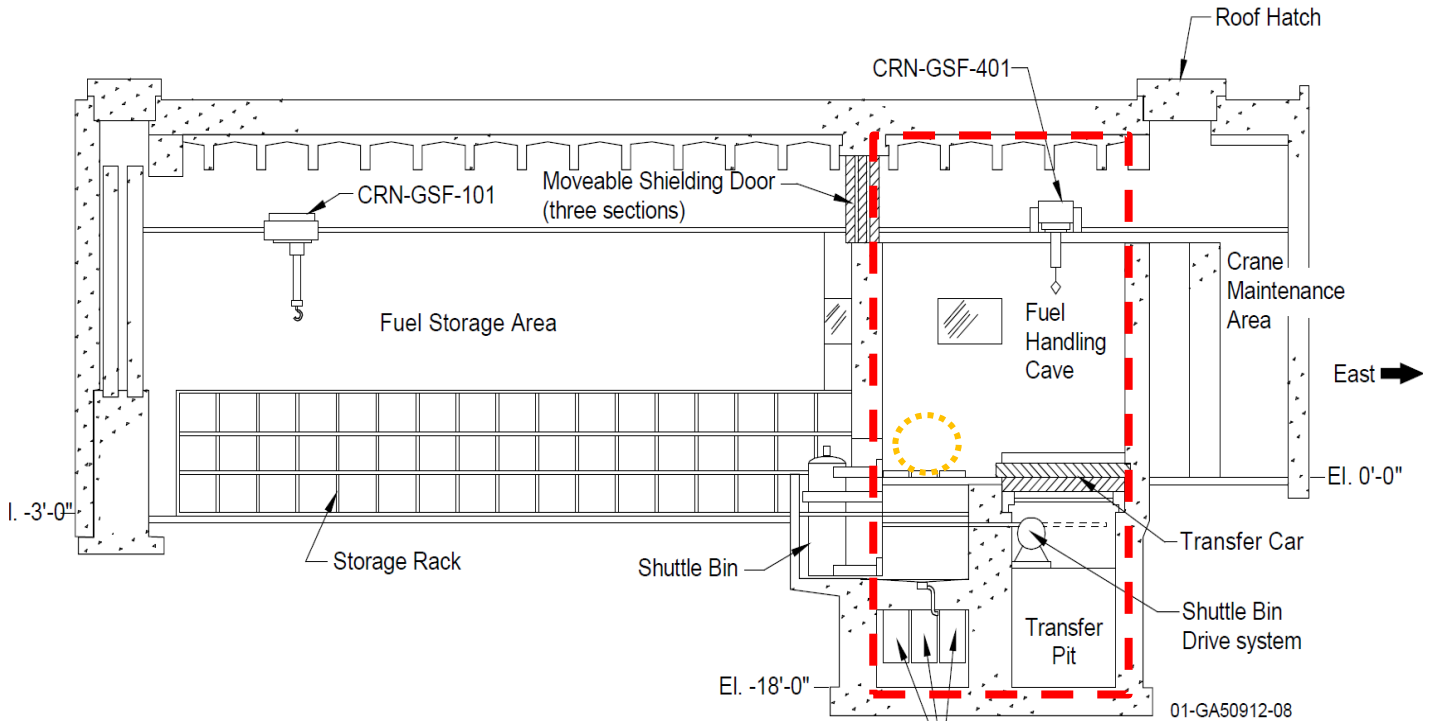
View South-West

CPP-603 IFSF FHC (Continued)



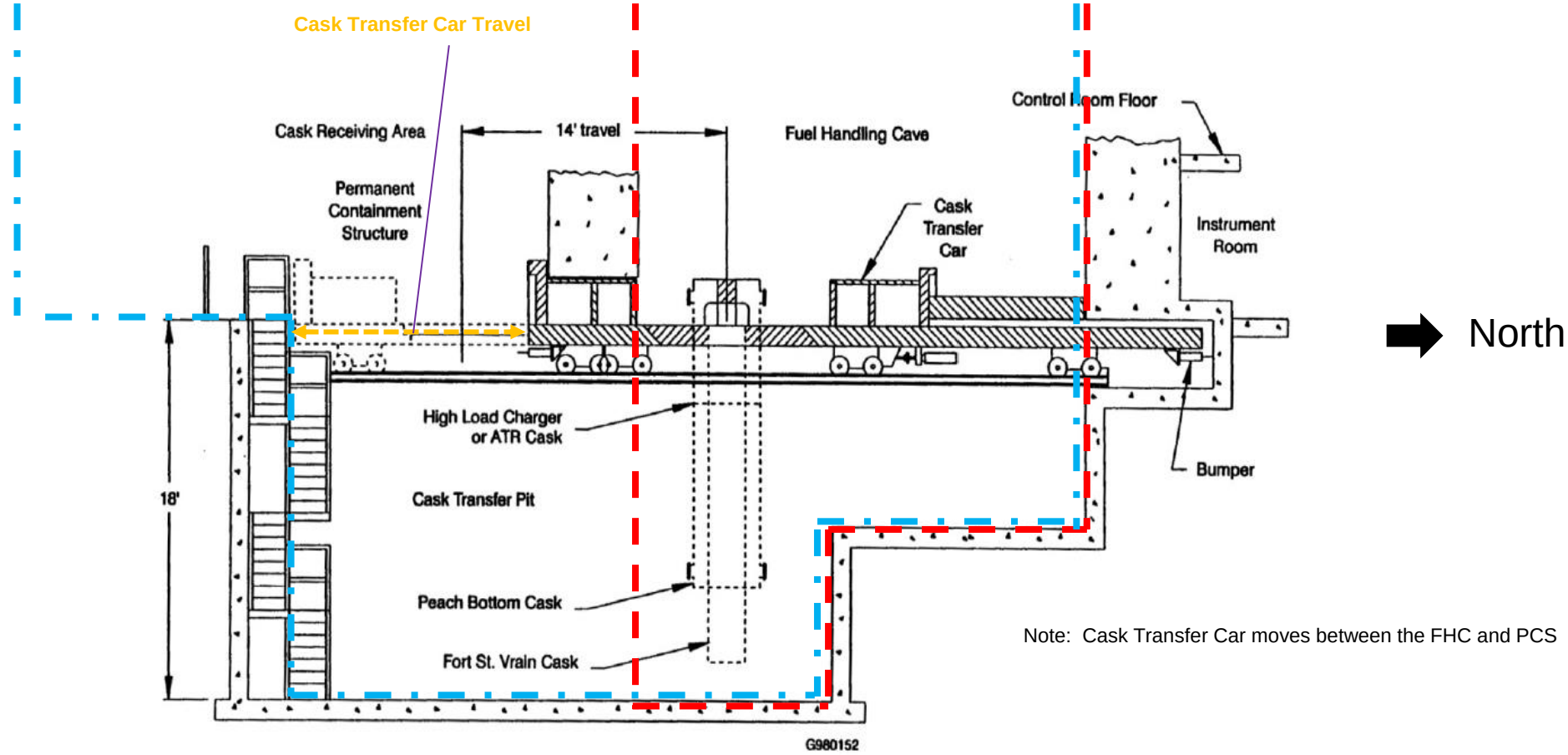
Plan View Down

CPP-603 IFSF FHC (Continued)



Cross-Sectional View North

CPP-603 IFSF FHC (Continued)

