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Revision 1

Preliminary Evaluation of Loading DOE Standardized Canisters in the CPP-603 Irradiated Fuel Storage Facility

Daniel A. Thomas

October 2019

Idaho National Laboratory

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Idaho National Laboratory
Used Fuel Management, Nuclear Science and Technology Directorate
Idaho Falls, Idaho 83415

http://www.inl.gov

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Used Fuel Management, Science and Technology Directorate

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Prepared by:

Daniel A. Thomas 10/01/2019

Daniel A. Thomas
Senior Spent Fuel Analyst

Date

Approved by:

Josh J. Jarrell 10/01/2019

Josh J. Jarrell
Department Manager, Used Fuel Management

Date

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ABSTRACT

This evaluation looks at the equipment and operations necessary to load United States Department of Energy (DOE)-owned Spent Nuclear Fuel (SNF) into DOE SNF Standardized Canisters in the CPP-603 Irradiated Fuel Storage Facility (IFSF) in the Idaho Nuclear Technology and Engineering Center (INTEC) area at Idaho National Laboratory (INL). Two types of fuels are looked at in this evaluation: Advanced Test Reactor (ATR) fuel (uranium-aluminide fuel with aluminum cladding) and Peach Bottom fuel (thorium-uranium carbide fuel in a graphite matrix). The ATR fuel ready for loading would come from fuel storage canisters in the CPP-603 facility, while the Peach Bottom fuel ready for loading could come from either fuel storage canisters in the CPP-603 facility and or containers in the CPP-749 Underground Fuel Storage Facility (UFSF) – Generation I Vaults. The evaluations describe the facility, the fuel types, the DOE SNF Standardized Canisters, and existing equipment; lists the needed loading operations; reviews facility features and equipment to perform the operations; and then lists the decisions, analyses, designs, demonstrations, and modifications that will be needed to perform the loading of DOE-owned SNF into DOE SNF Standardized Canisters in the CPP-603 IFSF.

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SUMMARY

Department of Energy (DOE)-owned Spent Nuclear Fuel (SNF) is currently stored across the national laboratory complex. In some cases, the current storage facilities are reaching capacity and/or are being used beyond their planned lifetimes. A canister type has been proposed, termed the DOE SNF Standardized Canister to allow a broad range of fuels to be loaded, stored, transported, and disposed of by relying on the robustness of the canister instead of the condition of the fuel, thus avoiding the need to re-open the canister after initial loading and handling the SNF. The DOE SNF Standardized Canisters are to be used in conjunction with overpacks (storage, transport, and disposal) to meet the regulatory requirements of each function.

This Evaluation looks at the equipment and operations necessary to load DOE-owned SNF into DOE SNF Standardized Canisters in the CPP-603 Irradiated Fuel Storage Facility (IFSF), in the Idaho Nuclear Technology and Engineering Center (INTEC) area at Idaho National Laboratory (INL) site. Two types of DOE-owned fuels are looked at in this evaluation: Advanced Test Reactor (ATR) fuel (uranium-aluminide fuel with aluminum cladding) and Peach Bottom fuel (thorium-uranium carbide fuel in a graphite matrix). The ATR fuel ready for loading would come from fuel storage canisters in the CPP-603 facility, while the Peach Bottom fuel would most likely come from the fuel storage canisters in the CPP-603 facility, but could also come from containers in the CPP-749 Underground Fuel Storage Facility (UFSF) – Generation I Vaults.

The operations considered in this evaluation include handling the fuel (in ATR4 buckets for ATR fuel and bare assemblies in the case of Peach Bottom fuel), handling of non-fuel components (lid assemblies, empty canister, baskets, weld wire, gas tanks, etc.) fuel inspection, addition of inserts for criticality control (for the ATR fuel in ATR4 buckets), drying operations, addition of a moisture getter, lid welding, lid weld non-destructive examine (NDE), lid weld repair, inerting/backfill, leak test, final inerting port weld, inerting port weld NDE, inerting port weld repair, surface contamination measurements, decontamination procedures, and handling of loaded and sealed DOE SNF Standardized Canisters. The equipment considered in this evaluation includes handling tools, drying systems, remote welding/NDE/weld-repair systems, systems for inerting/backfilling, remote leak testing, surface contamination measurements, and decontamination systems.

The end result of this evaluation is lists of needed loading operations; review of the facility features and equipment to perform the operations; and a list of the decisions, analyses, designs, demonstration programs, and facility modifications needed to perform the loading operations of DOE-owned SNF into DOE SNF Standardized Canisters in the CPP-603 IFSF.

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ACKNOWLEDGEMENTS

The author would like to thank Holtec International, Nuclear Assurance Corporation International, and Orano TN for their inputs and information on current commercial industry experience, equipment, and processes.

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CONTENTS

FIGURES

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ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ATR	Advanced Test Reactor
AWS	Automated Welding System
CFM	cubic feet per minute
CMA	Crane Maintenance Area
CPP	Chemical Processing Plant / Idaho Chemical Processing Plant
CRA	Cask Receiving Area
CTC	Cask Transfer Car
CTP	Cask Transfer Pit
DHLW	defense high-level waste
DOE	U.S. Department of Energy
DP	Decontamination Pad
FCS	Fuel Conditioning Station
FHC	Fuel Handling Cave
FHD	Forced Helium Dehydrator
FSA	Fuel Storage Area,
Gd	Gadolinium
$GdPO_4$	Gadolinium Phosphate
HLAW	Hybrid Laser Arc Welding
ID	inner diameter
IFSF	Irradiated Fuel Storage Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
ISFP	Idaho Spent Fuel Project
MERF	Mobile Examination and Remediation Facility
NDE	non-destructive examine
NRC	U.S. Nuclear Regulatory Commission
NSNFP	National Spent Nuclear Fuel Program
OD	outer diameter
ORNL	Oak Ridge National Laboratory
PCS	Permanent Containment Structure
PSIG	pounds per square inch gauge
QA	quality assurance
SNF	spent nuclear fuel

TAD	Transport, Aging, and Disposal
TIG	tungsten inert gas
UK	United Kingdom
US	United States
VDS	Vacuum Drying System

Preliminary Evaluation of Loading DOE Standardized Canisters in the CPP-603 Irradiated Fuel Storage Facility

1. Introduction

1.1 Background

Department of Energy (DOE)-owned Spent Nuclear Fuel (SNF) is currently stored in several Idaho Nuclear Technology and Engineering Center (INTEC) facilities on the Idaho National Laboratory (INL) site and across the national laboratory complex. In some cases, the current storage facilities are reaching capacity and/or are being used beyond their planned lifetimes. A canister type has been proposed, termed the DOE SNF Standardized Canister to allow a broad range of fuels to be loaded, stored, transported, and disposed of by relying on the robustness of the canister instead of the condition of the fuel, thus avoiding the need to re-open the canister after initial loading and handling the SNF. The DOE SNF Standardized Canisters are to be used in conjunction with overpacks (storage, transport, and disposal) to meet the regulatory requirements of each function, similar to the concept of a multi- or triple-purpose (i.e., storage, transportation, and disposal) canister is consistent with the Transportation, Aging, and Disposal (TAD) concept developed for commercial Spent Nuclear Fuel (SNF), as well as the naval canister developed for the Naval Reactors Program. It is anticipated that utilizing DOE SNF Standardized Canisters could significantly reduce the number of canisters needed for storage, increase the loading throughput, and expedite potential backup storage options at the INL site.

1.2 Purpose/Objective

The purpose of this evaluation is to identify the operations and equipment necessary to perform canister loading operations in the CPP-603 Irradiated Fuel Storage Facility (IFSF). DOE SNF Standardized Canisters are to be loaded with Advanced Test Reactor (ATR) and Peach Bottom fuels. Any specialty equipment that needs to be developed, and any operations that need to be demonstrated, are to be identified. The expectation is that this work will lead to a refined list of decisions, analyses, designs, demonstration programs, and facility modifications needed to perform the loading operations for DOE SNF Standardized Canisters in the CPP-603 IFSF.

2. Descriptions

2.1 CPP-603 Irradiated Fuel Storage Facility

The CPP-603 Irradiated Fuel Storage Facility is located in the southwest corner of the INTEC area of INL. Construction of the Irradiated Fuel Storage Facility (IFSF) portion of CPP-603 was completed in December 1974. The IFSF was designed to provide safe, interim, fuel storage pending retrieval of the stored fuel for final disposal. To meet this goal, the main operations performed in the IFSF include receiving nuclear fuels from other facilities, repackaging and conditioning fuels for interim storage, safely storing fuels, storing fuel-loaded storage casks on an interim basis, and packaging fuels for removal from the facility. The facility mission will continue until all fuels have been removed. It is projected that the facility will continue to store fuel until 2035. During the life of the facility, activities resulted in contamination of some areas of the building. Decontamination efforts were made in the areas that are readily accessible; however, all areas have not been decontaminated to a clean state. This facility is monitored by the Radiation Protection Program to ensure protection of facility workers.

CPP-603 facility's IFSF functional areas include the (1) truck bays (including Cask Receiving Area (CRA), east/west truck bay, and north/south truck bay), (2) Cask Transfer Pit (CTP) and Permanent Containment Structure (PCS), (3) Fuel Handling Cave (FHC), (4) Fuel Storage Area (FSA), (5) control room/instrument room, (6) Crane Maintenance Area (CMA), and (7) Decontamination Pad (DP). Fuel, packages, and heavy equipment are moved into the facility via the truck bays, then into the PCS and CTP into the FHC using the Cask Transfer Car (CTC). After various operations in the FHC, fuel in storage canisters are moved into the FSA via a Shuttle Bin and placed in storage racks with the crane (CRN-GSF-101).

A detailed description of the CPP-603 IFSF is provided in Chapter 2 of the Safety Analysis Report for the Irradiated Fuel Storage Facility (IFSF) [1]. The key location for this evaluation is the FHC, and additional details for it are provided in the following sections.

2.1.1 Fuel Handling Cave (FHC)

The FHC is used for receiving fuel and packaging from the CRA on the CTC, transferring materials between shipping casks and storage containers, preparing materials for storage, examining fuel with the in-cell examination system, and conditioning fuels in the Fuel Conditioning Station (FCS). To perform these functions, the FHC is equipped with manipulators, cranes, two shielding windows, video cameras; floor wells for temporarily storing fuel; and a Shuttle Bin for transferring fuel storage canisters between the FHC and the FSA. In addition, the IFSF is serviced by the CTC to move casks and other equipment between the FHC and the CRA. The CTC travels over the CTP, which connects the East side of the FHC with the PCS in the CRA. A 1' thick Steel Floor Plate covers the north end of the CTP in the FHC and provides a potential laydown area or staging for lids and equipment. The access area into the Labyrinth enters into the area on the Steel Floor Plate. The FHC is 24 ft wide × 23 ft long.

The south wall between the CRA and the FHC is 57 in. thick. A shielding window and two wall-mounted manipulators are located near the center of the wall. The manipulators can be used to handle fuel and equipment in the FHC. A 20-ft-high shielding wall extends north and south just under the crane bridge, separating the CMA from the FHC. The wall is sufficiently effective in reducing radiation fields from fuel in the FHC to allow personnel to work in the CMA, even though some scatter may come over the wall. A labyrinth in the wall allows passage between the two areas while still providing shielding. A catwalk platform to crossover between the north and the south shield wall may be installed to allow access to equipment while performing maintenance tasks.

The 57-in.-thick north wall separates the FHC from the control and instrument room. A shielding window and two ports for wall-mounted manipulators are located near the center of the wall in the control room. The manipulators are not installed. The several offset penetrations in the wall allow camera and instrument leads to be run into the control room.

The FHC is separated from the FSA by a 36-in.-thick concrete wall that extends from the floor well pit floor 18 ft below grade to 20 ft above grade, just under the crane bridge. A movable shielding door rolls along the top of the wall so that the area between the wall and the facility roof can be closed off. A removable plug is built into the top of the shielding wall near the south end, which when removed, provides sufficient clearance for the CRN-GSF-401 Crane with the electromechanical manipulator (MAN-GSF-401) to pass into the FSA. An opening in the lower portion of the wall, measuring 3 ft wide × 15 ft high, allows the Shuttle Bin to move fuel storage canisters and equipment between the FSA and FHC. Approximately 5 ft of the opening is above floor level.

The FHC's manual manipulator window work station is at the floor level (south wall, near west corner near the South Floor Wells) and one upper level control room window (north wall, near west corner near the North Floor Wells) from which the electromechanical manipulator, Shuttle Bin, and the CRN-GSF-101 crane can be operated. The FSA has one window from which the CRN-GSF-101 crane is controlled when it is placing canisters in the grid or retrieving them for placement in the Shuttle Bin. To maintain the crane, it must be moved to the Crane Maintenance Area adjacent to the FHC. Personnel access to the FHC is possible if all fuel has been removed.

Sectional and plan views of the CPP-603 facility are shown in Figures 1 and 2. A sectional view of the Cask Transfer Car (CTC) in FHC, CTP, and CRA is shown in Figure 3. A cut-away 3D view of the FHC is shown in Figure 4.

2.1.2 FHC Floor Wells

The FHC pit occupies the west half of the FHC. The FHC pit contains the Shuttle Bin pit, two cave storage floor well racks, and the cave exhaust plenum. The Shuttle Bin is located in the center of the FHC's west wall, with a storage rack on both the north and south sides. The two racks contain a total of 15 carbon-steel floor wells for temporary storage of fuel, fuel packages, or equipment. Each well has an assigned number for inventory control and tracking.

Wells 1 through 9 are in the north rack, and 10 through 15 are in the south rack. Wells 1 through 11 are sized for the IFSF fuel storage canister. These wells are 20.5 in. in diameter and 13 ft 3 in. deep and must use an adapter sleeve to support an IFSF fuel storage canister. Wells 12 and 15 were sized for Fort St. Vrain fuel. These wells are 20.5 in. in diameter and 16 ft 7 in. deep. Wells 13 and 14 were sized for Peach Bottom fuel shipping baskets at 26 in. in diameter and 13 ft 3 in. deep. Well 13 is used for the FCS (for a more thorough discussion of the FCS see Section 2.5.8.1). If smaller containers are placed in the wells, adapter sleeves may be used to reduce the diameter and depth of the wells. The wells may be covered with removable, steel cover plates. A 1-in.-diameter drain line at the bottom of each well connects to a 2-in.-diameter common header that discharges to the cask transfer pit sump. The floor around the floor wells and the lower 6 in. of the cave walls are lined with stainless steel.