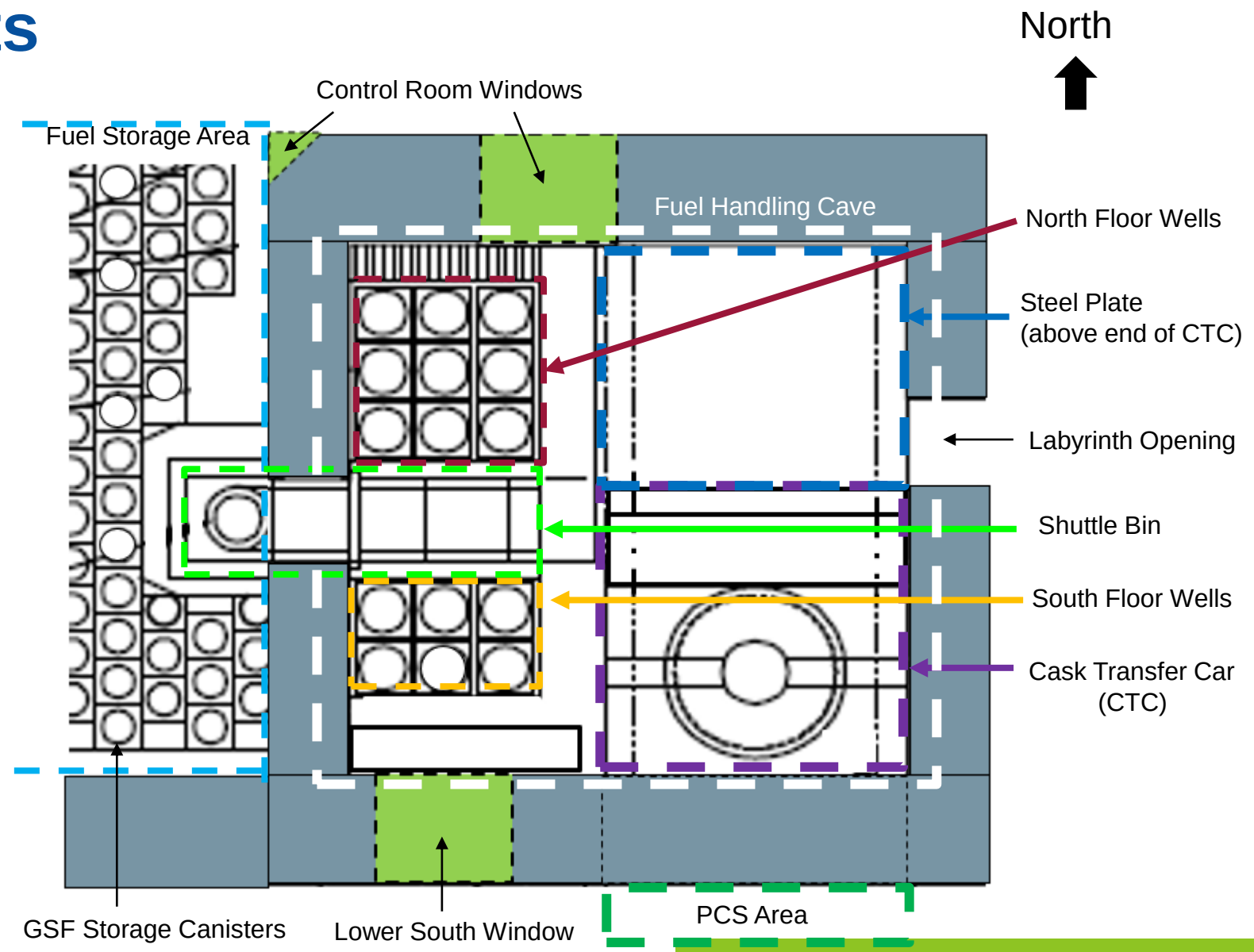


Note: Cask Transfer Car moves between the FHC and PCS

Cross-Sectional View West

FHC Access Points

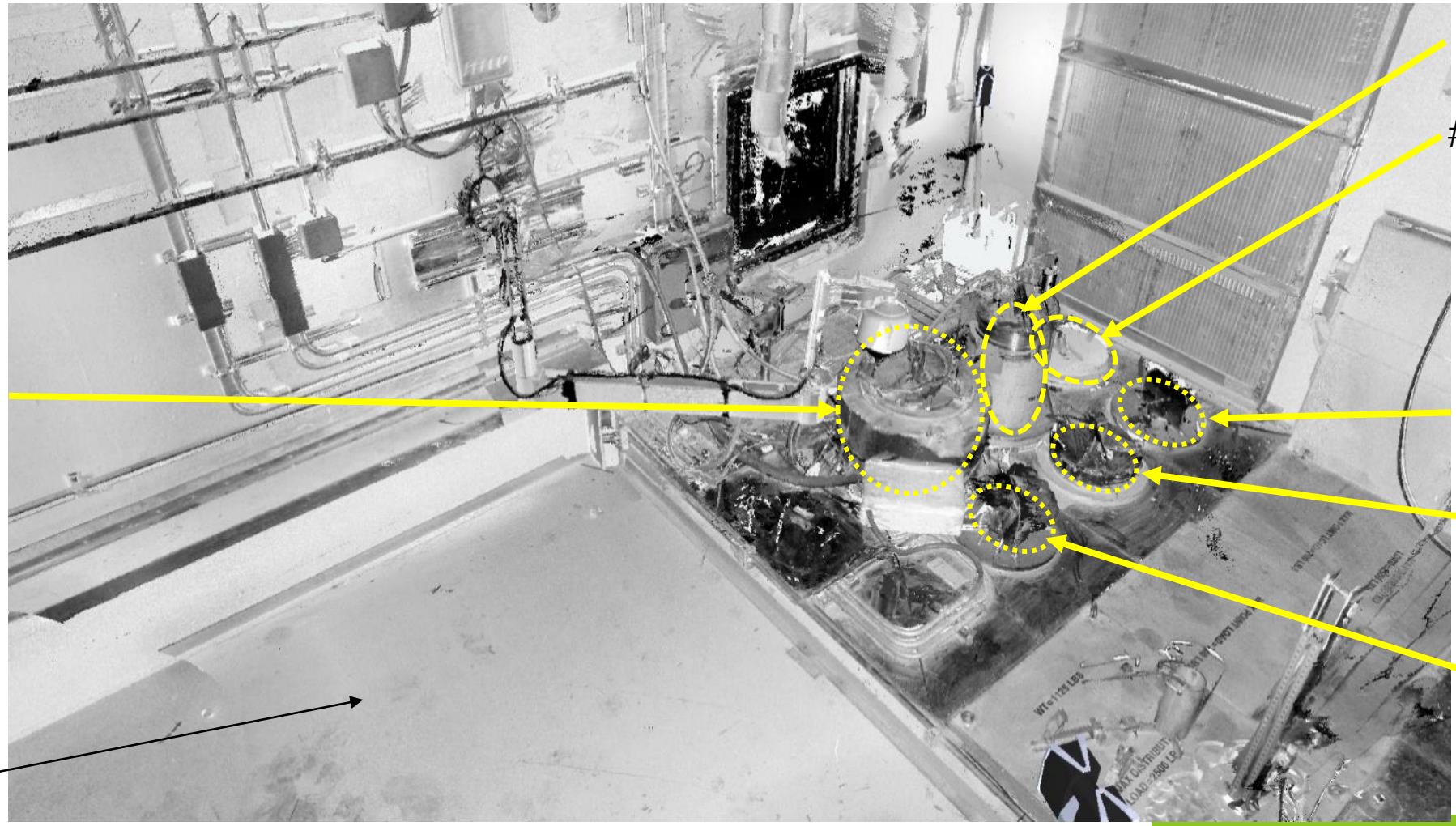
- Access points to FHC are
  - Personnel entry is via the labyrinth (not while SNF is in the FHC)
  - GSF Storage Canisters from the Fuel Storage Area (FSA) via the shuttle bin
  - Large casks/canisters/ equipment are moved in from the Permanent Containment Structure (PCS) via the Cask Transfer Car (CTC)



Worktable Design

- Functions
  - Clear area to perform loading and closing operations for a DOE Standard Canister
  - Shield/protect the FCS from DOE Standard Canister loading and closing operations
- Preliminary Requirements
  - Able to support itself and equipment sleds placed on it for normal and seismic loadings
  - Able to be brought into the FHC via the CTC
  - Able to be lifted by crane
  - Able to be assembled by one or two workers
  - Able to be attached to the floor
  - Have shielded access into floor well #14
  - Have attachment points for the Canister Loading Sleeve
  - Have tele-manipulator compatible data, gas, lighting, and power line attachment points to support the various equipment sleds
  - Have calibration stands/stations with heaters for NDE equipment calibration
  - Racks for handling tools and attachment point for fuel element length gauge
  - Fire suppression system

LIDAR Image of South-West Corner of FHC



#13 – 26”x13’3”
Fuel Conditioning Station (FCS)

Cask Transfer Car (Closed Plate)

#14 – 26”x13’3”
Stand/table for FCS lid

#15 – 20.5”x16’7”
Empty

#12 – 20.5”x16’7”
Storage: loading guides

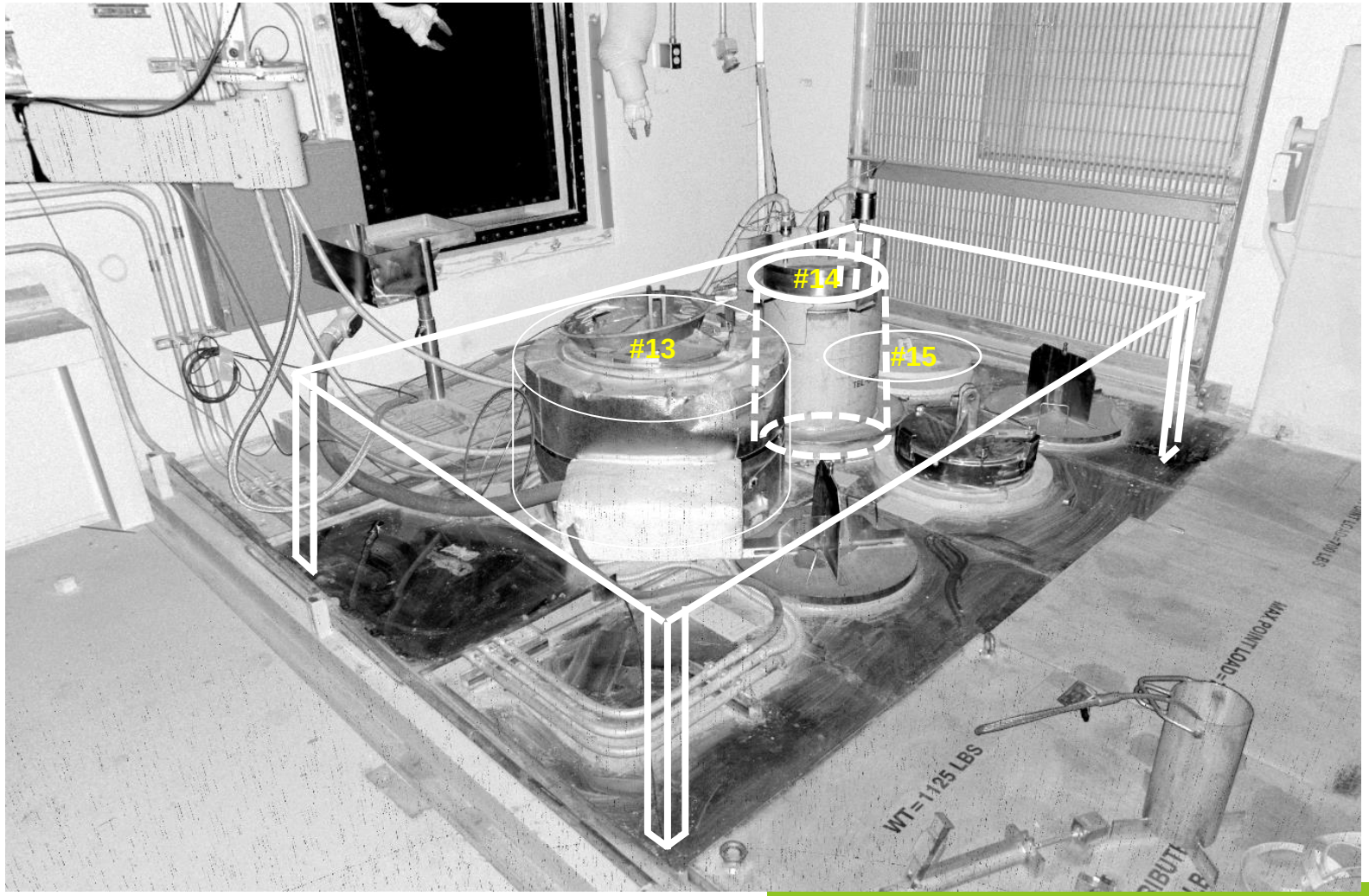
#11 – 20.5”x13’3”
Storage: canister for interim storage of fuel baskets

#10 – 20.5”x13’3”
Storage: loading guides

17

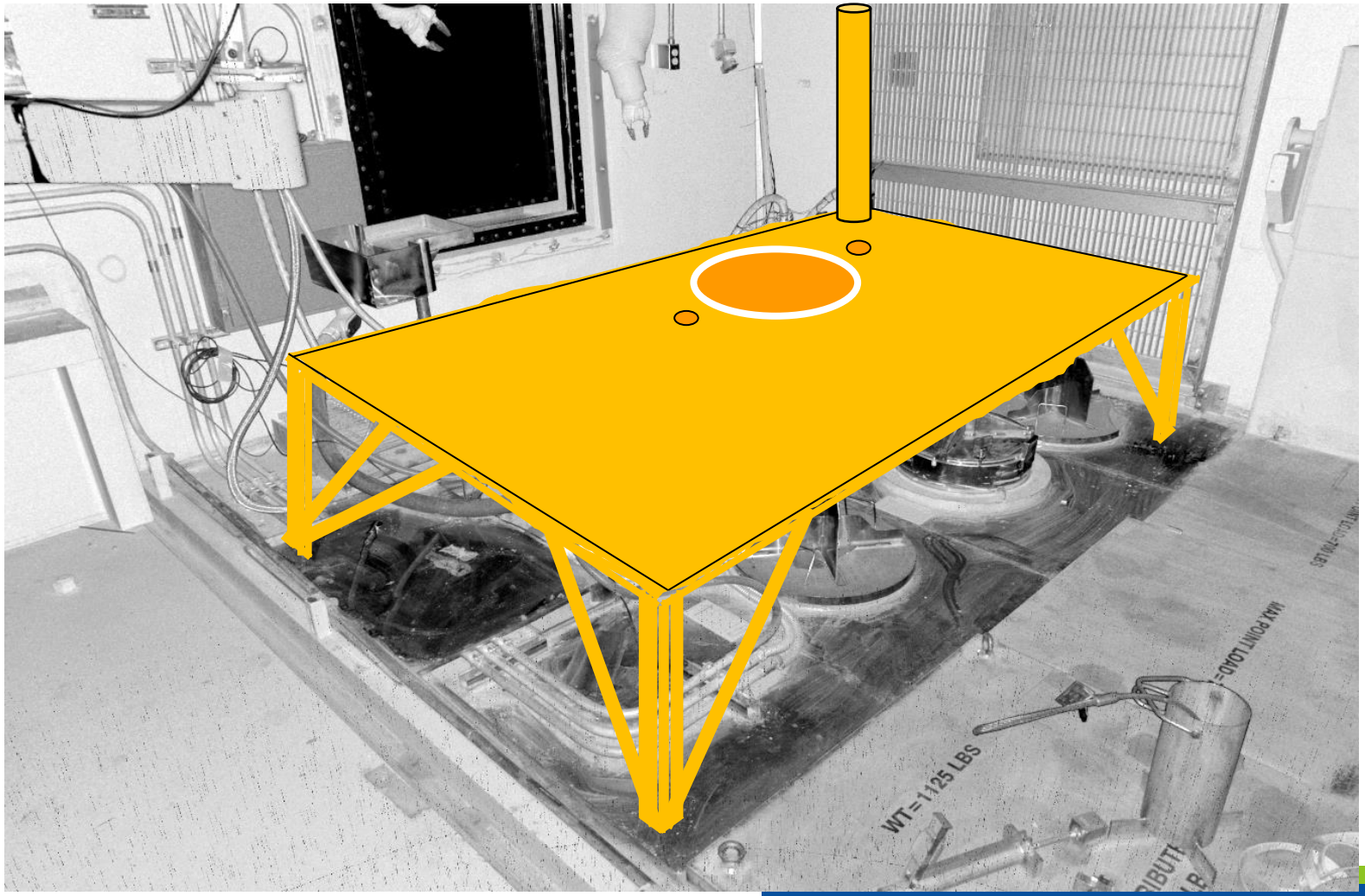
Worktable

- Worktable is a table over south floor wells
  - Emplaced prior to canister loading campaign
  - Bolted to FHC floor
- Hole down to floor well #14
- Shield/sheath between floor well #13 and floor well #14
- Mounting points for Canister Loading Sleeve (CLS)
- Mounting points as needed for equipment sleds (weld/NDE/repair/stress relief, dry/inert/backfill, etc.)
- Will require footstool at bottom of floor well #14



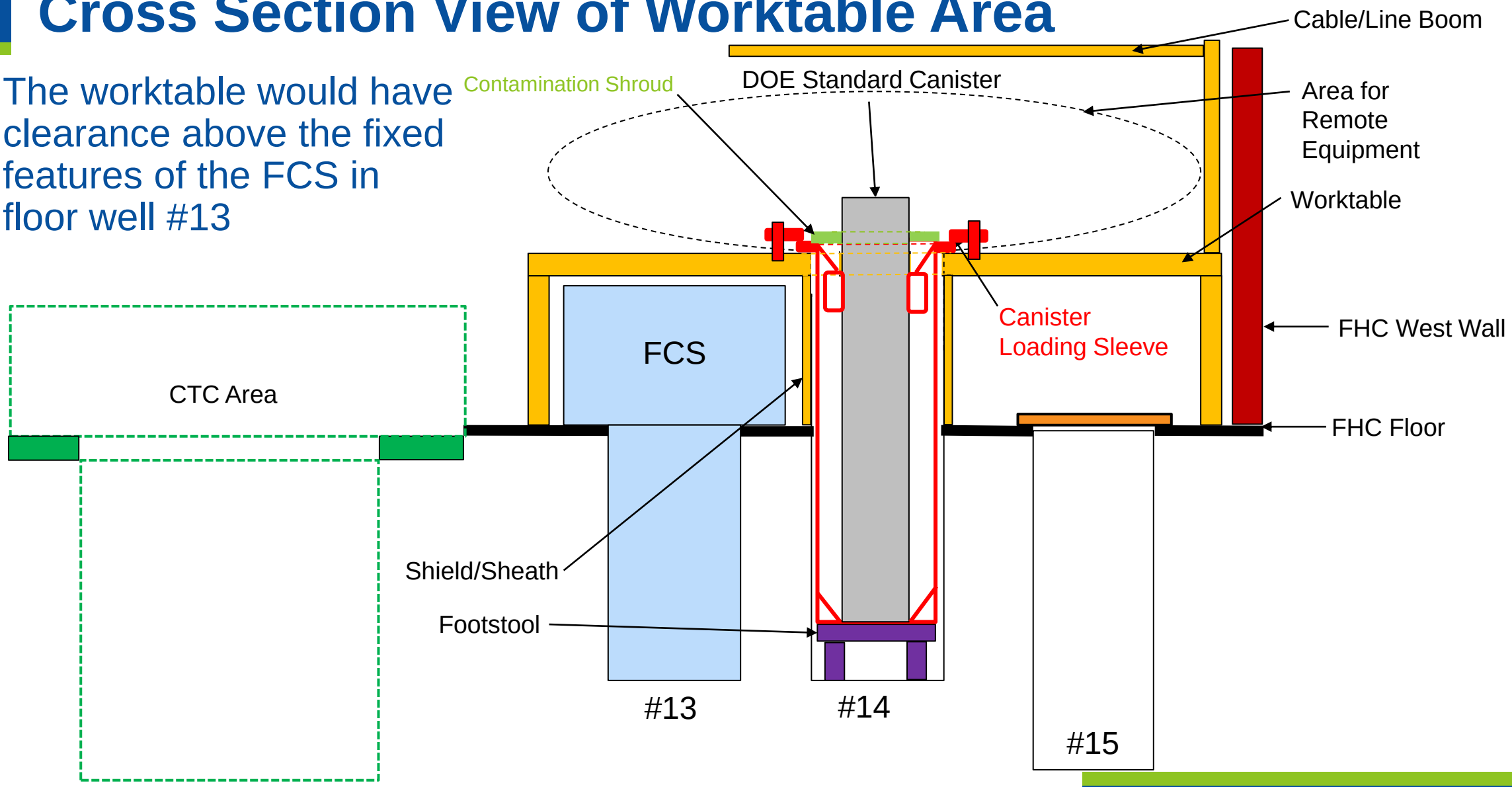
Worktable - Continued

- Solid view
- White ovals are hole with sheath/shield leading down into floor well #14
- Black lined ovals are holes where the canister loading sleeve would attach
- Number of features not shown yet
  - Extra legs & braces
  - Calibration stations
  - Cable/line boom