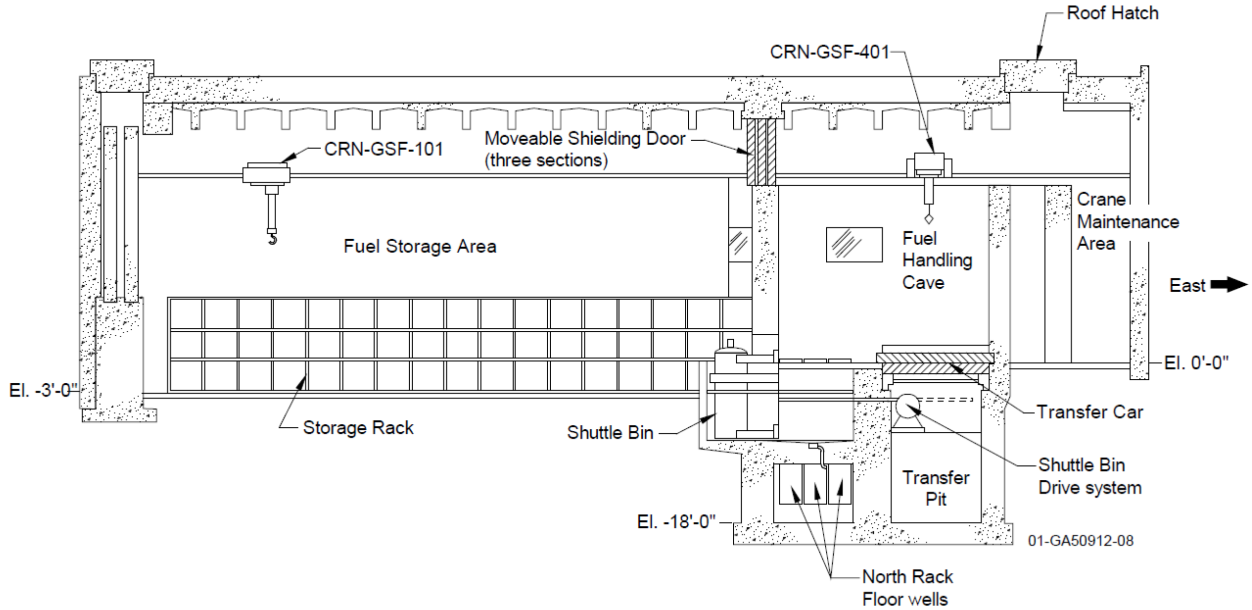

Figure 1. Section View of CPP-603 Irradiated Fuel Storage Facility.

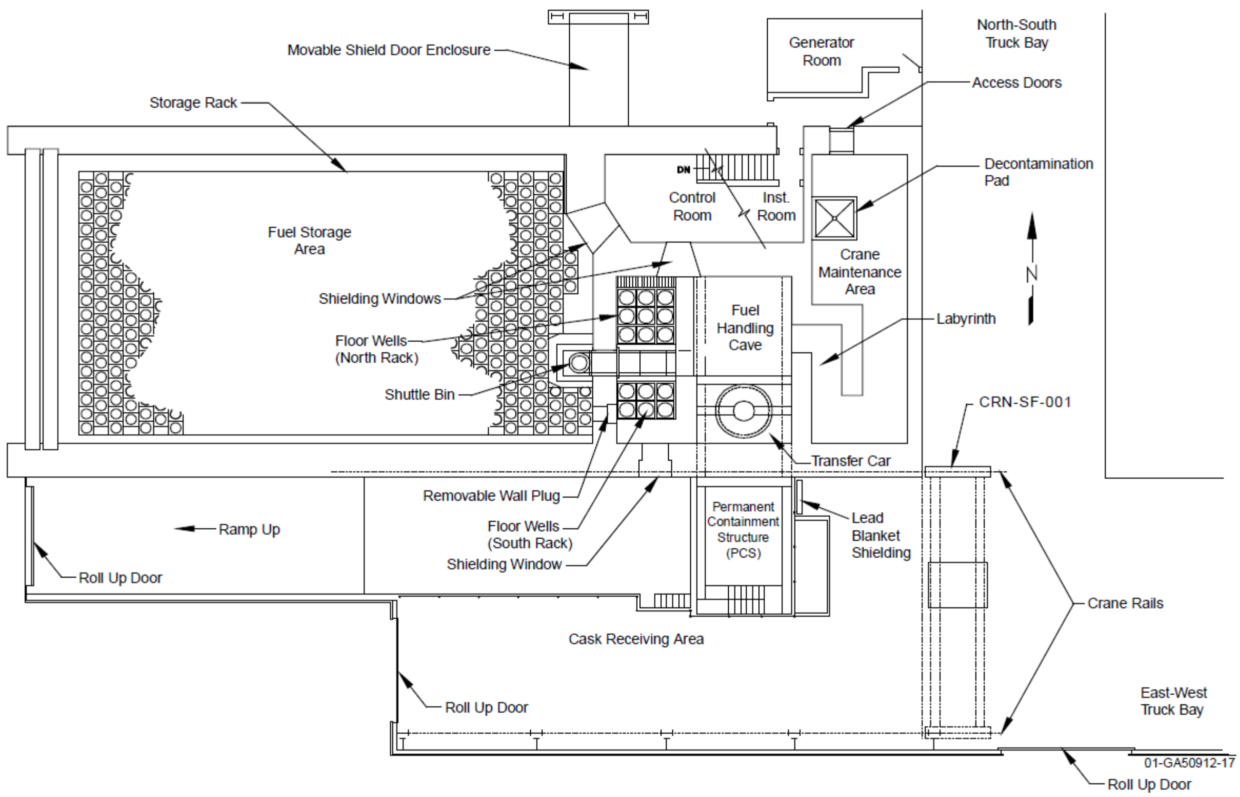

Figure 2. Plan View of CPP-603 Irradiated Fuel Storage Facility.

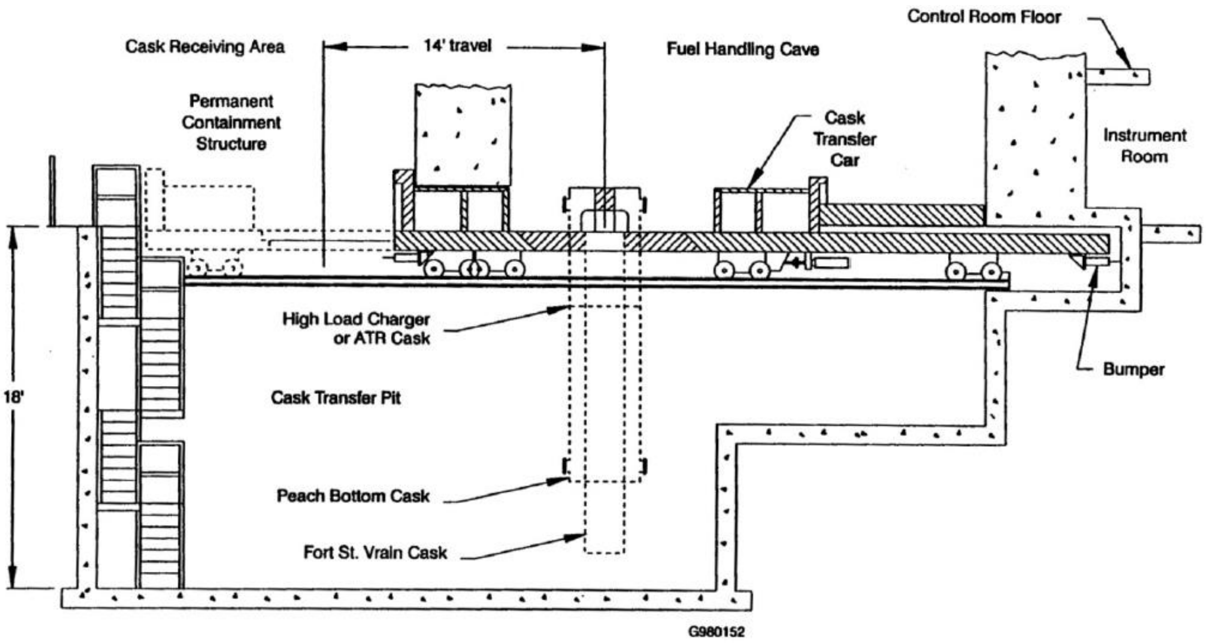

Figure 3. Section View of Cask Transfer Car (CTC) in FHC, CTP, and CRA.

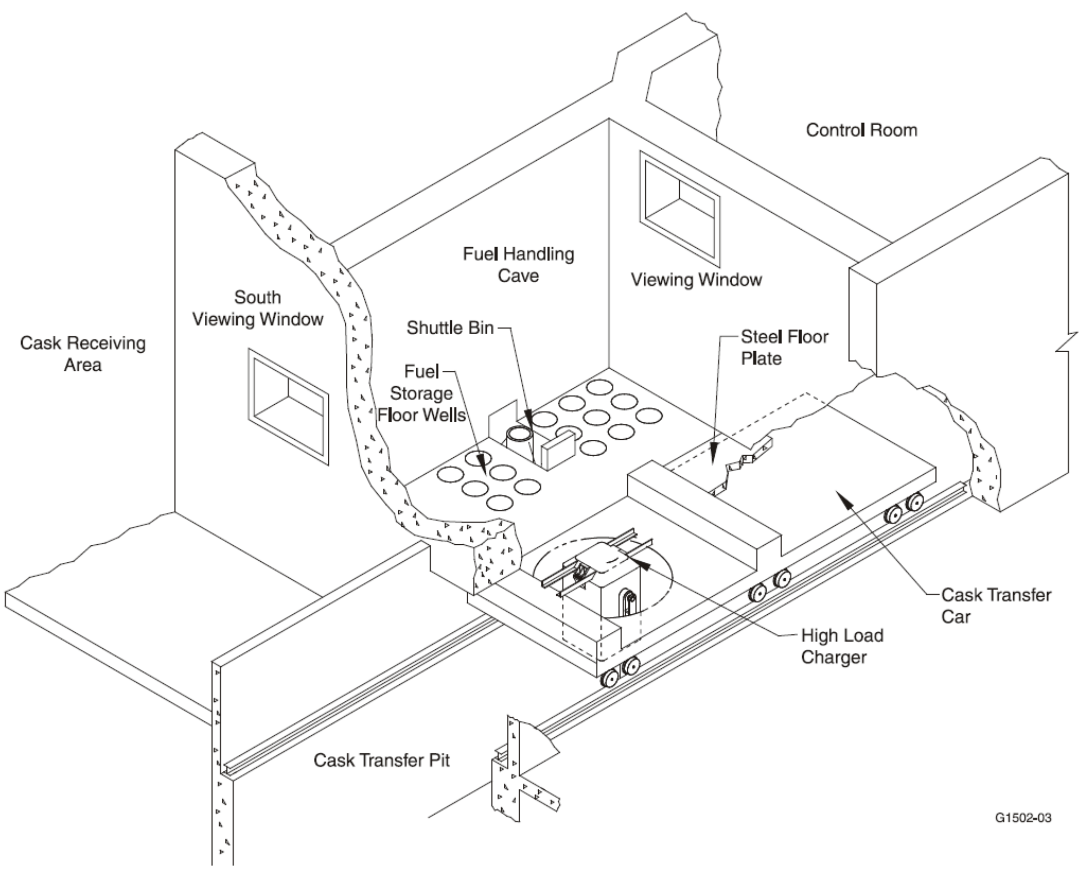

Figure 4. Isometric View of the CPP-603 Fuel Handling Cave (looking North-West).

2.2 Fuel Types

For this evaluation, two types of irradiated fuel will be looked for loading into DOE SNF Standardized Canisters: ATR Fuel and Peach Bottom Fuel. The fuel types are descripted in the following sections.

2.2.1 Advanced Test Reactor Fuel

2.2.1.1 ATR Fuel Elements

ATR fuel is a uranium-aluminide fuel with aluminum cladding. The intact fuel assemblies are about 66.3 inches long, but for post-irradiation storage, the ends are cut off so that the cropped assembles are less than 51 inches long (nominally 49½ inches), with an active fuel region that is 48 inches long. The stored fuel elements consist of 19 fuel plates held together by two non-fueled side plates. The fuel plates are swaged into grooves in the side plates. The fuel loading of each plate varies slightly with the nominal fuel loading of the entire element at 1,075 g of U-235 with an enrichment of 93.5 wt%. The element is 2.57 inches thick from the inner plate to the edge of the outer plate. The plates have a thickness of 0.05 inch except for plates 1 and 19, which have a thickness of 0.08 inch and 0.10 inch, respectively. The water gap between the plates is 0.078 inch. The inner radius of the inner fuel plate is 3.015 inches and the outer radius of the outer fuel plate is 5.45 inches. A diagram of the ATR fuel element is shown in Figure 5. The end structures are removed from the ATR fuel elements prior to transfer from the ATR Complex. The cut element length is typically less than 50 inches, while the uncut fuel length is approximately 66 inches. A comb at both ends of the fuel plates is pinned in place through the end cladding of the plates and the comb at the top is used to handle individual elements at the Fuel Storage Area (FSA) with a small hook tool, since the end structures have been removed. A further description of the ATR fuel may be found in previous evaluations [2].

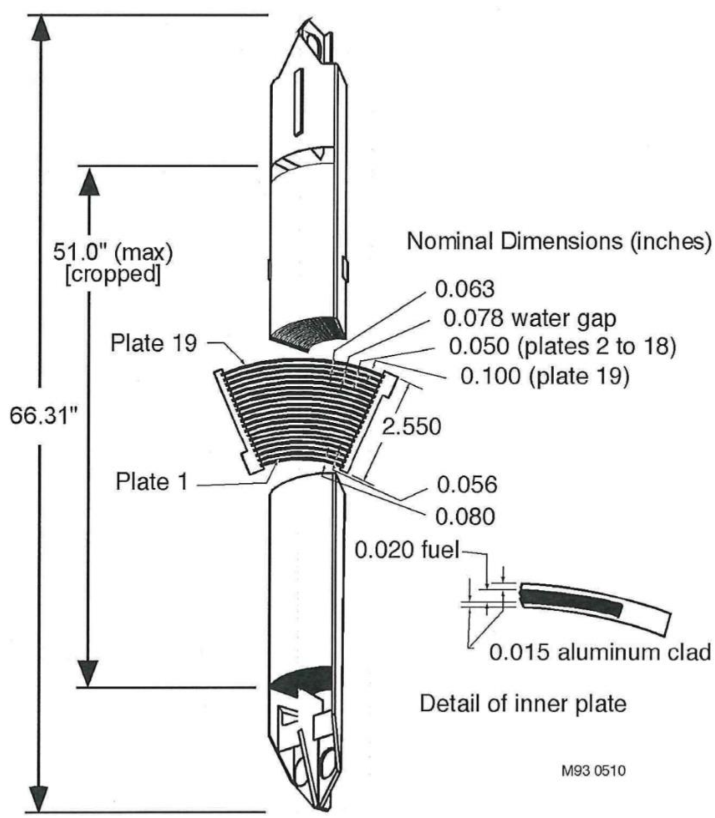

Figure 5. ATR Fuel Assembly

2.2.1.2 ATR4 Bucket

The ATR Fuel elements in the CPP-603 Facility in Storage Canisters are “pre-packaged” in buckets (open containers with handling fixtures). These buckets are formally called “CPP-603 Irradiated Fuel Storage Facility (IFSF) 4 Compartment Bucket for ATR Fuel”, or ATR4 Buckets for short. The description details of the ATR4 Buckets can be found on drawing number 808038, titled “CPP-603 IFSF 4 Compartment Bucket for ATR Fuel” [3]. The ATR4 bucket is divided into 4 storage compartments for the ATR elements. The dimensions that follow are nominal dimensions. The outer walls of the bucket are constructed of 16-gage (0.059 inch) stainless steel sheet with an outer radius of 8.5 inches and nominal widths of 8.43 inches on the flat sides. The four compartments are partitioned by 0.105 inch (12-gage) stainless steel sheet bent to interface with the center rectangular tube. The outer bucket walls and inner (center) walls are 49.64 inches from the top of the bottom plate, while the inner (center) walls have an additional projection with a height of 50.6 inches to aid with loading of the fuel elements. The design of the compartments allows only one element per compartment. The central rectangular tube, which serves as a lifting fixture, is square stock with 16-gage walls (0.065 in.) and dimensions of 1 inch by 3 inches. The base plate is 1/8 inch thick. The bucket drains contained water through the thirty-four holes with a ¼ inch diameter in the base plate and through a total of six 1.0-inch diameter half circle holes at the bottom of the outer walls. There are two half-circle drain holes per outer wall, which overlap the Base Plate by 1/16 inch. A diagram of an ATR4 bucket is shown in Figure 6, which is an isometric view of the ATR4 bucket. The plan view of the ATR4 bucket is shown in Figure 7 along with a closer view of the lifting features.

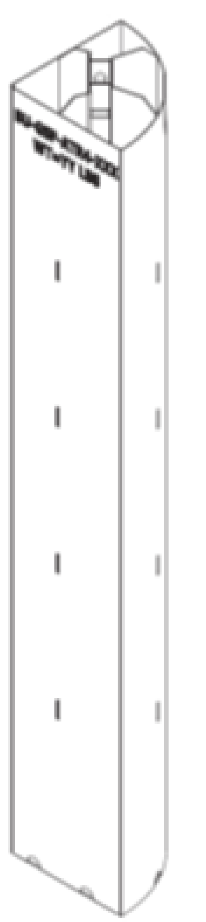

Figure 6. BU-GSF-ATR4 Bucket

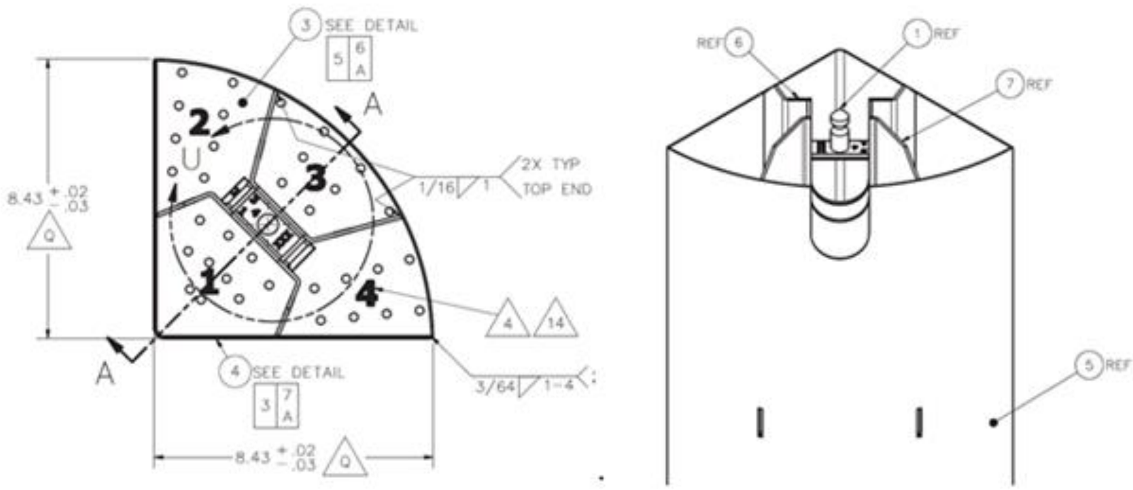

Figure 7. Plan and Detail Views of the BU-GSF-ATR4 Bucket

2.2.2 Peach Bottom Fuel

Peach Bottom fuel is a thorium-uranium carbide fuel in a graphite matrix. The assemblies have the outward appearance of a graphite cylinder 3.5 inches in diameter and 144 inches long for the intact fuel assemblies (see Figure 8). For post-irradiation storage in the IFSF, the top approximate 18 inches were cut off, and the cropped assembles are now approximately 126 inches long (see Figure 9). Additional details about the fuel can be found in a summary report about the Peach Bottom fuel [4], and an earlier report [5] much of the summary report was based on.

NOTE:

> In addition to the intact Peach Bottom Core 1 fuel assemblies and cropped/shortened Peach Bottom Core 2 fuel elements, there is one Peach Bottom element that was dropped and shattered into pieces [18]. These broken graphite SNF pieces are contained in a single Storage Canister. The broken Peach Bottom fuel element is not being addressed or considered in this evaluation. The CPP-603 Facility is not setup to handle broken graphite SNF, since there is too much manned entry required in the FHC and CMA. If the broken Peach Bottom fuel needs to be addressed, an idea is to pack the current Storage Canister whole and unopened into a Large-Long DOE SNF Standardized Canister with appropriate spacers.

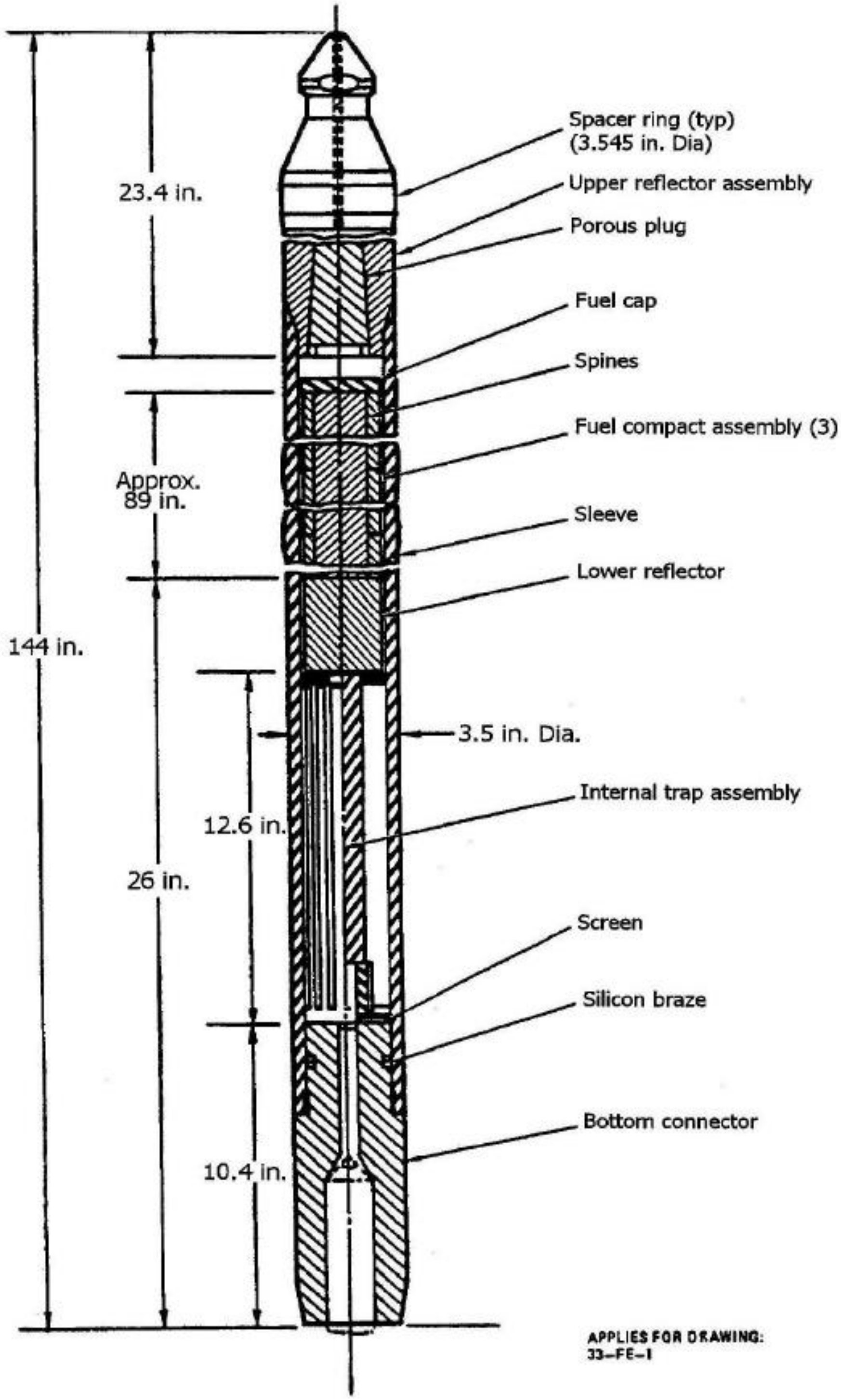

Figure 8. Peach Bottom Core 1 Fuel Element ([4] Figure 3, [5] Figure 3-1)

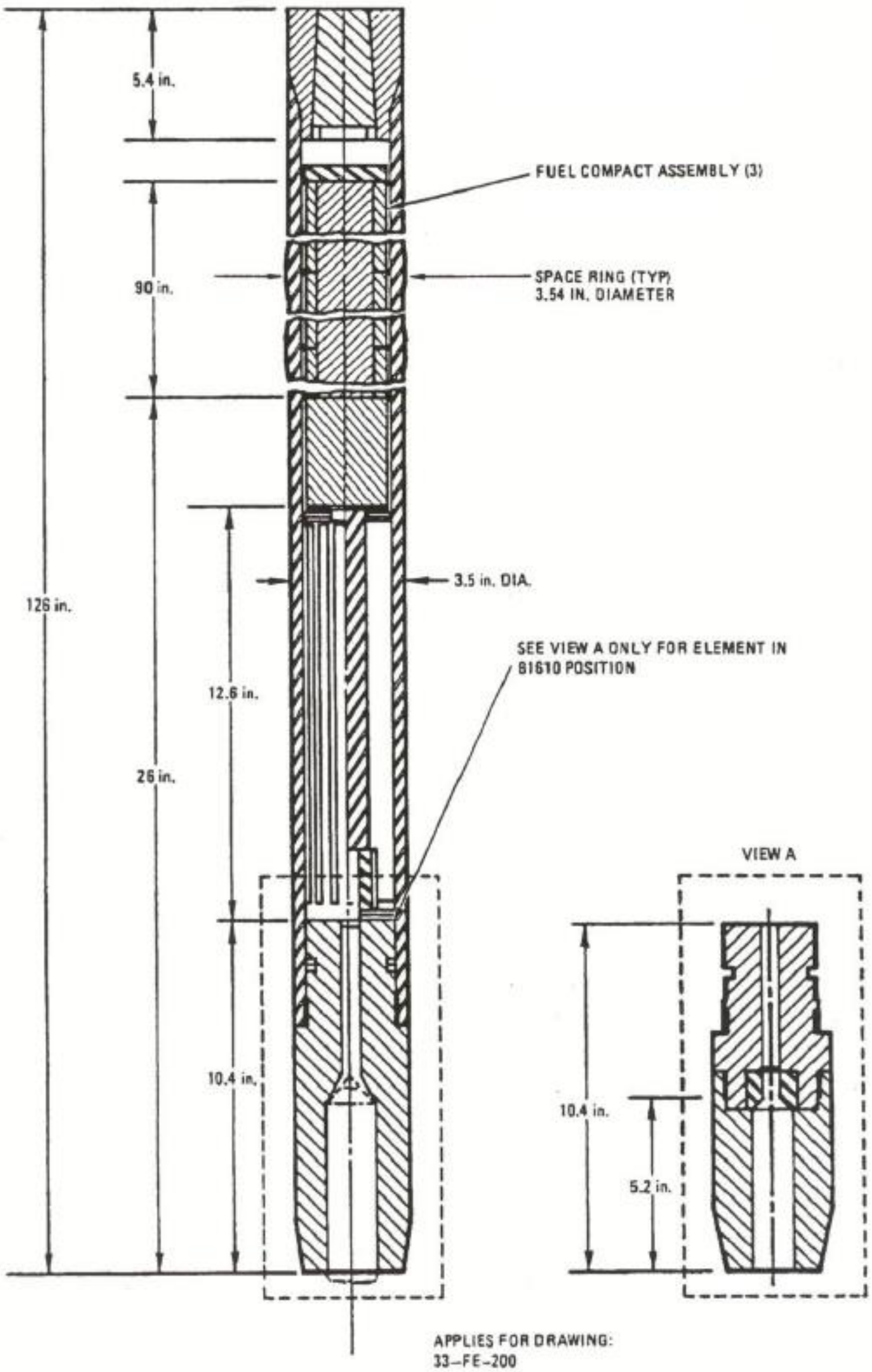

Figure 9. Peach Bottom Core 2 Fuel Element (as cut for storage in IFSF; [4] Figure 10, [5] Figure 3-4)

2.3 DOE SNF Standardized Canisters

The DOE SNF Standardized Canister concept was introduced by the National Spent Nuclear Fuel Program (NSNFP) to provide a timely, cost-effective technical solution for DOE-owned SNF management. These DOE SNF Standardized Canisters have the purpose of 1) providing a standard and easy-to-handle unit to confine DOE SNF; 2) providing durable units for storing SNF; 3) providing easily transportable units; and 4) ultimately, providing a unit for final disposal at the national repository, without the necessity of the DOE SNF being removed from the canister or reopening a sealed canister. A large percentage of the DOE-owned SNF lacks qualified information. To minimize the need to characterize the large number of DOE-owned SNF types, the solution was devised to rely on the standardized canister as the basis for compliance with safety requirements.

The design specification for the DOE SNF Standardized Canister requires them to be designed and fabricated using the quality assurance (QA) principles of the American Society of Mechanical Engineers (ASME) code to support the bases for a low-failure probability argument (i.e., ASME Section III Division 3). DOE SNF Standardized Canister are to be leak-tested in accordance with procedures in compliance with the American National Standards Institute (ANSI) N14.5, 1987, *American National Standard for Radioactive Materials-Leakage Tests on Packages for Shipment*.