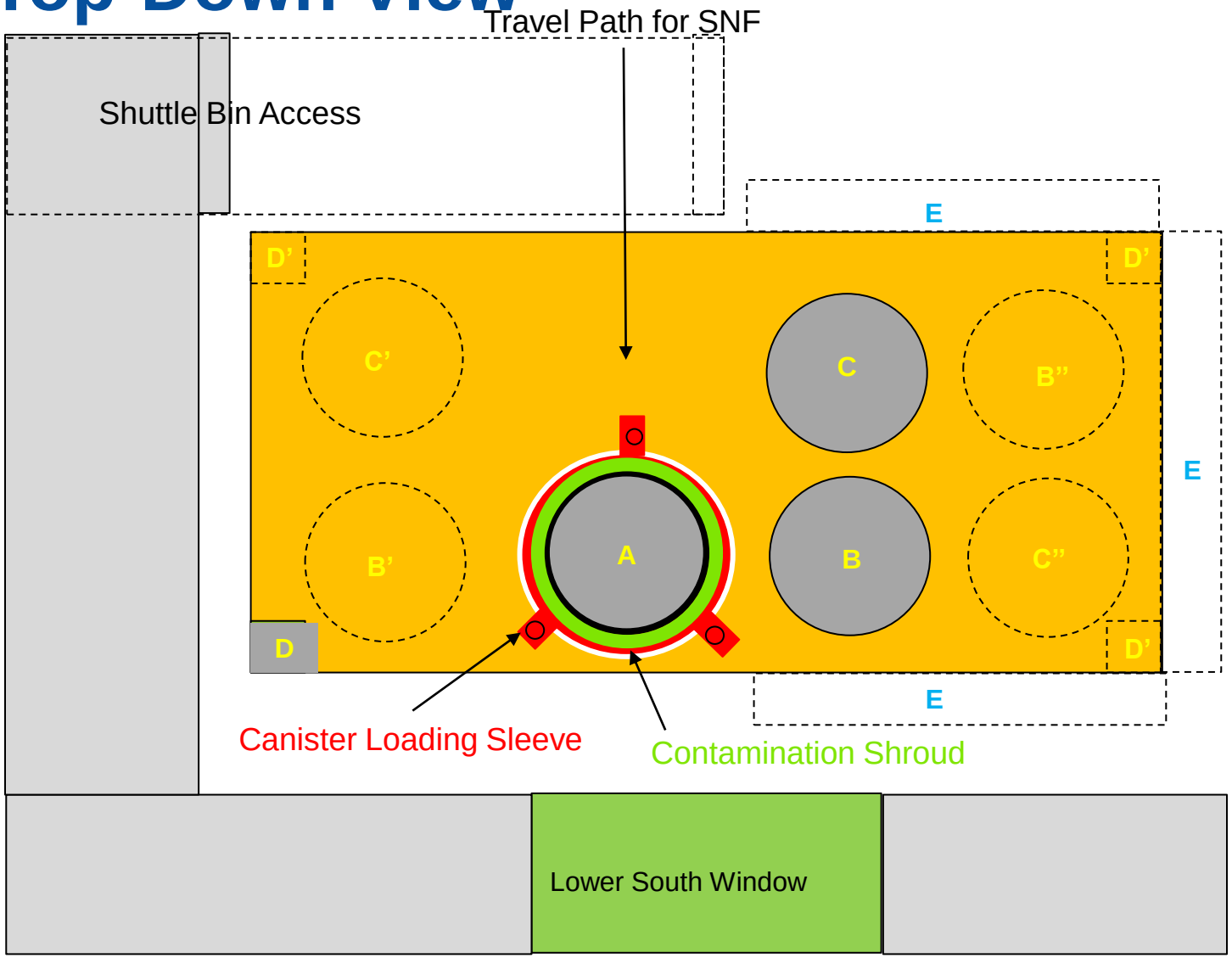
Cross Section View of Worktable Area

- The worktable would have clearance above the fixed features of the FCS in floor well #13

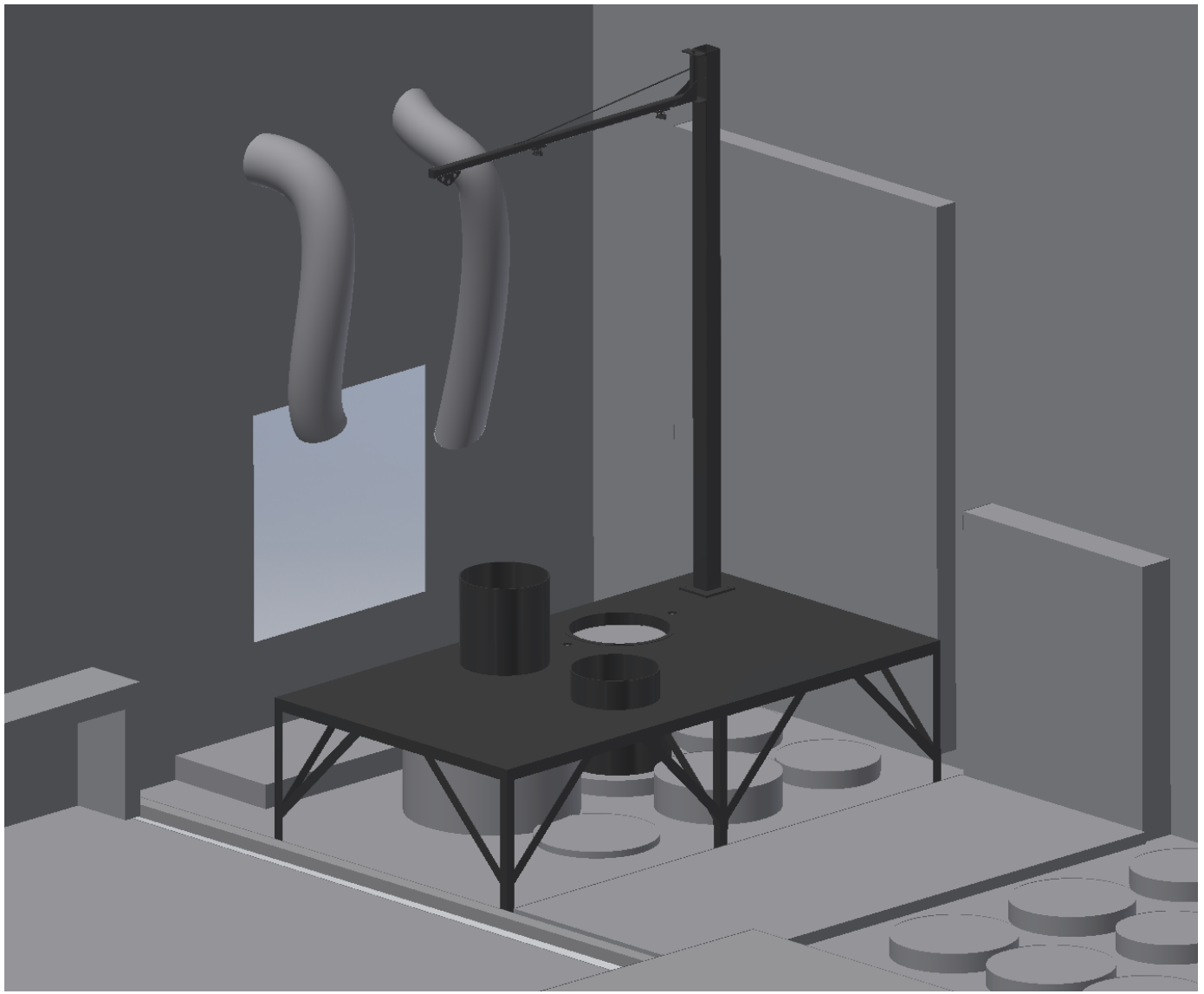


Worktable Layout – Top-Down View

- A – DOE Standard Canister
- B – site for process verification/calibration stand for circumferential weld NDE tools
- B’ – alternative site
- B’’ – alternative site
- C – site for process verification/calibration stand for vent port weld NDE tools
- C’ – alternative site
- C’’ – alternative site
- D – site for vertical post for cable/line boom
- D’ – alternative sites
- E – handling tool rack sites



Current Worktable 3D Model



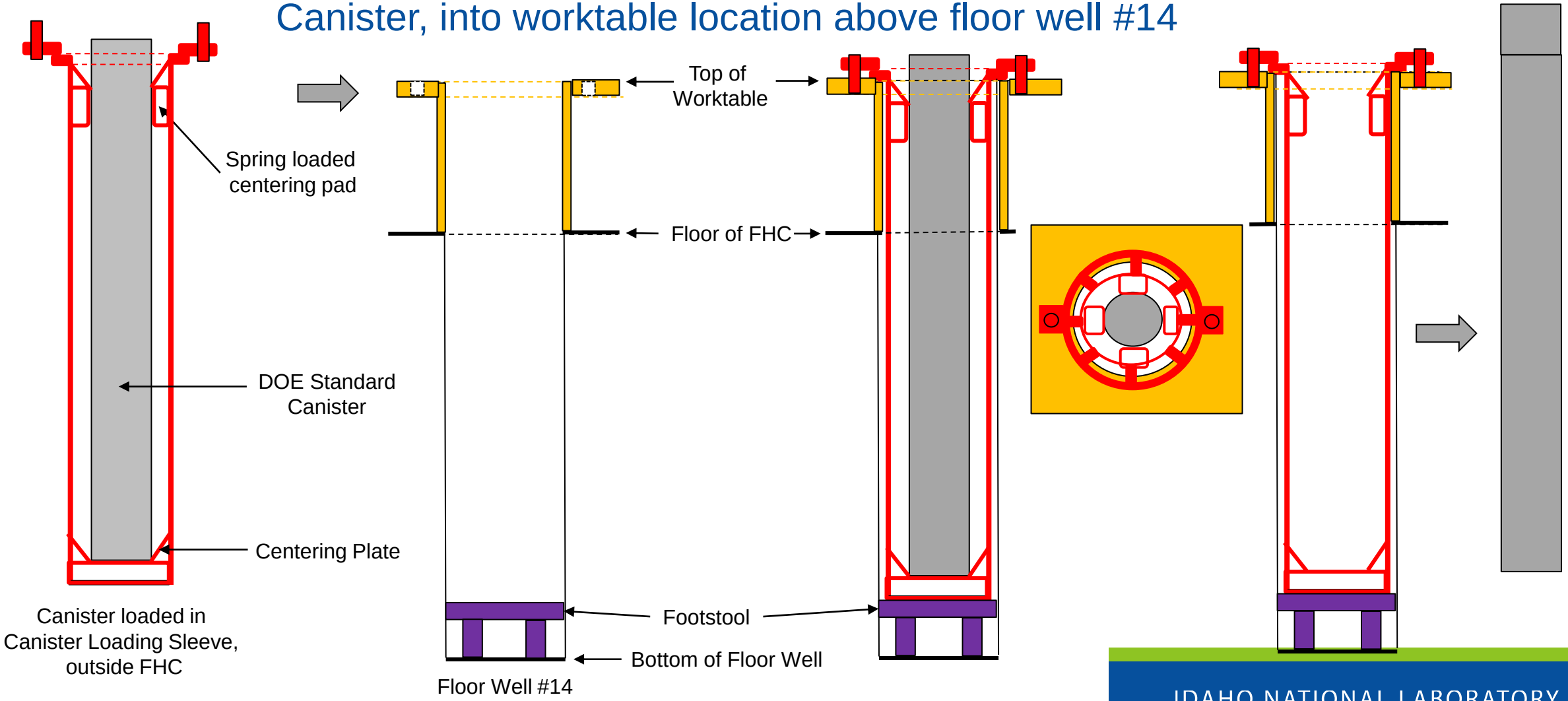
- Includes overhead cable boom for remote closure equipment
- Includes calibration stations for circumferential and vent port weld NDE inspection tools
- Does not include
  - Cable routing
  - Wall supports

Canister Loading Sleeve Design

- Functions
  - Provide lifting points/sling for empty DOE Standard Canister
  - Help center/support the DOE Standard Canister for loading and closing operations
  - Provide a contamination barrier for lower part of DOE Standard Canister
- Preliminary Requirements
  - Liftable by crane
  - Able to support itself and DOE Standard Canister (empty) for normal and seismic loadings
  - Able to be brought into the FHC via the CTC
  - Fit into worktable opening and floor well #14
  - Fit on foot stool in bottom of floor well #14
  - Have tele-manipulator compatible attachment/detachment points for the worktable
  - Have lift connections able to be moved out of the way, once the Canister Loading Sleeve is placed on footstool
  - Have tele-manipulator compatible “controls” for centering parts (e.g., spring loaded centering pads) (if needed)
  - Support mounting of contamination shrouds

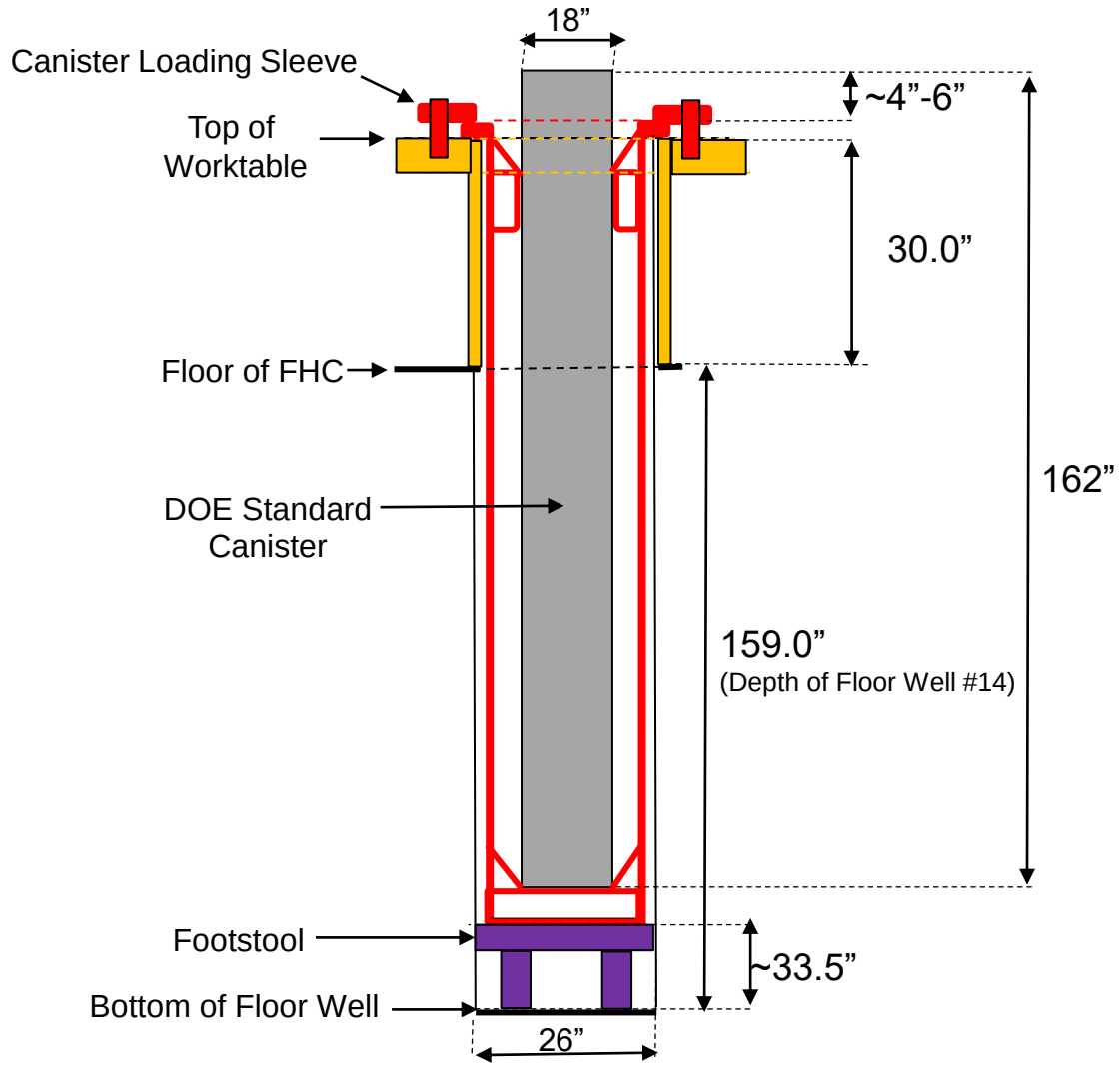
Canister Loading Sleeve

- Place Canister Loading Sleeve, loaded with DOE Standard Canister, into worktable location above floor well #14



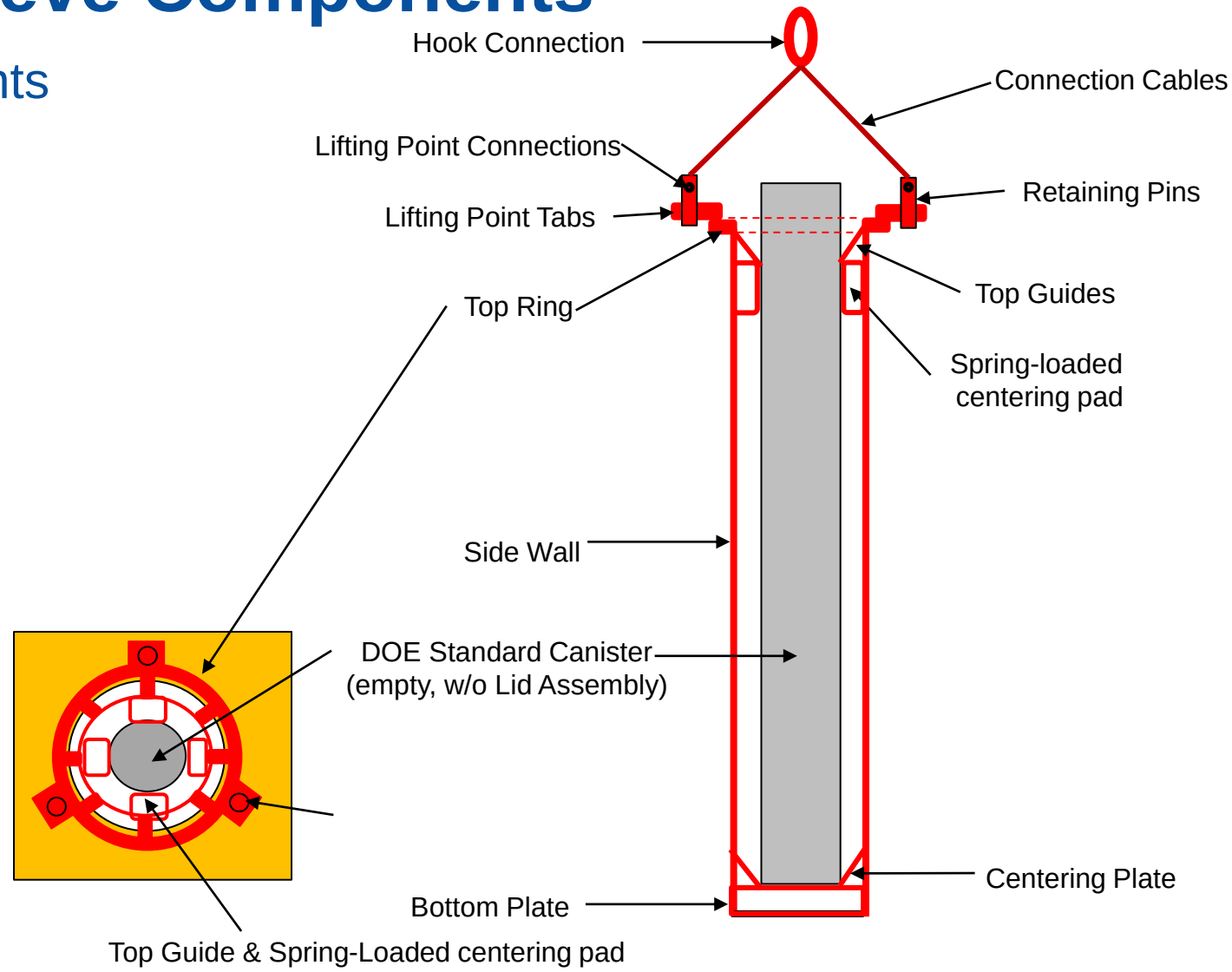
Rough Dimensions of the Canister Loading Sleeve