The design specification [7] mandates the DOE SNF Standardized Canister have an 18-inch or 24-inch diameter and approximate 10-foot or 15-foot length. The canister shells are to be fabricated from welded or seamless ASME SA312, 316L stainless steel pipe. The top and bottom heads are to be dished and flanged, fabricated from ASME SA240, 316L stainless steel, and butt-welded to the shell. The canister design are to incorporate an energy absorbing skirt that deforms on impact during accidental drop events, providing a significant amount of protection to the actual containment boundary of the canister, including the welds. This deformed skirt could be removed (cut off), if necessary, without disrupting the canister's containment, enhancing the canister's ability to still fit into other containers (e.g., a waste package) after a drop event. The canister design is to also incorporate the option of a threaded vent plug in the top and bottom heads. These plugs could be used for several functions, including canister draining, inerting, leak testing, venting, monitoring, and remote inspection. Installation or removal of the plug(s) is to be performed while inside a hot cell or other approved area. Plugs are to be seal-welded using an appropriately qualified process prior to transport. [8]

A general view of the DOE SNF Standardized Canister, and information about the four based designs (dimensions and maximum masses) are shown in Figure 10. Figure 11 shows a section view of the top of the canister, including the top vent plug/port. Details of the canister designs can be found in various drawings ([9], [10]).

Figures 12 shows a radial cross section view of a potential basket design for ATR fuel/ATR4 buckets in a large (24 inch OD)-short (10 feet-long) DOE SNF Standardized Canister [11] and Figure 13 shows a radial cross section view of a potential basket design for Peach Bottom fuel elements in a small (18 inch OD)-long (15 feet-long) DOE SNF Standardized Canister [12].

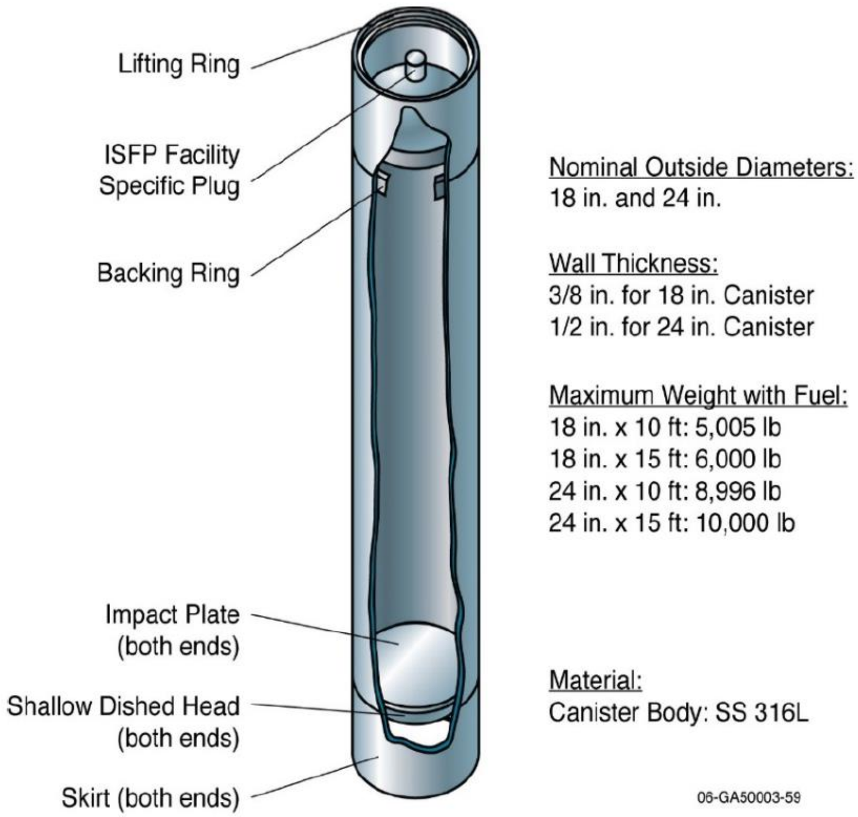

Figure 10. General Cutaway View of DOE SNF Standardized Canister without a Basket

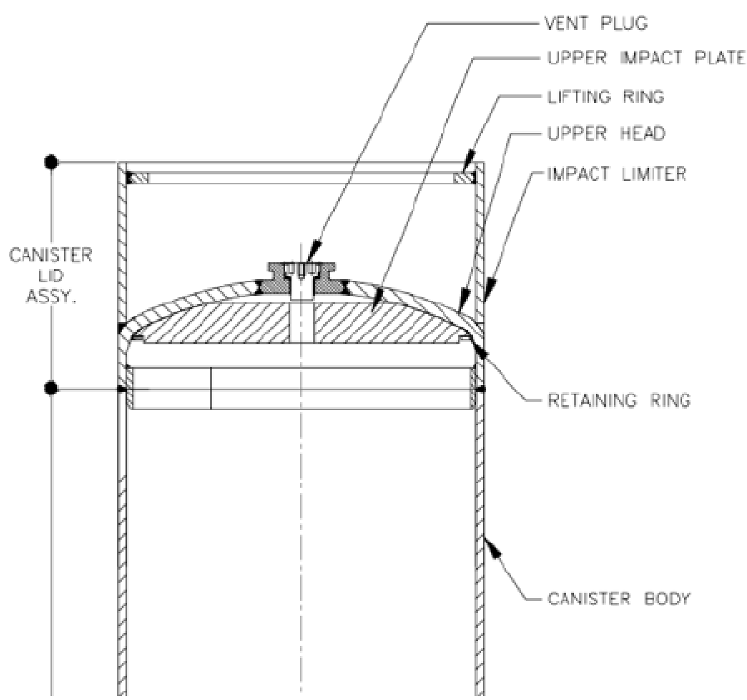

Figure 11. Section View of Top End of DOE SNF Standardized Canister

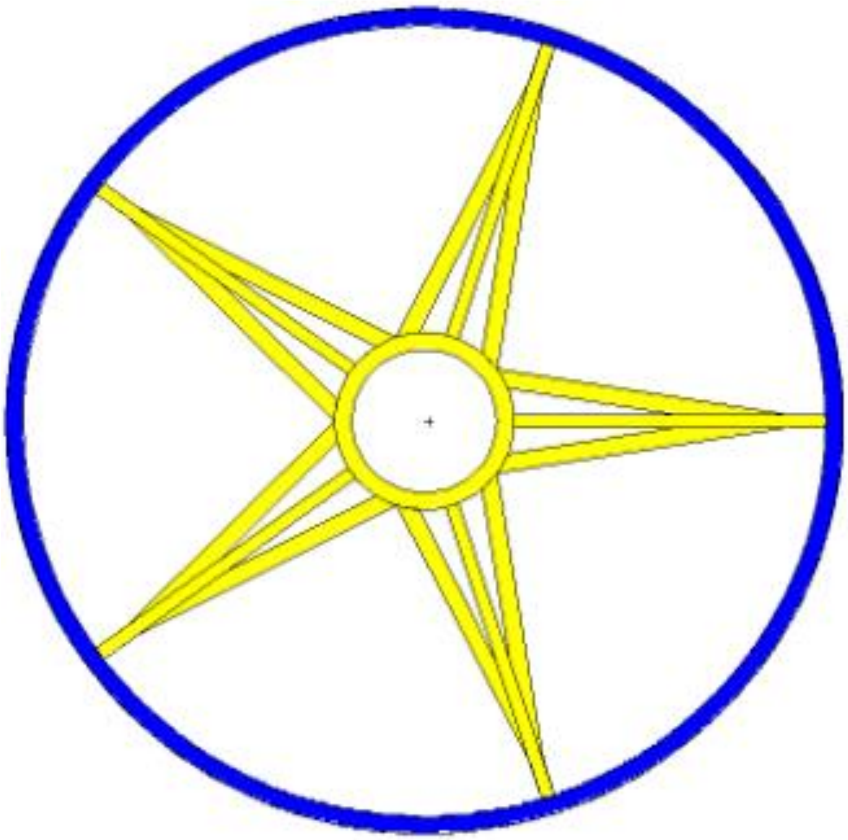

Figure 12. Cross Section View of a DOE SNF Standardized Canister Basket for ATR4 Buckets

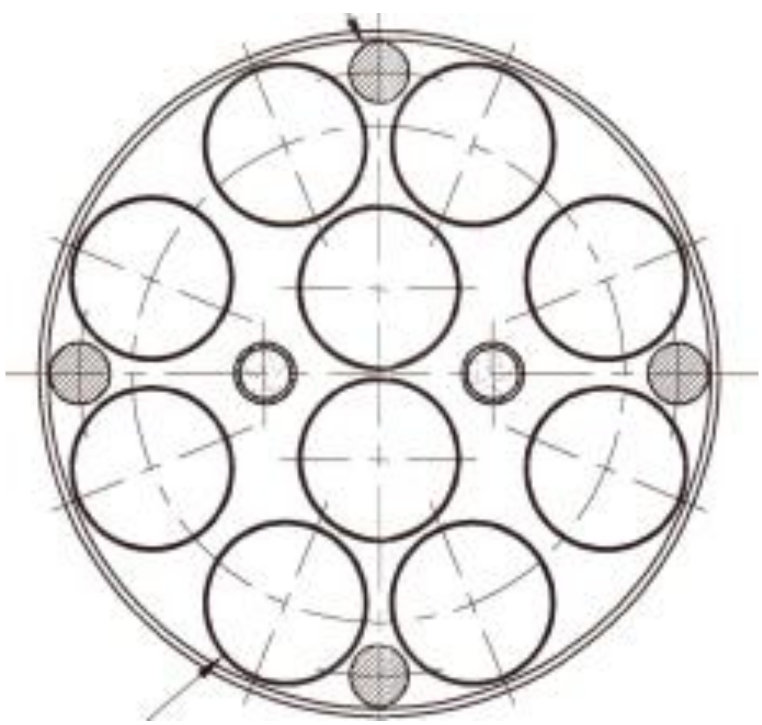

Figure 13. Cross Section View of a DOE SNF Standardized Canister Basket for Peach Bottom Fuel

2.4 Drying Equipment

This section describes the equipment used for drying cask and canisters systems for commercial light water reactor fuel at commercial nuclear power plants. In some cases, this equipment has also been used for drying cask and canisters systems for other fuel types at other reactors. In most cases, this equipment has been used to dry larger systems that have just recently been full of water.

2.4.1 Forced Helium Dehydrator (FHD) System

Holtec International (Holtec) has an US Nuclear Regulatory Commission (NRC) certified drying system called the Forced Helium Dehydrator (FHD), that they use for removing moisture from casks and canisters. It has been successfully deployed to 20 some commercial sites. Figure 14 shows a picture of Holtec's FHD.

Figure 14. Photo of Holtec's FHD System

The size of the full sized FHD system for large casks is:

- Main Skid Dimensions / Weight: 80" x 96" x 71" high; 6,000 lbs maximum
- Chiller Unit Dimensions / Weight: 46" x 130" x 78" high; 3,000 lbs (dry)

The power requirements for the full sized FHD system for large casks is

- FHD Skid Main Power: 460-480 VAC, 92 amps, 3 phase, 6-Hz
- FHD Instrumentation Heat Trace: 120 VAC, 10 amps, 1 phase, 60 Hz
- FHD Dew Point Sensor: 120 VAC, 10 amps, 1 phase, 60 Hz
- FHD Chiller Unit Power: 460-480 VAC, 60 amps, 3 phase, 60 Hz

The FHD system would also require a supply of helium gas.

Recovered moisture needs to be removed from the system during operations.

2.4.2 Vacuum Drying System (VDS)

Holtec, NAC International (NAC), and Orano TN (Orano) have used various Vacuum Drying Systems (VDS) for removing moisture from the casks and canisters they have loaded. These systems have also been NRC certified and have been successfully deployed hundreds of times at commercial sites. Holtec has moved to the FHD system (Section 2.4.1) and others have changed to integrated systems (e.g., NAC's system described in Section 2.8.3). Figure 15 shows a picture of a full-sized system for large casks and canisters used by Orano TN.

Figure 15. Photos of a typical VDS Used by Orano TN

The size of the shown full-sized VDS for large casks is approximately 4' wide by 6.5' tall by 3' deep and weighs approximately 1,000 pounds.

The power requirements for the shown full-sized VDS for large casks is a 480 volt -3 phase -30 AMP supply.

There are no gas requirements for VDS systems.

Recovered moisture needs to be removed periodically.

2.4.3 Storage Canister Drying System

The FCS is an insert (INRT-GSF-1) that fits into Floor Well 13 of the FHC and includes systems capable of drying a FSA Storage Canister loaded with DOE-owned SNF. The FCS insert is a 20"-diameter Schedule 5 stainless-steel pipe with a short funnel on the upper end (guide for lowering in canisters). Four guide bars inside the lower end of the insert center the FSA Storage Canister when it is in the FCS insert. The heated portion of the FCS is 10’-long with has thirteen bands of electric heaters. An insulated extension covers up, around the heaters to the rim of Storage Canisters placed in the FCS insert.

The FCS has a vacuum system located in the CMA to lower the pressure in the FSA Storage Canister in the FCS insert. The vacuum system consists of a vacuum pump, a sintered metal filter, a pressure control valve, a condensate catch tank, and isolation valves. The 1-in. Schedule 40 stainless-steel piping connects the vacuum system to the flexible connection at the vacuum lid located in the FHC. The vacuum pump outlet vents into a condensate catch tank that would contain any condensate from the system. The catch tank is vented to the CMA area and can be sampled, if required, for further disposition. The liquid level in the catch tank can be visually determined. Remote-actuated valves to control the vacuum in the canister and to bypass the vacuum pump are controlled from the DCS.

The sintered metal filter is installed in the piping in the off-gas line before the vacuum pump. The filter in the off-gas line collects particulate contamination that might be released from the fuel assemblies in the FCS.

The vacuum lid (LID-GSF-901) located near the FCS insert in the FHC is placed on an FCS-compatible FSA Storage Canister after it is loaded with fuel. A seal ring in the canister seals the vacuum lid when it is placed on the canister. The lid is not fastened to the canister; rather, the vacuum lid weight is sufficient to establish an initial seal. Atmospheric pressure on the lid makes the seal leak resistant as the vacuum in the canister increases. Flexible hoses connect fittings on the lid to the vacuum piping and the plant air supply piping.

2.5 Welding Equipment

This section describes the equipment used for welding cask and canisters systems. Section 2.5.1 has information about a conceptual remote welding system developed specifically for DOE SNF Standardized Canisters. The other sections describe welding equipment used by some of the commercial vendors for sealing their welded systems. The vendor systems are sized for full sized systems.

2.5.1 Conceptual Remote Welding System

Some preliminary design and mock-up work has been done on a remote welding system specifically for DOE SNF Standardized Canisters [13]. The design has a tower with a vertical positioning axis to locate the tooling over the center of the weld, and a horizontal axis to position the tooling radially in and out (Figure 16). This arrangement allows canisters of different heights and diameters to be welded and inspected. This design has the added benefit of accommodating slightly out of round canisters, or canisters that may not be positioned exactly on the vertical centerline of the carousel’s rotation.

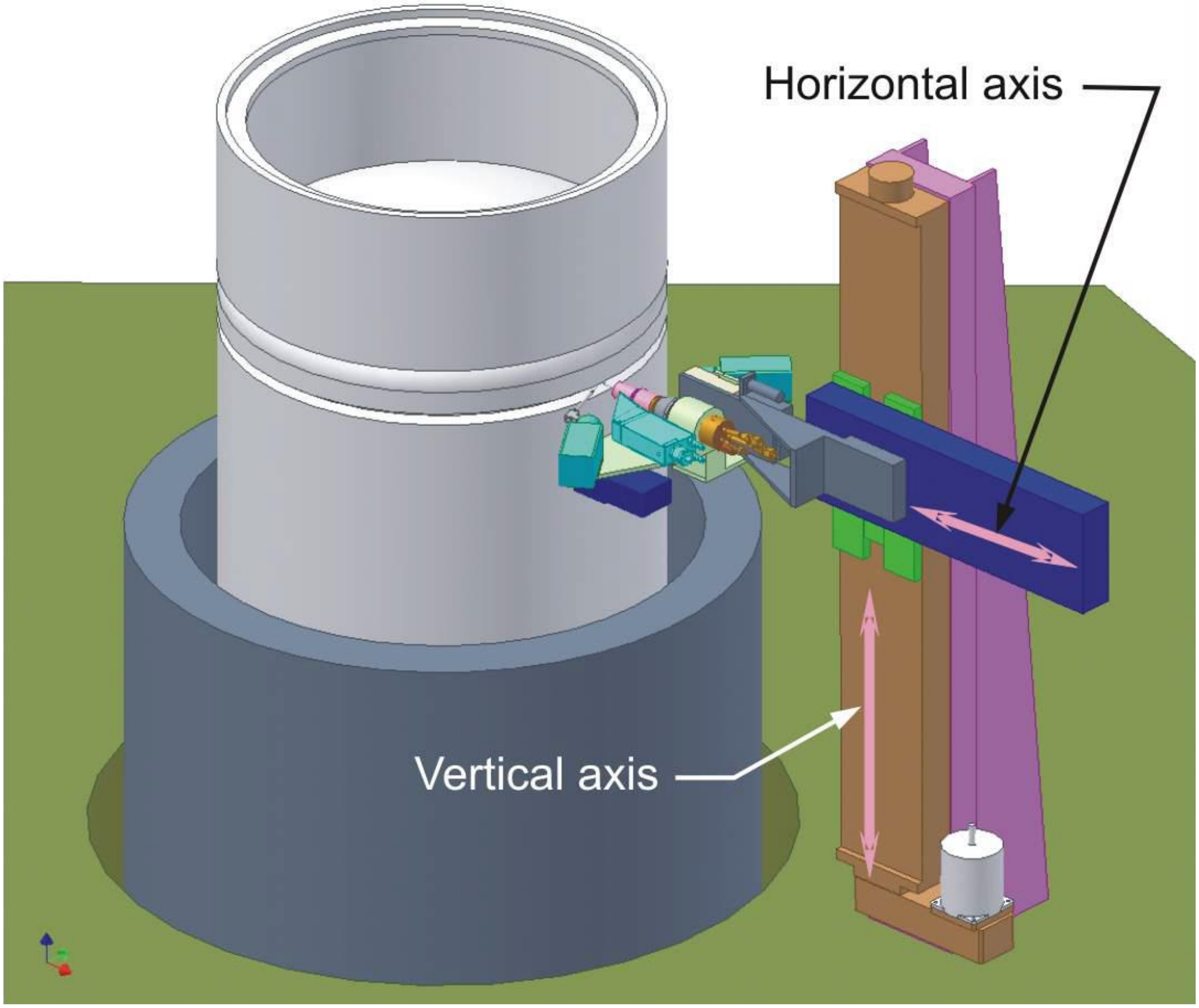

Figure 16. Vertical Axis and Horizontal Axis Welding Head on Tower Against Canister

The system is designed to use cold-wire tungsten inert gas (TIG) welding at up to 300 amps. The torch operates using touch starting instead of high frequency arc starting to eliminate the potential for stray high-frequency voltages that could damage sensitive computer hardware. The head consists of an air-cooled gas tungsten arc welding torch, a wire-feed positioner, dual arc viewing cameras, and a seam tracking/visual inspection sensor. The entire weld head can be oscillated vertically across the weld joint when weaving is required. The radial positioning axis is controlled automatically during welding to provide a constant arc voltage. This arc voltage control cancels any variations caused by uneven fill from the previous weld passes.

Figure 17 shows a picture of the welder welding on a mock-up DOE SNF Standardized Canister. Figure 18 shows pictures with closer top and underside views of the welding end effector over the weld joint on the mock-up DOE SNF Standardized Canister.

Figure 17. Welding System Shown Welding on a Mock-up Canister

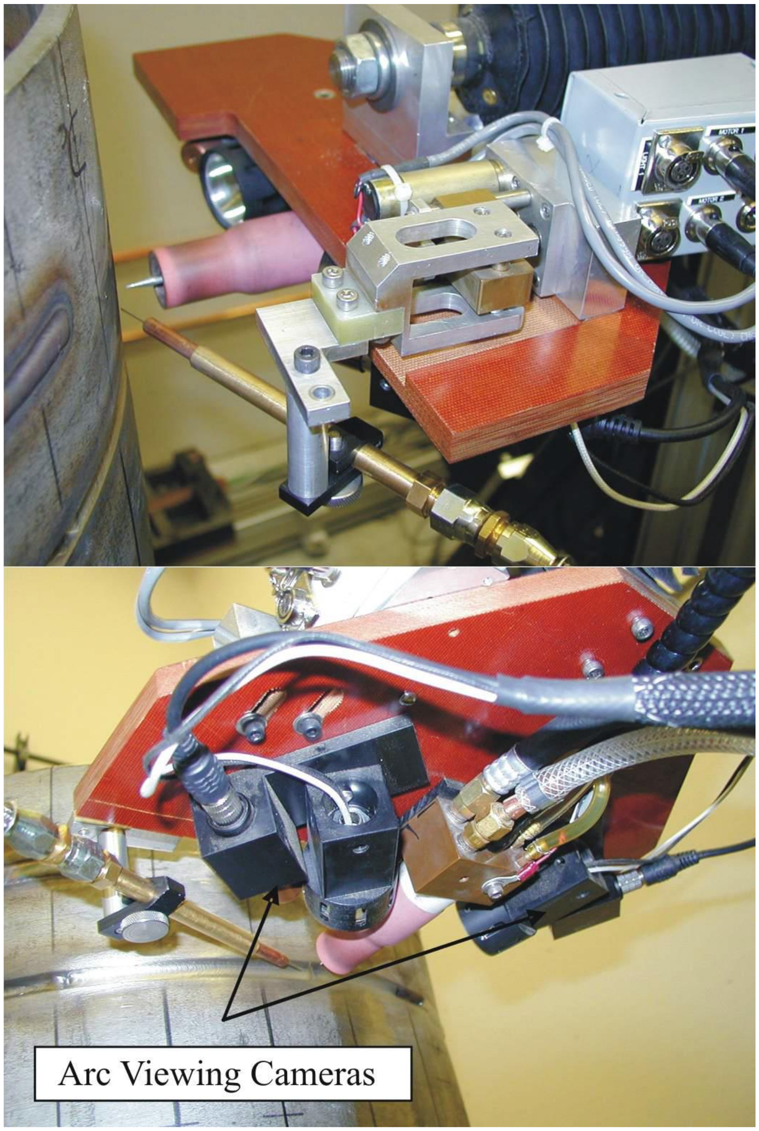

Figure 18. Top (top) and Underside (bottom) Views of Welding End Effector Positioned Over Mock-up DOE SNF Standardized Canister

2.5.2 Holtec Welding Systems

Holtec has used several different welding systems for attaching lids on SNF Canisters. A system currently under development with DOE funding in a Hybrid Laser Arc Welding (HLAW) system.

2.5.3 NAC Remote Welding System

NAC has used several different welding systems. The exact type and size of the system is in part dictated by the available space to deploy the system, the available means of remote system delivery/positioning, and the expected environmental conditions. An example of a remote welding system used by NAC is a computer-controlled robot machine-operated weld system including TV cameras, weld wire feed system, welding head, weld power supply and gas lines designed by Liburdi Dimetrics. The remote system weighs 3,450 lbs. and is secured to the concrete overpack and over the canister system for unobstructed access to the canister closure weld. Cameras are used to monitor the closure lid welding operations and are also used to perform the remote visual inspections of the installed weld layers.

The remote welding system NAC used for full sized canisters typically requires:

- 480V 3 phase 50/60 hz 30amp electric power feed for the power supply cabinet,
- 480V 3 phase 50/60 hz 15amp electric power feed for the robotic arm,
- 115 1 PH 10A power feed source for the camera system,
- 100 PSIG air, and
- Shield Gas for the weld torch (Argon) typically supplied by Dewar.

2.5.4 Orano TN Automated Welding System (AWS)

Orano TN has used several different welding systems. The Concept Systems Inc automated welding system (AWS) currently used by Orano TN for full sized canisters has the following major components and sizes:

- AWS console: 2' x 2' x 6'
- AWS power supply: 2' x 3' x 3'
- AWS water cooler: 1' x 1' x 2'
- Argon pressurized gas T cylinder: 10" x 10" x 4'7"

The power requirements for the AWS are:

- 40 amp 480V for AWS console
- 60 amp 480V for the AWS power supply
- 5.6 amp 115V for the AWS water cooler

Orano TN is also looking at a new welding system from Liburdi Dimetrics.

2.6 NDE Equipment

This section describes the equipment used for NDE of cask and canisters system closure welds. Section 2.6.1 has information about a conceptual remote NDE system developed specifically for DOE SNF Standardized Canisters. The other sections describe NDE equipment used by some of the commercial vendors for NDE of welds on their systems. The vendor systems are sized for full sized systems.

2.6.1 Conceptual Remote NDE System

The welds will undergo surface and volumetric inspection in accordance with ASME Boiler and Pressure Vessel Code, Section III, Division 3, Subsection WB. In addition, a surface inspection of repair grooves will verify that the flaw has been removed. The tower contains probes to perform surface inspection with eddy current examination and volumetric inspection with ultrasonic examination (Figures 19 and 20). The welding subsystem contains the laser-based sensor that will be used for visual surface inspection.

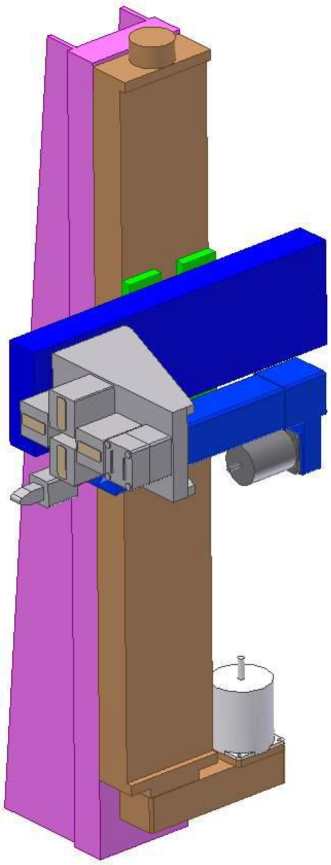

Figure 19. Tower Mount with NDE Concept

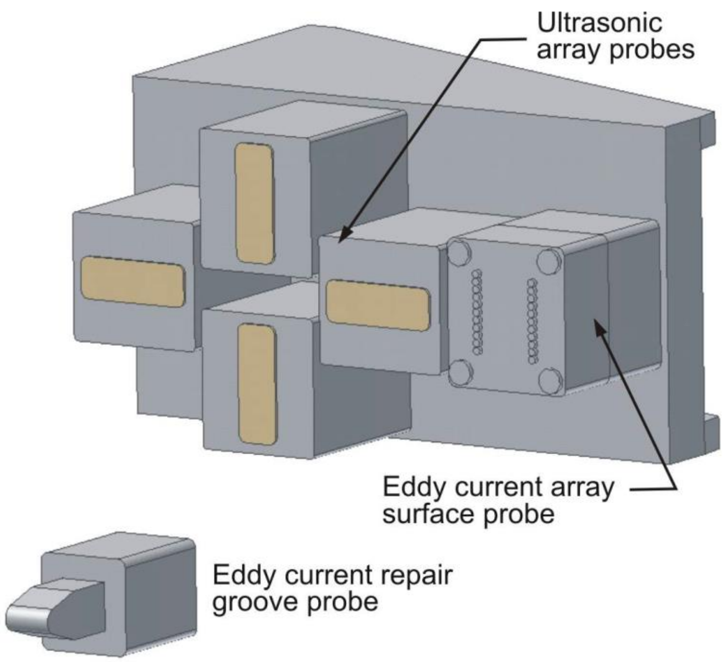

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Figure 20. Detail of NDE Head Concept

2.6.2 Holtec NDE System

Holtec has used several different NDE systems. A combined inspection and repair system is described in Section 2.8.2.

2.6.3 NAC NDE System

NAC has used several different NDE systems, including remote visual inspections equipment as part of the remote welding equipment. Besides visual testing, many of the closure welds for commercial SNF canisters use dye penetrant testing, but these are in only semi-remote mode.

2.6.4 Orano TN Remote NDE System

Orano TN has used a number of different NDE systems (visual, ultrasound, eddy current, etc.). The systems are mounted in a scanning head (similar to what is shown in Figure 20). Getting the scanning heads access to all the welds and surfaces of the canisters is the current focus of system improvements. A picture of the Orano TN Inspection Ring (US Patent: 9724790, UK patent: 2504795) which performs NDE on all shell welds while pulling a canister through the ring (e.g., from concrete module to transfer cask) is shown in Figure 21. A demonstration at a nuclear power plant is planned in December 2019.

Orano TN's new NUHOMS Matrix is designed for 100% canister surface inspection, as shown in Figure 22, the Matrix roller tool can raise and rotate the canister for complete surface NDE, while the canister is still inside the concrete module.

Both the ring and roller tool are designed for full sized (e.g., 72" OD, 196" long) canisters.

Figure 21. Inspection Ring for NDE

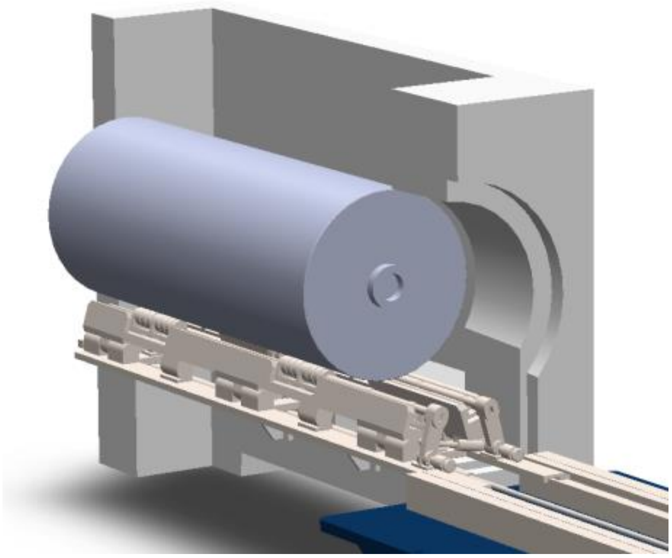

Figure 22. Matrix Roller Tool for NDE

2.7 Welding Repair Equipment

This section describes the equipment used for repair of cask and canisters system closure welds. Section 2.7.1 has information about a conceptual weld repair system developed specifically for DOE SNF Standardized Canisters. The other sections describe weld repair equipment used by some of the commercial vendors for their systems. The vendor systems are sized for full sized systems.