- Floor well #14 is 159” deep
- Worktable will be 30” tall
- Length of DOE Standard Canister main shell (excluding lid assembly height) is ~162”
- Want approximately 4 to 6” of clearance around the top edge of the DOE Standard Canister main shell for remote closure equipment tools and cameras
- If canister loading sleeve components (bottom plate and top lip) total ~0.5” in thickness (which is to be determined as part of the design process)
- Footstool height will need to be ~33.5”



Canister Loading Sleeve Components

- Canister Loading Sleeve components
  - Hook connection
  - Connection cables
  - Lifting point connections
  - Retaining pins
  - Lifting point tabs
  - Top ring
  - Side walls
  - Top guides
  - Spring-loaded centering pads
  - Centering plate(s)
  - Bottom plate



Considerations (Continued)

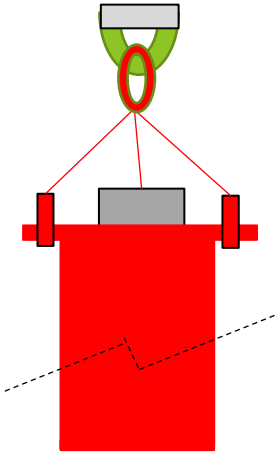
- The Canister Loading Sleeve will be loaded manually outside the FHC (with the empty DOE Standard Canister, contamination shroud, contamination shroud extension (if used), weld joint protective cap, and empty canister protective cap).
- The Canister Loading Sleeve needs to center and securely hold the empty DOE Standard Canister during handling operations outside and inside the FHC.
- Shrouds and protective caps need to be remotely removed at various times
  - Empty canister protective cap is removed after placement in worktable
  - Weld joint protective ring is removed just prior to placement of lid assembly
  - Contamination shroud extension is removed just prior to closure operations
  - Contamination shroud is removed just prior to movement of sealed canister.
- Canister Loading Sleeve needs to be remotely released from the sealed DOE Standard Canister just prior to lifting of the canister from the worktable.

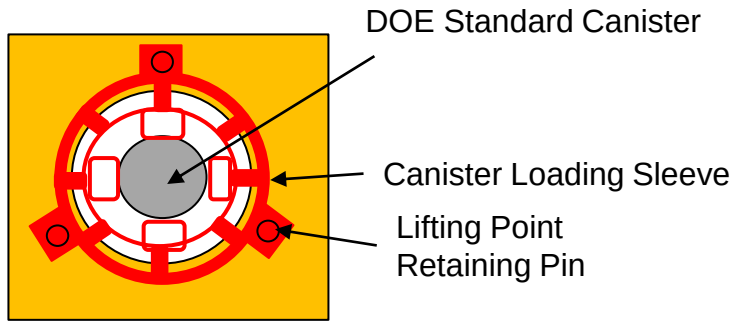
Considerations (Continued)

- Hook Connection
  - Need to interface with cranes in FHC and truck bay
  - Need safety retaining features
- Connection Cables
  - Interface with hook connection
  - Each cable able to support full weight with margin
  - Need to be able to be remotely and easily put the cables out of the way when the Canister Loading Sleeve is in the worktable
  - Need to be remotely and easily reattached to the hook connection after the DOE Standard Canisters is removed from the Canister Loading Sleeve

Considerations (Continued)

- Lifting Point Connections and Tabs
  - Some of the simple conceptual drawings in the previous slides show only 2 lifting points 180 º from one another for ease of creating the images, but this is obviously unstable.
  - Will want 3 lift points, each at 120 º angles from the other two
  - Interface with crane hook needs to be out of the way during loading and closing operations
- Retaining Pins
  - Want the Canister Loading Sleeve to “lock-in” with the worktable during loading and closure operations, then disengage when the sealed DOE Standard Canister is to be moved
  - Table engagement/retaining pins are an option (other options can be considered)
  - Useable by tele-manipulators (MSM or PaR arm)





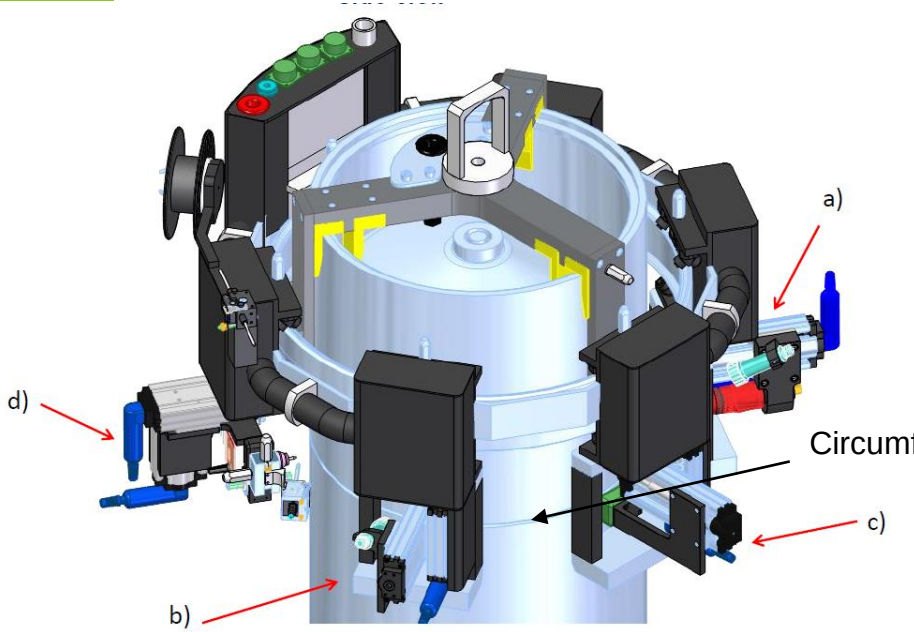
Considerations (Continued)

- Lifting Point Tabs
  - Interface with retaining pins and top ring
  - Support full weight when Canister Loading Sleeve is lifted
- Top Ring
  - Rests on top of the worktable
  - Support full weight when Canister Loading Sleeve is lifted
  - Interface with lifting point tabs and side walls
  - Possible interface with supports for top guides and centering pads (if not just attached to side walls)
- Side Walls
  - Provide contamination barrier around the lower portion of the DOE Standard Canister.
  - Interfaces with top ring and bottom plate can interface with top guides, centering pads, and centering plate (if separate support ribs aren’t used)

Considerations (Continued)