2.7.1 Conceptual Remote Weld Repair System

The repair subsystem performs dual roles. After a welding pass, it first wire brushes the weld joint to remove the oxides formed during welding. Then the weld is inspected and, if defects are found, the repair subsystem grinds out the defect and creates a repair cavity with a controlled, consistent geometry for rewelding.

The head has remotely changeable tooling to allow different grinding and brushing wheels to be used (Figures 23 and 24). The tower design includes a tool caddy for storing wire brushes and grinding wheels. The head has a compliance joint that allows the wire brush or grinding head to float over uneven weld surfaces without creating excessive tool loads that might damage the wheels. The head has a contact sensor to provide feedback to the control system when the wheel first comes into contact with the canister. This provides a zeroing feature to the coordinate system and accommodates unknown weld fill and canister location.

The grinding operation is completely computer controlled. The grinding control system gets information from the inspection system on defect location, depth, and size. From this information, the grinding control system develops a grinding profile that removes the minimum material necessary to completely eliminate the defect, while maintaining the original joint geometry as closely as possible. This simplifies the process of inspecting and rewelding the repair cavity.

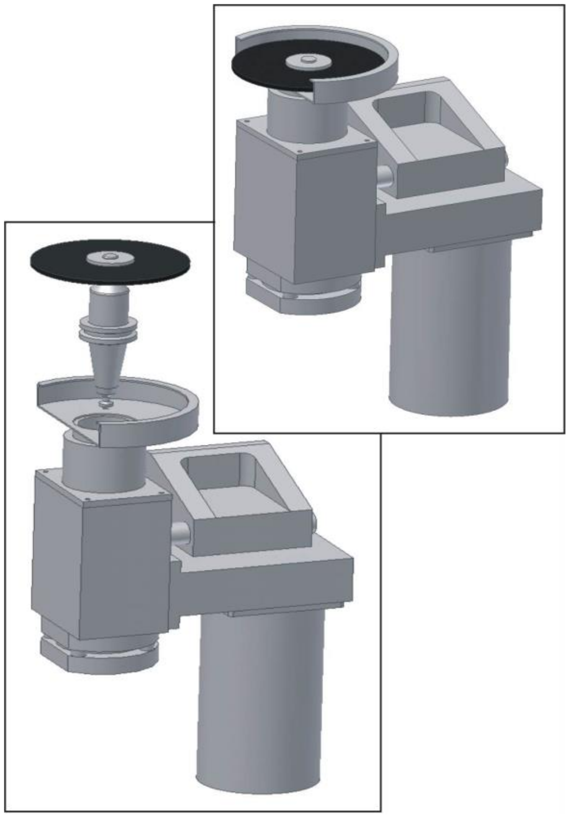

Figure 23. Image of Conceptual Grinder Wheel for Weld Repair on DOE SNF Standardized Canisters

Figure 24. Picture of Repair Grinding Apparatus

2.7.2 Holtec Remote Weld Repair System

Holtec has used several weld repair systems. A combined inspection and repair system is described in Section 2.8.2.

2.7.3 NAC Remote Weld Repair System

NAC has developed remote weld removal tooling capability as part of their dry cask storage system implementation programs and has performed dry runs. For the West Valley Demonstration Project, the weld repair tool was an air operated rotary tool that attached to the robotic arm of the AWS. However, to date, there has been no need to remotely remove or repair the welds on any NAC canisters. NAC is currently working with Liburdi Dimetrics to develop a robust weld removal and repair system that can be deployed in harsh environments where area radiation levels may exceed 1R/hour.

2.7.4 Orano TN Remote Weld Repair System

The Mobile Examination and Remediation Facility (MERF) [20] concept for horizontal systems is shown in Figure 25. Orano is providing some support to ORNL in the development of this system, which is planned to include remote welding capabilities to repair potentially failed welds.

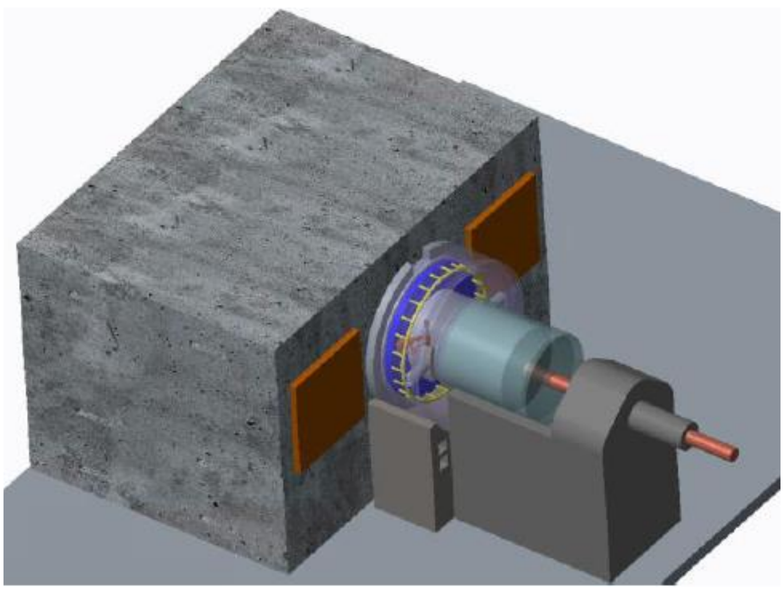

Figure 25. MERF

2.8 Integrated Equipment

This section describes the combined or integrated equipment that perform several different operations associated with canister preparation and closure. Section 2.7.1 has information about a conceptual welding/NDE/repair system developed specifically for DOE SNF Standardized Canisters. The other sections describe integrated equipment used by some of the commercial vendors for their systems. The vendor systems are sized for full sized systems.

2.8.1 Combined Welding, Inspection, and Repair

Preliminary design work has been done on a combined welding, inspection, and repair system. Each of the three subsystems, welding, inspection, and repair, is mounted on a separate tower. Each tower has a vertical positioning axis to locate the tooling over the center of the weld, and a horizontal axis to position the tooling radially in and out (Figure 26). This arrangement allows canisters of different heights and diameters to be welded and inspected. This design has the added benefit of accommodating slightly out of round canisters, or canisters that may not be positioned exactly on the vertical centerline of the carousel's rotation. [13]

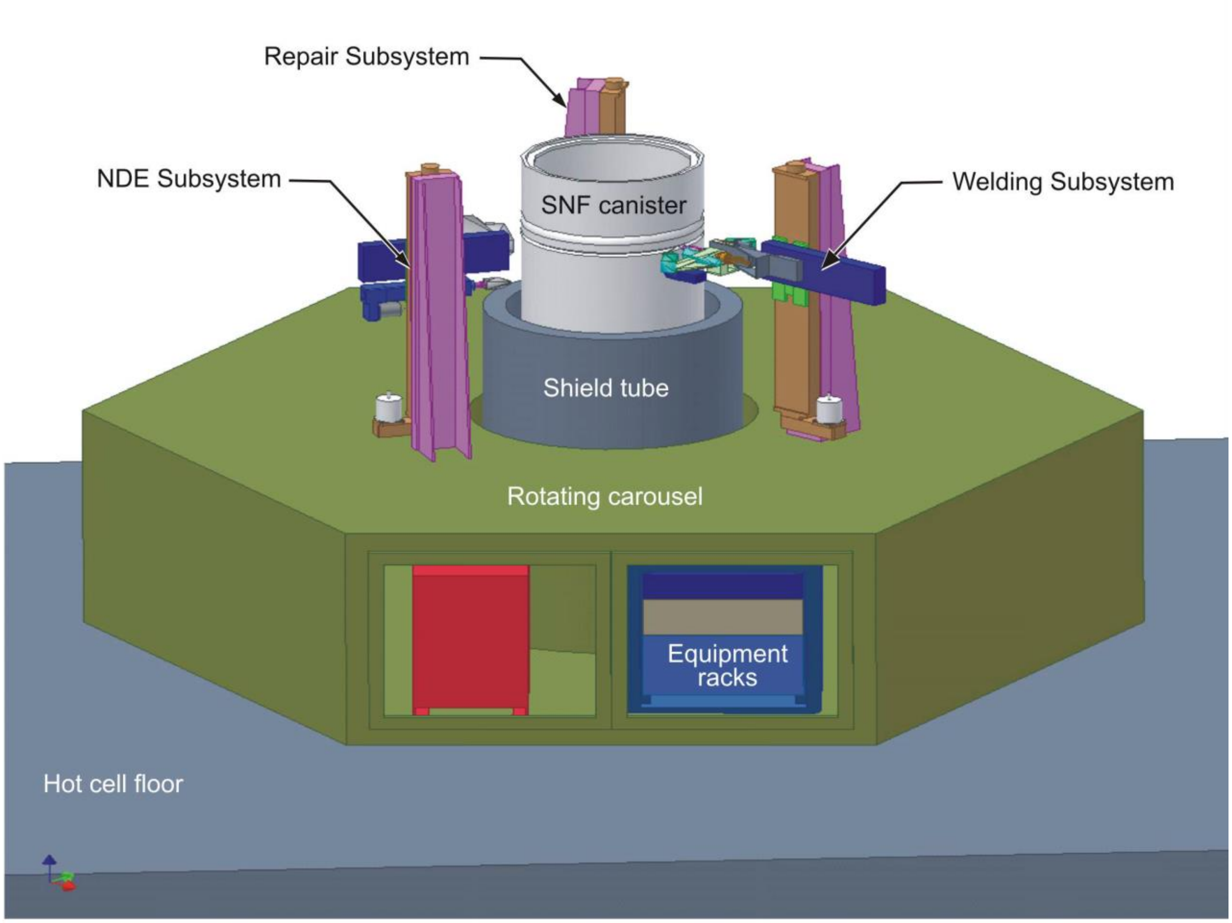

Figure 26. Picture of Integrated Welding, NDE, and Repair System

2.8.2 Holtec Inspection and Repair

Holtec is developing a HI-TRAC based remote weld inspection and weld repair system.

2.8.3 Integral Vacuum Drying and Pressure Gas Inerting System

NAC has used combination vacuum drying and inerting-backfilling system. An example of an integrated vacuum/pressure gas drying system sourced from EMS Solutions is shown in Figure 27.

A typically full-sized EMS Solution vacuum drying package used by NAC measures 60” wide X 45” deep X 64” high and weighs ~2,000 lbs. Remote connections are made between the VDS unit and the cask/canister using hard piped booms that have short metal flexible hoses.

The power requirements of a system would be 480V or 208V 3 phase electric power.

The gas requirements for such a system would include 1 CFM @ 80 PSIG air, 300 liters/min @ 20 PSIG Nitrogen, and 300 liters/min @ 20 PSIG Helium.

Figure 27. Picture of Integral Vacuum/Pressure Gas Drying Equipment Skid

3. Operations

For purposes of this evaluation, operations are divided into three categories: standard, logistical, and new. The operations are discussed in the following sections.

3.1 Standard Operations

The operations categorized as Standard Operations in this evaluation are operations that are currently performed on a regular basis in the CPP-603 facility. Examples of standards operations are bringing Fuel Storage Canisters from the FSA into and out of the FHC via the Shuttle Bin, taking off and putting on the Fuel Storage Canister lids, bringing Fuel Transport Casks into and out of the FHC, taking off and putting on the Fuel Transport Cask lids, and moving fuel into and out of the Fuel Transport Casks and Fuel Transport Casks. There is nothing unique or different about these operations, so no new tools, equipment, or processes are required to demonstrate the ability to perform these operations in the CPP-603 IFSF.

3.2 Logistical Operations

The operations categorized as Logistical Operations in this evaluation are operations for bringing equipment and materials into the CPP-603 FHC. This type of operation is performed on a regular basis in the CPP-603 facility, but not necessarily with same equipment and materials needed for loading DOE SNF Standardized Canisters. Examples of these operations are bringing in equipment (weld/NDE/repair, dryer, inert/backfill, vent plug sealing, leak testing), consumables (weld wire, helium gas, lubricates, etc.), empty DOE SNF Standardized Canisters, DOE SNF Standardized Canister components (basket assemblies, divider plates, lid assemblies, vent plugs, etc.), and materials (spacers, criticality control inserts, getter materials, etc.) into the FHC and moving them around. These types of operations are fairly common, and don't necessarily have to occur completely remotely. Some specific tooling may need to be developed for some of the specific operations, but that is easily tested and corrected.

3.3 New Operations

The operations categorized as New Operations in this evaluation are operations new or unique for loading fuel into DOE SNF Standardized Canisters in the CPP-603 FHC, or that haven't been performed for many years, so that there is no recent experience and or tooling for the operations. Planning for these operations will take advantage of the experience of commercial cask vendors and DOE complex operators for similar operations performed at other locations. The exact operational sequence will depend on the specific fuel and source of the fuel. Initial listings of the new operations for ATR4 Buckets with ATR fuel and for Peach Bottom fuel are listed in the following sections.

3.3.1 FHC Operations with ATR4 Buckets

The following is a list of the new operations needed for handling ATR4 Buckets, DOE SNF Standardized Canisters, and equipment for preparing DOE SNF Standardized Canisters. The four operations shown in *blue-italics* are specific for ATR fuel, while the others will be common for most fuel types.