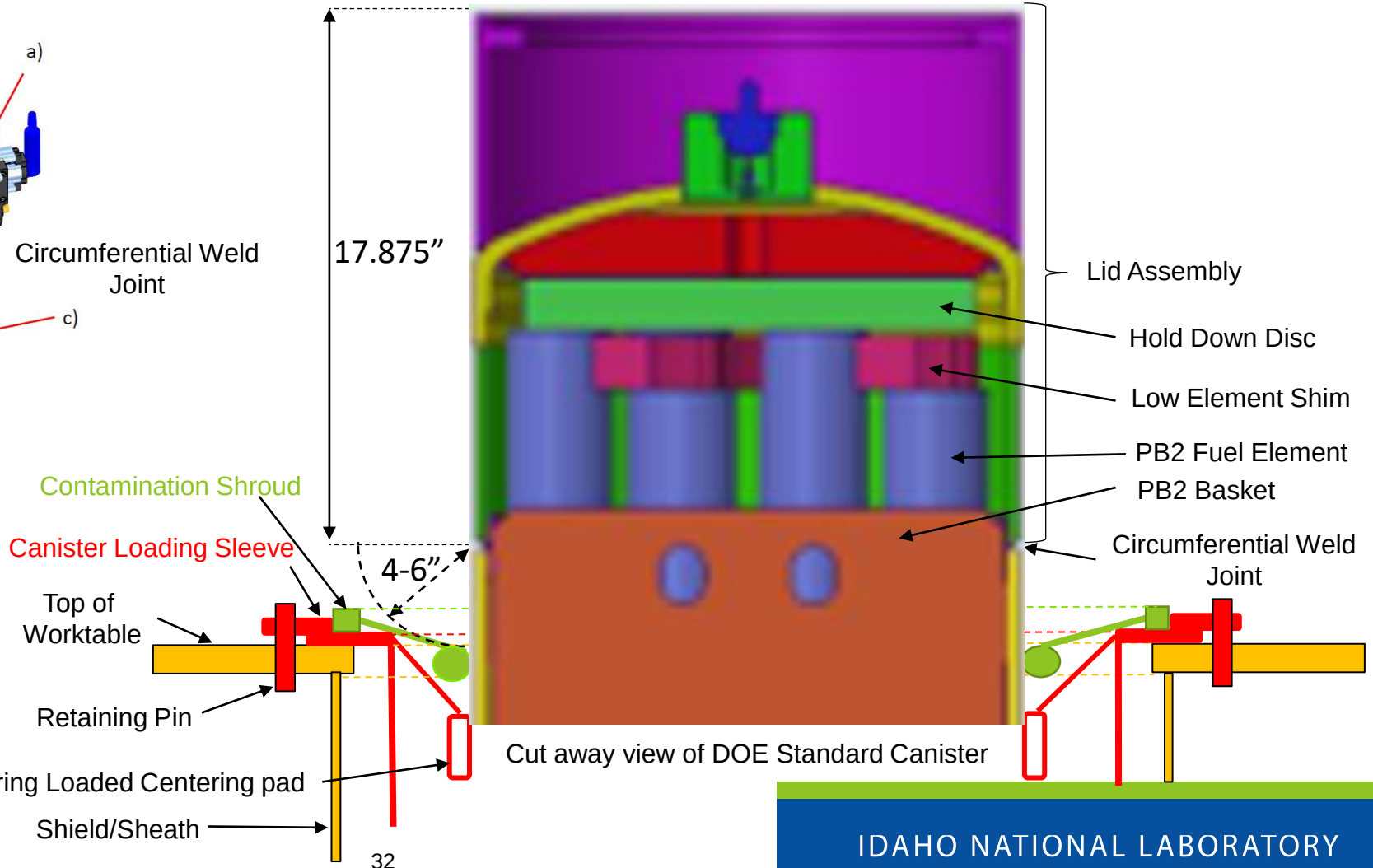
- Top Guides
  - Helps guide in and center empty DOE Standard Canister when it is being loaded
  - Attached to side wall (or support ribs attached to the top ring)
- Spring Loaded Centering Pads
  - Centers and locks the empty DOE Standard Canister into place
  - Needs to remotely release the DOE Standard Canister when it is to be moved
  - Attached to side wall (or support ribs attached to the top ring)
- Centering Plate(s) (sloped plate[s] at the bottom of the side wall)
  - Helps center empty DOE Standard Canister when it is being loaded
  - Attached to side wall (or support ribs attached to the top ring)
- Bottom Plate
  - Support full weight when Canister Loading Sleeve is lifted
  - Attached to side wall (and/or support ribs attached to the top ring)

Clearance Around Circumferential Weld Joint



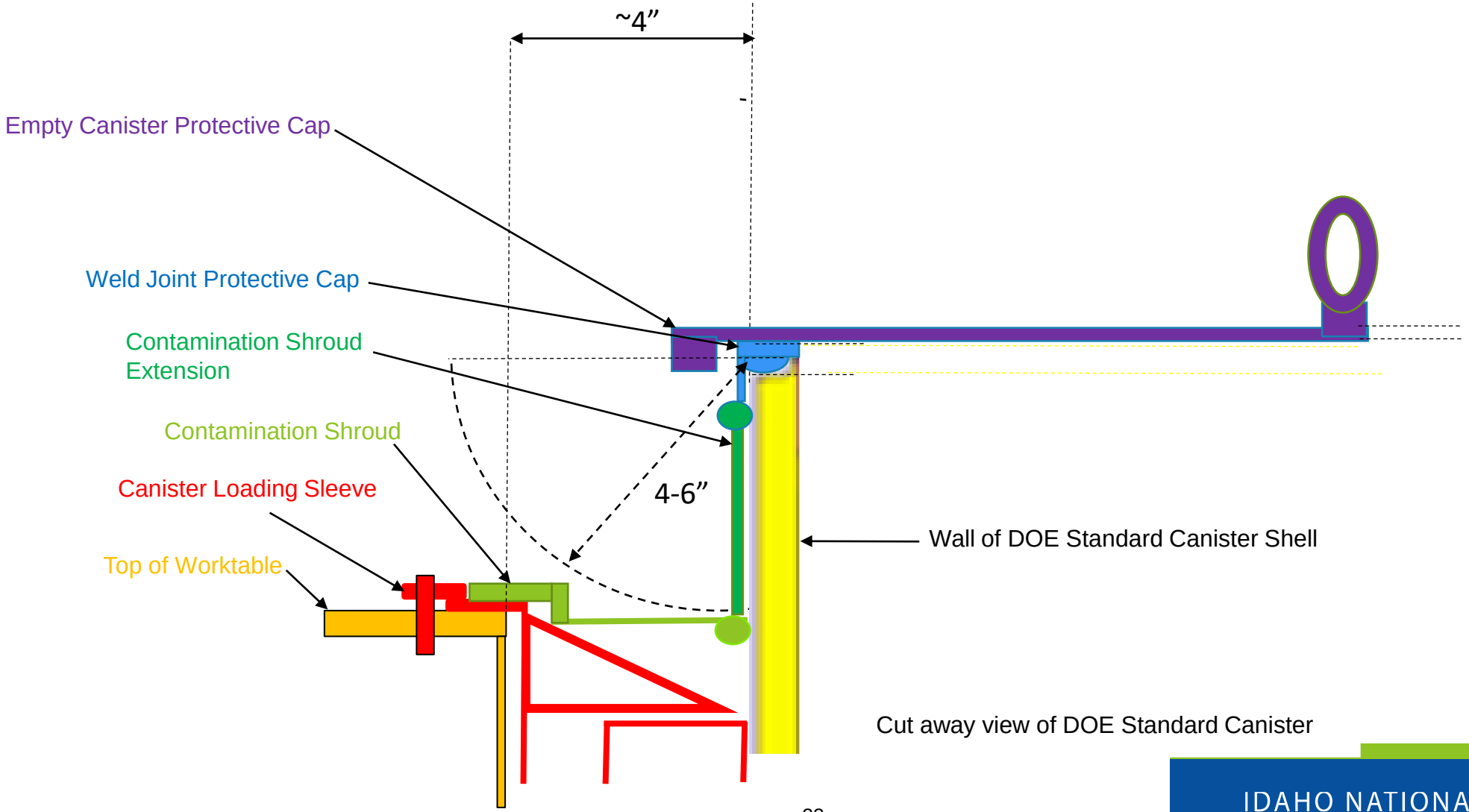
Remote Closure Equipment on DOE Standard Canister

- Want 4 to 6” around the weld joint for the remote closure equipment (welder, NDE probes, repair tool)