ATR Fuel From CPP-603

1. Place empty DOE SNF Standardized Canister in Floor Well position
2. *Load criticality control inserts into ATR4 Buckets with Manipulators and Crane (CRN-GSF-401)*
3. *Load ATR4 Buckets into lower basket level of DOE SNF Standardized Canister*
4. Place spacers into DOE SNF Standardized Canister
5. *Place Level Separator Plate/Upper basket in DOE SNF Standardized Canister using Crane (CRN-GSF-401)*

6. *Place ATR4 Buckets into upper basket level of DOE SNF Standardized Canister*
7. Place spacers into DOE SNF Standardized Canister
8. Place Lid Assembly on DOE SNF Standardized Canister
9. Place/attach/align Remote Lid-Shell Welding/NDE/Repair Equipment on DOE SNF Standardized Canister
10. Perform Remote Welding & NDE operation
11. If needed, perform Remote Repair operation(s) on any welds with unacceptable flaws
12. Remove Lid-Shell Welding/NDE/Repair Equipment
13. Place/attach/align Drying/Inerting/Backfilling Equipment to DOE SNF Standardized Canister
14. Perform Drying/Inerting/Backfilling operation (including seal weld and test)
15. Insert Vent Plug & Test for leaks
16. Remove Inerting/Backfilling Equipment
17. Place/attach/align Remote Vent Plug Welding/NDE/Repair
18. Perform Remote Vent Plug Welding & NDE operation
19. Perform (if needed) Remote Vent Plug Weld Repair operation(s) on any welds with unacceptable flaws
20. Remove Vent Plug Welding/NDE/Repair Equipment
21. Test for unacceptable surface contamination on outside of DOE SNF Standardized Canister
22. Perform decontamination process

3.3.2 FHC Operations with Peach Bottom Fuel

The following is a list of the new operations for handling bare Peach Bottom fuel, DOE SNF Standardized Canisters, and equipment for preparing DOE SNF Standardized Canisters. The two operations shown in *blue-italics* are specific for Peach Bottom fuel, while the others will be common for most fuel types. There will be some variation in the detailed process steps for handling fuel from the FSA in the CPP-603 IFSF and for handling fuel from the Generation I vaults in the CPP-749 UFSF, since the containers from the two locations have different numbers of assemblies per container (12 and 18).

Peach Bottom Fuel From CPP-603 or CPP-749/Generation I Vaults

1. Place empty DOE SNF Standardized Canister in Floor Well position
2. *Remove bare Peach Bottom fuel elements from Storage Canisters*
3. *Place bare Peach Bottom fuel elements in DOE SNF Standardized Canister*
4. Place spacers into DOE SNF Standardized Canister
5. Place Lid Assembly on DOE SNF Standardized Canister
6. Place/attach/align Remote Lid-Shell Welding/NDE/Repair Equipment on DOE SNF Standardized Canister
7. Perform Remote Welding & NDE operation
8. If needed, perform Remote Repair operation(s) on any welds with unacceptable flaws
9. Remove Lid-Shell Welding/NDE/Repair Equipment
10. Place/attach/align Drying/Inerting/Backfilling Equipment to DOE SNF Standardized Canister
11. Perform Drying/Inerting/Backfilling operation (including seal weld and test)
12. Insert Vent Plug & Test for leaks
13. Remove Inerting/Backfilling Equipment
14. Place/attach/align Remote Vent Plug Welding/NDE/Repair
15. Perform Remote Vent Plug Welding & NDE operation
16. Perform (if needed) Remote Vent Plug Weld Repair operation(s) on any welds with unacceptable flaws
17. Remove Vent Plug Welding/NDE/Repair Equipment
18. Test for unacceptable surface contamination on outside of DOE SNF Standardized Canister
19. Perform decontamination process

4. Evaluation

This section presents a review of facilities where the loading operations could occur; a review of the existing equipment; and the decisions, supporting analyses, designs, demonstration programs, and facility modifications that are needed to perform DOE SNF Standardized Canister loading operations in the CPP-603 IFSF.

4.1 Facilities

From a review of the facility description in Section 2.1 and the operations listed in Section 3, the CPP-603 FHC does appear to have the necessary features to allow the loading of DOE-owned SNF into DOE SNF Standardized Canisters. The South Floor Wells near the Lower Shielding Window and Manipulator Arms would be a logical location within the FHC to perform the loading operations (handling, welding/NDE/repair, drying/inerting-backfill, leak test, etc.).

The equipment for the operations will required the addition of power, data, and compressed gas lines into the FHC. These can be routed through various ports in the walls of the FHC (the ports have to be unsealed, unpacked, lines run, new packing added, and the ports resealed) or routed from adjacent areas (Labyrinth, CMA).

The existing equipment for drying FSA Storage Canisters (FCS insert in Floor Well 13) will need to be removed to provide room for the new equipment in front of the Lower Shielding Window. Several of the South Floor Wells will need to have adaptors added to accommodate the DOE SNF Standardized Canisters or cover plates added to provide extra room for the new equipment near the Floor Wells with the DOE SNF Standardized Canisters. The Floor Well adaptors will need to position the DOE SNF Standardized Canisters along diameter and length/height for the welding/NDE/repair equipment to access the lid assembly to shell weld area. With some fuel types, the active fuel region will be above the floor of the FHC when the DOE SNF Standardized Canisters are in Floor Wells, so the dose rate in the FHC could be significant. This is one of the reasons for the need for remote operations.

To handling the Logistical Operations discussed in Section 3.2, a container or bin will need to be added to the CTC. The new equipment and supplies will need to be secured in the CTC as it brings the materials into the FHC from the PCS via the CTP. This is not a complex device; it just needs to secure to the existing CTC mounting points and be large enough to carry the new equipment into the FHC.

Another required function for the FHC is the storage of the new equipment, consumables, empty canisters, and other materials for loading operations, when they are not immediately needed. There may be two or three different equipment sleds that could take up significant room. There is likely a need for some new storage racks within the FHC to accommodate these things.

A possible second location (with some negative impacts for logistical and possible other operations) where loading operations could be conducted would be in the CTC when it is in the FHC. This would complicate the loading of DOE SNF Standardized Canisters into Storage Units (casks, transfer cask, over-canisters, etc.), that would normally take place in that location.

4.2 Equipment

From a review of the descriptions in Sections 2.4 – 2.8, the types of equipment to perform the necessary loading operations (handling, welding/NDE/repair, drying/inerting-backfill, leak test, etc.) to allow the loading of DOE-owned SNF into DOE SNF Standardized Canisters within the CPP-603 IFSF already exists. Although most of the existing equipment consists of separate components; is only semi-remote, requiring some human assistance in initial positioning; and is sized for the full-sized Commercial SNF canisters/casks, so it is much larger than would be needed for the smaller DOE SNF Standardized Canisters (or that could easily fit within the FHC).

The earlier NSNFP efforts started looking demonstrating fully remote integral/combined equipment specifically designed and sized for DOE SNF Standardized Canisters. There are already efforts underway by the Commercial Cask Vendors to combine various equipment components (examples in Sections 2.8.2 and 2.8.3). If needed, the Manipulator Arms in the FHC may be able to substitute for direct human positioning with the existing semi-remote equipment designs.

The NSNFP remote integral/combined equipment for DOE SNF Standardized Canisters did not have any specific size goals, so its conceptual/preliminary designs (e.g., Figure 26) are larger than they need to be. New refined designs should be able to reduce the size/footprint of the equipment to fit within the available areas in the FHC.

An idea discuss about the new equipment is the idea of setting up a positioning mount around the Floor Well that will contain the DOE SNF Standardized Canister, then have detachable sleds with various sets of the new equipment that would connect/disconnect to the positioning mount.

An initial idea would have one equipment sled for attaching the lid-assembly to the shell, welding/NDE/repair, a second equipment sled for performing the drying/inerting-backfilling (with getter adder if needed), and a third equipment sled for doing the leak tests and vent plug cover weld/NDE/repair. Further evaluations may add or subtract functions to the equipment sleds or add or subtract the number of sleds.

The FCS equipment currently in the FHC are not directly applicable to DOE SNF Standardized Canister (e.g., heaters and seal lid), but some of it (e.g., the vacuum pump and lines) might be usable with new equipment components.

4.3 Decisions

The decisions needed to proceed with the evaluation of loading DOE SNF Standardized Canisters in the CPP-603 IFSF are listed in this section and are divided into categories of general, and specific to each fuel type.

4.3.1 General

This section has the general decisions, independent of fuel type, that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Perform loading demonstration in CPP-603? – A fundamental decision is to continue to pursue the idea of loading DOE SNF Standardized Canisters in the CPP-603 IFSF, versus other alternatives. The purpose of this evaluation is to provide information helpful in making this decision. A decision to proceed introduces very little programmatic risk, because much of the work done for this decision would be applicable or useful for alternatives (e.g., equipment needed for welding DOE SNF Standardized Canisters in the CPP-603 IFSF would be the same as equipment needed for welding DOE SNF Standardized Canisters in other existing facilities or in a new dedicated facility).
2) What disposal requirements? – The idea is that DOE SNF Standardized Canisters, once sealed, will remain sealed for storage, transport, and disposal. The storage and transport requirements are well established, but there is uncertainty with the disposal requirements. The decision that needs to be made is where to assume the current requirement documents [15] and other associated documents [16] will continue to apply, or if new constrains and requirements should be considered. The decision will impact the needed criticality controls and some potential operations.

3) What dryness level? – The required Dryness Level for DOE SNF Standardized Canisters hasn't been established. The Standard Review Plan for Dry Storage points to PNL-6365 [17] as something the NRC has accepted in the past, but leaves it open for the licensing to specify (and defend). Per its title, the PNL-6365 [17] report addresses LWR Spent Fuel, so its applicability to many types of DOE-owned SNF may be questionable. The Dryness Level question also raises the question of what water: residual liquid water, surface (physisorbed) water, and/or chemically bound water (like aluminum hydrates)? Drying equipment sizing and operational timing will need a target number, such as the 3.0 Torr (4.0E-04 MPa, 4 millibar, 3.0 mm Hg) given as an example in the Standard Review Plan [15]. Selecting to focus on residual liquid water/water vapor and picking a target Dryness Level (e.g., 3.0 torr) seems low risk and appropriate in general. Specific SNF types may require additional levels or treatments.

   Related to the dryness level, is the option to add moisture/water getter materials to a DOE SNF Standardized Canister prior to sealing. The moisture getter material will chemically bind with free H_2O, H_2, or O_2, and stop it from increasing pressure and/or promoting corrosion from the inside of a sealed canister. The addition of a moisture getter material would be a defense-in-depth measure that would address any remaining liquid water left after the normal drying process and could address other water (surface or chemical) that might be released over time. Addressing the release of other water might be important for some fuel types. The inclusion of moisture getter materials would impact equipment and operations.

4.3.2 Specific for ATR Fuel

This section has the decision specific to ATR Fuels that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Canister size (diameter) to use for ATR fuel? – The original work looked at placing 10 ATR fuel elements in the small (18" OD) DOE SNF Standardized Canister with the Type Ia basket. Wet to dry operations have placed many ATR fuel elements in ATR4 Buckets, which would be much easier and efficient to load. A recent feasibility report [11] found that there could be fit problems for more than two of the ATR4 Buckets per level in a 18"-OD DOE SNF Standardized Canister, but 5 ATR4 Buckets per level would fit in the large (24"-OD) DOE SNF Standardized Canister. The decision is then whether to stay with trying to load 4 ATR4 Buckets per level in the 18"-OD canisters (with the risk of fit problems, and resulting operational complications and delays), or load 5 ATR4 Buckets per level in the 24"-OD canisters (with potential repository interface issues, as the number of 18"-OD canisters for the Co-disposal Waste Package center locations drop, and the number of 24"-OD canisters increase which take-up DHLW glass canister positions in the Co-disposal Waste Packages). The DOE SNF Standardized Canister diameter is key to the design, and will influence operations, and will determine if some facility modifications are required.

2) Canister length to use for ATR fuel? – The DOE SNF Standardized Canister length selected for ATR fuel is tied/related to the number of basket levels (short (10'), long (15'), or custom (e.g., 10'3", 15'6")). It will determine some equipment, may require some specific demonstration programs, and will determine if some facility modifications are required.

3) Number of basket levels to have? – Without modifications, 1 level of ATR4 Buckets will fit in a short (10-foot long) DOE SNF Standardized Canister and 2 levels of ATR4 Buckets will fit in a long (15-foot long) DOE SNF Standardized Canister. With minor modifications, extending the canister length a few inches, 2 levels of ATR4 Buckets will fit in a short (~10'3" long) DOE SNF Standardized Canister and 3 levels of ATR4 Buckets will fit in a long (~15'6"foot long) DOE SNF Standardized Canister. A second (and or third) level will impact handling operations and require some specific demonstration programs.

4) Basket arrangement to use for ATR fuel? – The DOE SNF Standardized Canister diameter selected will determine which baskets (none or simple cross for 18”-OD; simple cross, flux trap, spokes, or star for 24”-OD) are feasible in the design. The design will influence operations and will determine if some facility modifications are required.

5) Use of ATR4 Buckets? – The use of ATR4 Buckets provides some clear advantages for handling operations but adds some complexity (or precludes) loading in small diameter DOE SNF Standardized Canisters and requires some updated analyses. If it is decided ATR4 Buckets will not be used, then some new operational steps will be required, and some new tooling (gripper for bare ATR fuel elements), new demonstration programs will need to be developed (handling bare ATR fuel elements), and new basket designs will need to be implemented.

4.3.3 Specific for Peach Bottom Fuel

This section has the decision specific to Peach Bottom Fuels that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) What basket for Peach Bottom fuel elements? – Which basket will determine how many elements can be loaded in a DOE SNF Standardized Canister. The number of fuel elements will impact operations, as how many DOE SNF Standardized Canisters will be required to empty storage canisters from the different facilities (Fuel Storage Canisters in CPP-603 IFSF each have 12 Peach Bottom elements, and Fuel Storage Containers in CPP-749 UFSF each have 18 Peach Bottom elements).

   Three different basket configurations have been evaluated.

   1. Preliminary – with 13-15 Peach Bottom Elements with nothing or iron oxide

   2. Type Ia – with 10 Peach Bottom Elements with Gd Alloy plates

   3. Foster Wheeler – with 10 Peach Bottom Elements with $GdPO_4$ Tubes

   The Type 4 basket (Figure 28), or a similar 12 pack, although not directly analyzed, would likely work based on the results for the 1. Preliminary cases.