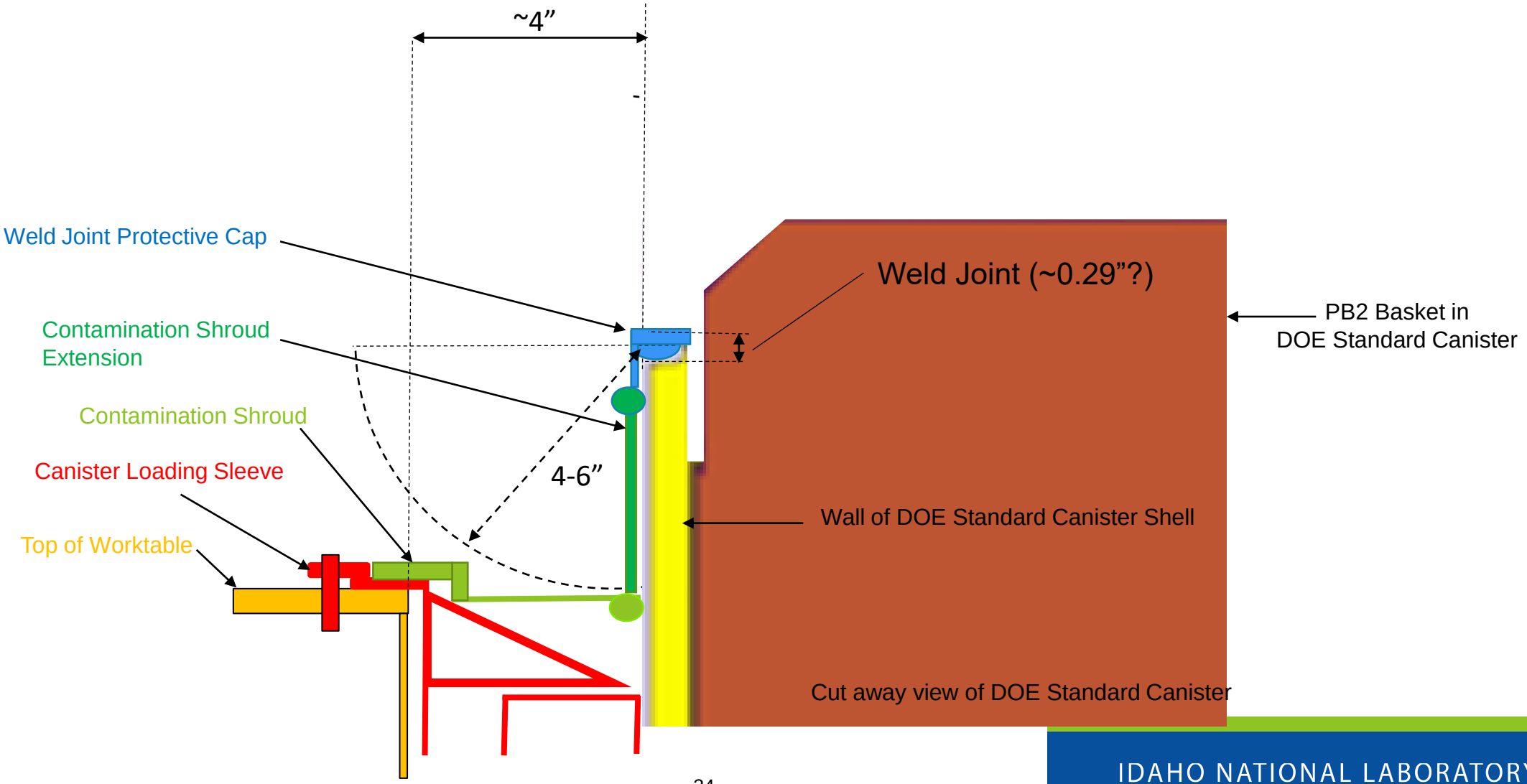
Cut away view of DOE Standard Canister

Closeup of Empty Canister Top

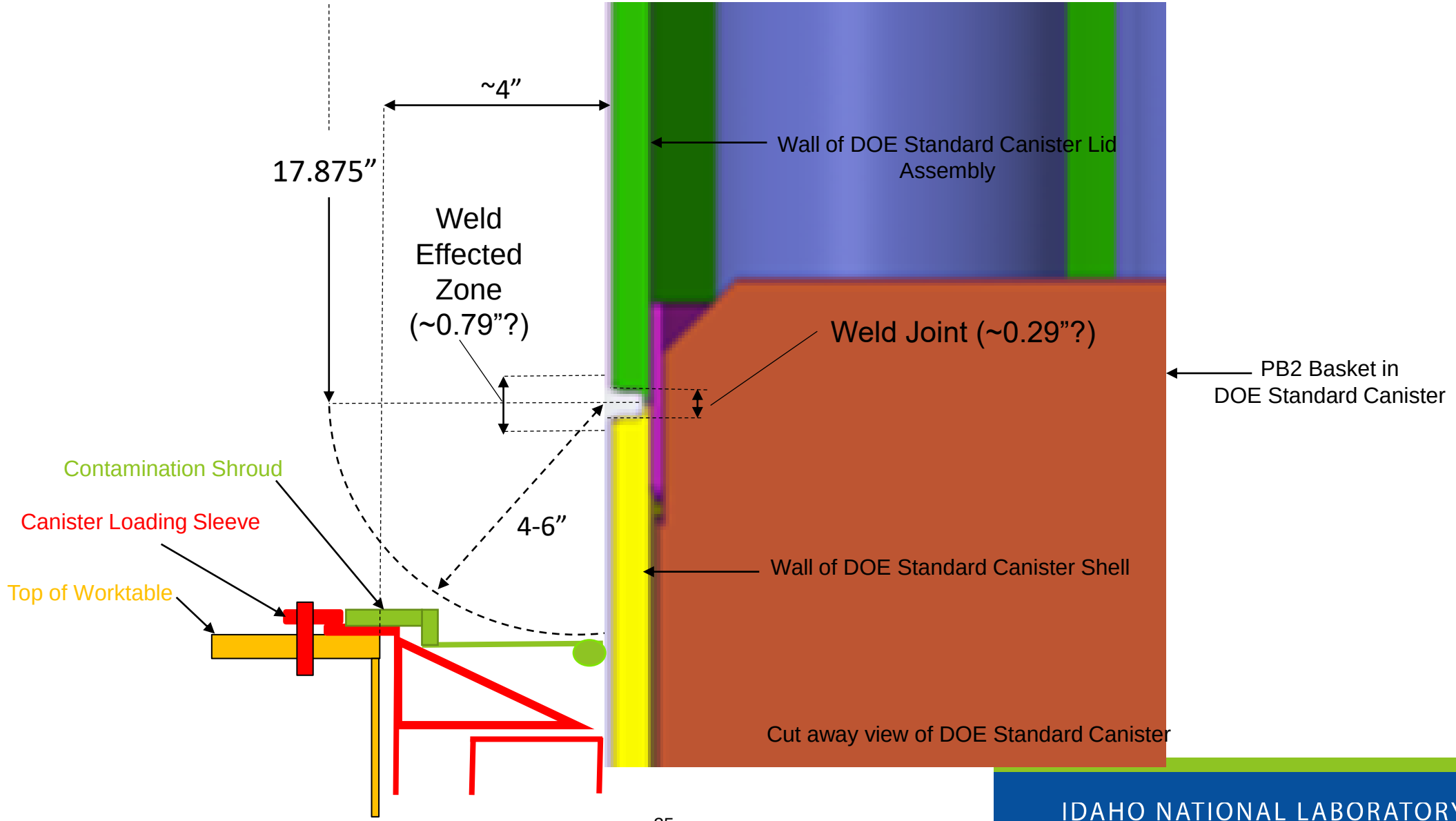


Cut away view of DOE Standard Canister

Closeup of Top of Canister with Basket (No Fuel)

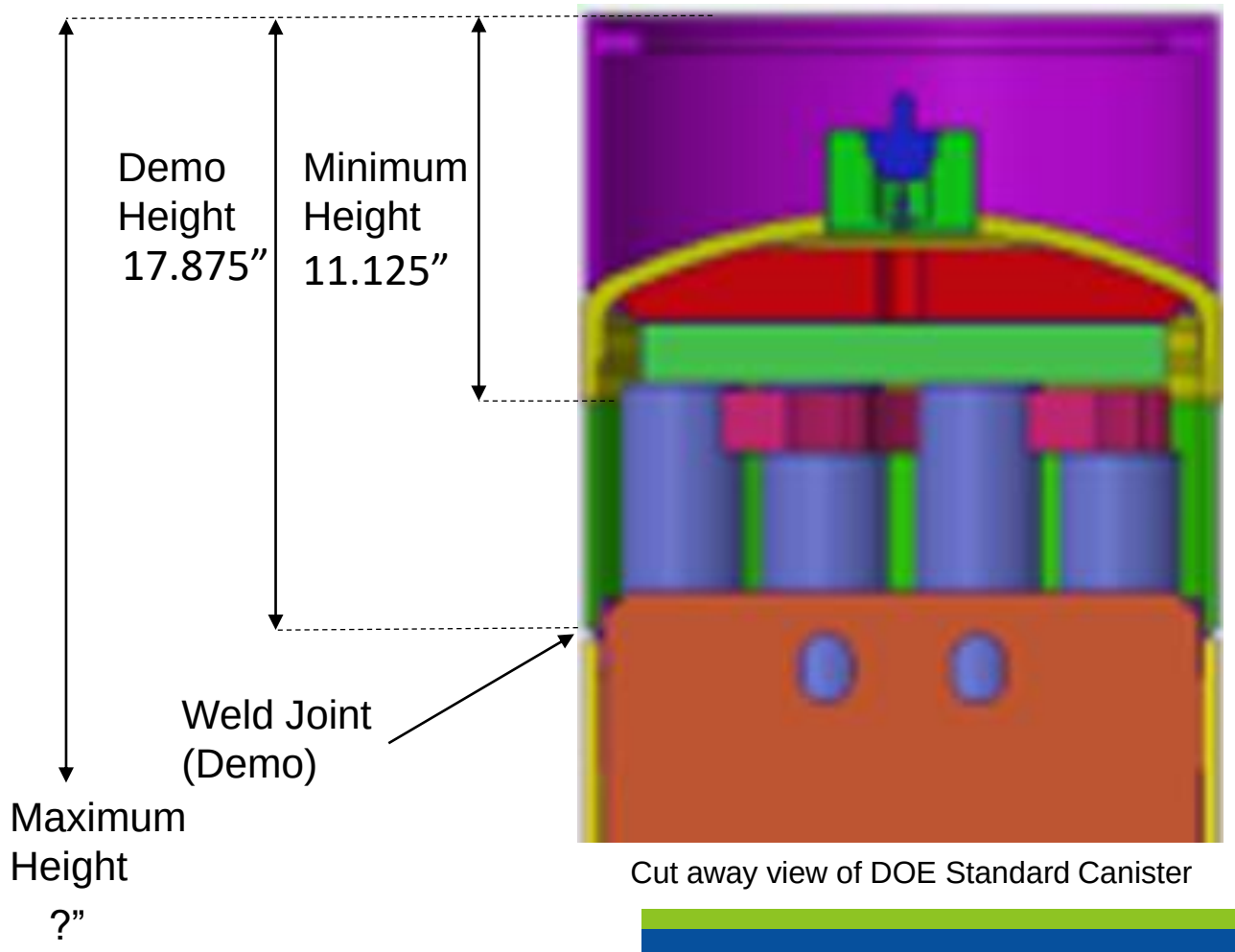


Closeup of Circumferential Weld Joint



Different Lengths

- Dimensions for the DOE Standard Canister to be used in the Packaging Demonstration are known.
- But besides the two ODs and overall lengths, the lengths of the lid assemblies may change for future DOE Standard Canister configurations to accommodate different fuel basket configurations.



Cut away view of DOE Standard Canister

Questions?