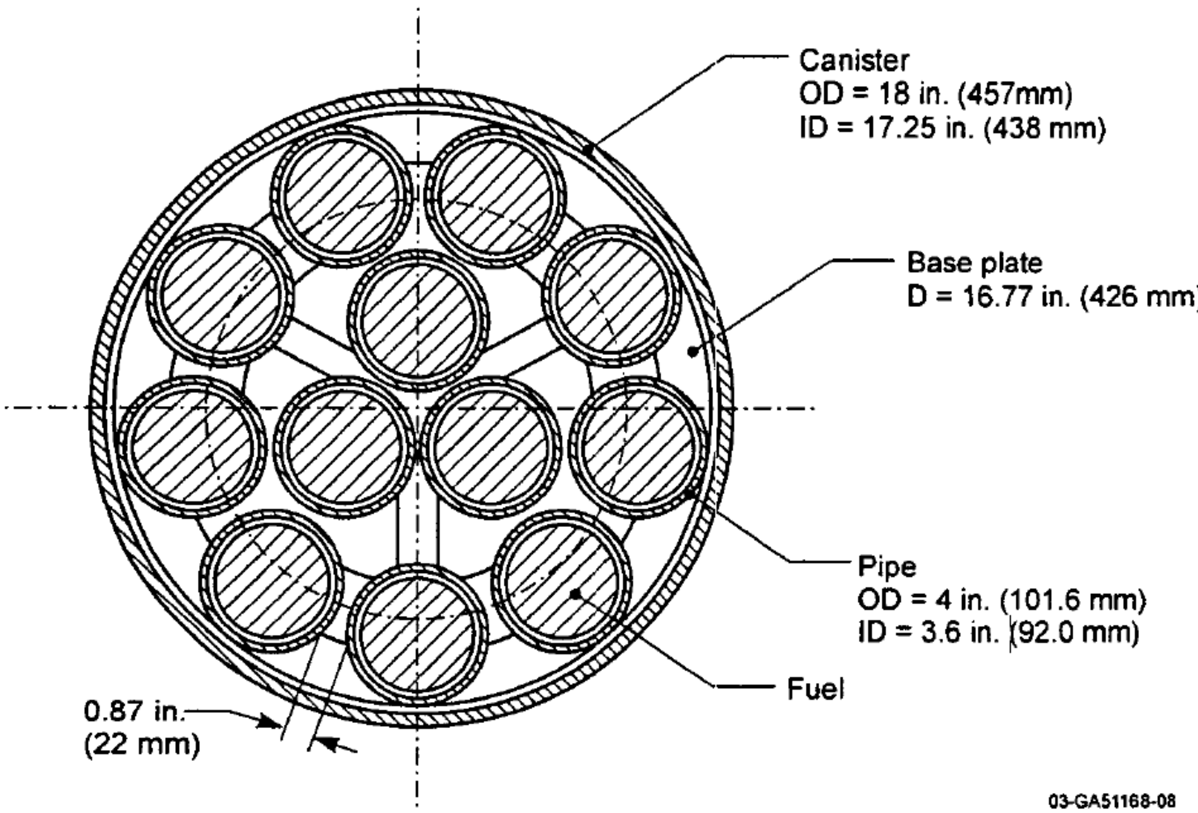

Figure 28. Type 4 Basket for the 18”-OD DOE SNF Standardized Canister

The Preliminary basket has the advantage of maximizing elements, but the disadvantage of requiring more detailed design work and analyses. The Type Ia basket has the advantage of being completely analyzed, but the disadvantages of a low capacity and requiring an undeveloped material (Gd-alloy plate) and additional detailed design work. The Foster Wheeler design has the advantage of having most of the design work completed but has the disadvantages of a low capacity and still needing the disposal analyses. The Type 4 like basket has the advantages of good capacity and some design work completed, but the disadvantages of needed detailed design and needing the disposal analyses. Based on the Preliminary analyses, the disposal analyses should be only confirmatory.

2) Should a neutron absorber be included or only iron? – Based on the Preliminary analyses, a neutron absorber may not be needed for disposal. But the preliminary analyses may not bound the latest disposal configurations. This effects design and details of any analyses. This is essentially a preliminary assumption that can be verified by the criticality analyses.

4.4 Analyses

The supporting analyses listed in this section are divided into categories of general, and specific to each fuel type.

4.4.1 General

This section has the general supporting analyses, independent of fuel type, that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Geochemical/corrosion analysis for long term internal corrosion – Need to determine what general level of dryness is needed to prevent long term internal corrosion. Subject to the decision for Moisture Getter, a general getter geochemical analysis and corrosion analysis should also be performed to justify the defense-in-depth provided by the getter (if used).
2) Update CPP-603 Criticality Analysis for additional plastic – If plastic will be used for contamination control on the outside of DOE SNF Standardized Canisters, the CPP-603 criticality analysis needs to be updated to ensure criticality safety for the facility.
3) Process flow time motion analysis – Optimized the handling and processing operations within the FHC.

4.4.2 Specific for ATR Fuel

This section has the decision specific to ATR Fuels that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Preliminary criticality analyses – If decision for DOE SNF canister and basket size not included in current criticality analyses, need to evaluate criticality for new basket/canister design combo over the required storage and transport conditions and over a range of credible disposal scenarios.
2) Licensing analyses – Need full licensing calculations for final DOE SNF Standardized Canister and Basket Design. These should include: Criticality safety (Criticality safety analysis will need Upper Safety Level determination based on available benchmarks and bias determined by TSUNAMI or WHISPER codes), Shielding, Thermal, Structural, etc.

4.4.3 Specific for Peach Bottom Fuel

This section has the decision specific to Peach Bottom Fuels that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Preliminary criticality analyses – Need a criticality analysis for the selected basket design which looks at the range of disposal configurations and validate decision on including neutron absorbers or just iron (which will form iron oxide filler as it corrodes).
2) Licensing analyses – Need full licensing calculations for final DOE SNF Standardized Canister and Basket Design. These should include: Criticality safety (Criticality safety analysis will need Upper Safety Level determination based on available benchmarks and bias determined by TSUNAMI or WHISPER codes), Shielding, Thermal, Structural, etc.

4.5 Designs

The additional design work needed listed in this section is divided into categories of general, and specific to each fuel type.

4.5.1 General

This section has the additional design work required, independent of fuel type, that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Tool(s) for handling empty DOE SNF Standardized Canisters.
2) Vent Plug detail. – Need details of ports, any threading and seals, any cap, welds for cap, etc.
3) Lid assembly weld detail. – Need to refine details on finish, angles, and back plate.
4) Remote equipment for Lid-to-Shell Welding/NDE/Repair.
5) Remote equipment for Drying/Inerting-Backfilling.
6) Remote equipment for Vent Plug Seal Welding/NDE/Repair and Leak Test
7) Remote equipment for Contamination Swipe (if needed)
8) If moisture getters are to be used, remote equipment for heating and adding Moisture Getter to the DOE SNF Standardized Canister.

4.5.2 Specific for ATR Fuel

This section has the additional designs specific to ATR Fuels that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Basket design detail. – Include weldments/attachments to shell or end impact plates. Interface with lid assembly weld back plate.
2) If 2+ levels, need divider plate and upper basket design detail. – Include weldments and connections to end impact plate and lower basket.
3) Detailed design for criticality control inserts. – Include materials, dimensions, and attachment points.
4) Spacer design. – For ATR4 Buckets with the different levels.

4.5.3 Specific for Peach Bottom Fuel

This section has the decision specific to Peach Bottom Fuels that need to be made for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Tool(s) for handling bare Peach Bottom fuel elements.
2) Basket design detail.
3) Any criticality control features. – Include materials, dimensions, and attachment points.
4) Spacer design. – For bare Peach Bottom elements.

4.6 Demonstration Programs

The demonstration programs needed for loading DOE SNF Standardized Canisters in the CPP-603 IFSF are listed in this section are divided into categories of general, and specific to each fuel type. Many of these demonstration programs include a cold phase (where non-radioactive materials are handled) and a final hot phase, where the tested processes are used on actual fuel.

4.6.1 General

This section has the demonstration programs needed, independent of fuel type, for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Handling of empty DOE SNF Standardized Canisters.
2) Contamination controls for DOE SNF Standardized Canisters (wraps, metal shroud)
3) Remote Welding/NDE/Repair of Lid-to-Shell Weld
4) Remote Drying/Inerting-Backfilling of DOE SNF Standardized Canister
5) Remote Placement of Vent Plug/Vent Plug Weld Cover
6) Remote Welding/NDE/Repair of Vent Plug Seal Cover Weld
7) Remote Leak testing of DOE SNF Standardized Canister Seal Welds
8) Removal of Contamination controls (plastic, wax paper, or cloth wrap) (if required)
9) Remote Contamination swipe of DOE SNF Standardized Canister (if required)
10) Remote decontamination/cleaning (if required)

4.6.2 Specific for ATR Fuel

This section has the demonstration programs needed specific to ATR Fuels for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Loading of inserts (bars, rods, strips, and/or plates) into the ATR4 Buckets with ATR Fuel
2) Placement of spacers
3) If 2+ levels, loading of need divider plate and upper basket design detail
4) Loading of ATR4 Buckets or ATGR Fuel elements into lower (and middle) levels inside DOE SNF Standardized Canister

4.6.3 Specific for Peach Bottom Fuel

This section has the demonstration programs needed specific to Peach Bottom Fuels for loading DOE SNF Standardized Canisters in the CPP-603 IFSF.

1) Handling bare fuel
2) Placement of spacers
3) Repackaging of Storage Container with broken Peach Bottom fuel element pieces into Large-Long DOE SNF Standardized Canister. (24”-OD, 15’ long)

4.7 Modifications

This section discusses the modifications that may be required to the CPP-603 IFSF in order to load ATR4 Buckets with ATR fuel elements or bare Peach Bottom fuel elements into DOE SNF Standardized Canisters.

1) Add/open power ports – The FHC has several ports that will need to be opened to run power lines for the various new equipment.
2) Add/open ports for data lines – The FHC ports will need to be surveyed, and some opened to allow cablings (fiber optic or normal wire) for cameras and data associated with the new equipment.
3) Add gas lines – Various pieces of equipment require various compressed gases (argon, helium, nitrogen, etc.) to perform their function, and so gas lines will need to be run to them (unless process studies indicate that gas cylinders attached to the equipment are more efficient) from tanks inside the Labyrinth / Crane Maintenance Area.
4) Need to remove the current Storage Canister Drying equipment (FCS insert in Floor Well 13) to allow room for the new equipment.
5) Need to add an adaptor bin in the CTC to allow equipment to be shuttled into the FHC via the CTP from the PCS and Truck Bay.
6) If small (18"-OD) DOE SNF Standardized Canisters are to be used, need adapter sleeve(s) to hold the canister up-right in the 20.5" diameter Floor Well holes. This would be needed for Floor Wells #12 and or #15.
7) If large (24"-OD) DOE SNF Standardized Canisters are to be used, need an adapter sleeve to hold the canister up-right in the 26" diameter Floor Well hole. This would be needed for Floor Wells #13 or #14 (one will be needed for the Peach Bottom fuel shipping baskets, for shipments from the CPP-749 UFSF).
8) Depending on the size of the new equipment (welding/NDE/repair, drying/inerting-backfilling, etc.), some combination of Floor Wells #10-15 may need to be covered with removable, steel cover plates, to allow placement of the new equipment/establishment of a station of the various operations.
9) May need storage racks for the various new handling tools and new equipment, when it isn't in use and for the items like lid assemblies, criticality control inserts, spacers, weld wire, swipes, etc.

5. Summary

There are no identified showstoppers for performing loading of DOE SNF Standardized Canisters with either ATR or Peach Bottom fuel elements in the CPP-603 IFSF. There is a great deal of experience, that indicates all the necessary process are possible. However, several decisions need to be made, analyses performed, designs finalized, demonstration programs developed, and some facility modifications made before the loading of ATR or Peach Bottom fuel elements in DOE SNF Standardized Canisters can occur in the CPP-603 IFSF.

Need decisions to be made in order to finalize canister design elements and requirements. These decisions are needed to start the process moving, but most can be easily changed if analyses results point to more optimum solutions.

Need analyses to be performed in order to determine optimum time motion/process flow, verify design decisions, and support licensing efforts.

Need to design tools, canister components (vent plug/port, welds), baskets, inserts, spacers, and equipment (welding/NDE/repair, drying/inerting-backfilling, leak test). The detailed canister design and design of equipment for the handling/loading/closure operations are not unique to CPP-603. These designs are necessary for any facility that will package DOE SNF using standardized canisters.

Need to demonstrations processes for remote canister handling/loading/closing operations. The results of these demonstrations would optimize the designs and would also be beneficial for facilities other than CPP-603.

Need to perform some facility modifications to accommodate the equipment and canisters. These modifications are minor. Most are opening ports and running lines for power, data, and compress gases; or replacing modular components within the CPP-603 FHC with adaptors and plates. None are structural changes. The most significant are probably the addition of storage racks to optimize space for the new equipment.

Cost of processes and equipment was not addressed in this evaluation. The range of options being considered is still too large for useful values.

6. References

1. SAR-114, Revision 5. *Safety Analysis Report for the Irradiated Fuel Storage Facility IFSF*. June 2009.
2. CAL-DSD-NU-000007 Rev 00A, *Intact and Degraded Mode Criticality Calculations for the Codisposal of ATR Spent Nuclear Fuel in a Waste Package* EDF-11001.
3. Fluor Idaho Dwg 808038 REV 2, *CPP-603 IFSF 4 COMPARTMENT BUCKET FOR ATR FUEL BU-GSF-ATR4-XXX*.
4. INEEL/EXT-03099103 Revision 0. *Fuel Summary for Peach Bottom Unit 1 High-Temperature Gas-Cooled Reactor Cores 1 and 2*. April 2003.
5. INL/CON-05-00978 Remote Welding, NDE and Repair of DOE Standardized Canisters, May 2006.
6. GA-C18525, *Characterization of Peach Bottom Unit 1 Fuel*, October 1986.
7. DOE/SNF/REP-011 Revision 3. *Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters*. August 1999.
8. INL/EXT-18-51490 Revision 0. *Multi-Year Plan to Prepare DOE-Managed Spent Fuel for Transportation*. September 2018.
9. Foster Wheeler Dwg ISF-ME-S-16000 REV 4, *18" O.D. SNF CANISTER (SHORT) FABRICATION*.
10. Foster Wheeler Dwg ISF-ME-S-16002 Revision 4, *24" O.D. SNF Canister Fabrication (Long Canister)*.
11. RPT-3022527-000. *Feasibility Evaluation of ATR4 Buckets in DOE Standardized Canisters – Fit and Criticality*. June 2019.
12. Foster Wheeler Dwg ISF-ME-S-11021 Rev 2. Peach Bottom 1 & 2 Fuel Basket Layout. July 2002.
13. INL/CON-05-00978 Remote Welding, NDE, and Repair of DOE Standardized Canisters – Proceedings of 5th International Conference on NDE in Relation to Structural Integrity for Nuclear & Pressurized Components. May 2006.
14. DOE/RW-031 Rev 5. *Waste Acceptance System Requirements Document*. March 2008
15. YMP/TR-004Q Rev 2. *Disposal Criticality Analysis Methodology Topical Report*. November 2003.
16. NUREG-1536 Revision 1. *Standard Review Plan for Dry Cask Storage Systems*. July 2010
17. PNL-6365 Evaluation of Cover Gas Impurities and Their Effects on the Dry Storage of LWR Spent Fuel. November 1987.
18. EDF-1702, Revision 0. *Description of Peach Bottom Core 2 Spent Nuclear Fuel Unloading, Cuttng and Placement into IFSF Storage*. September 2000.

Appendix A

Time Estimate for Closing a DOE SNF Standardized Canister

Time Estimate:

Based on vendor experience, here are time estimates for closing a DOE SNF Standardized Canisters in the CPP-603 Facility based on the preliminary steps:

- Place Lid Assembly on DOE SNF Standardized Canister: 3 hours
- Attach Lid-Shell Welding/NDE/Repair Equipment: 3 hours
- Perform Welding, NDE, and any Repair (if needed) operation: 12-24 hours (depending on design of the weld)
- Remove Shell Welding/NDE/Repair Equipment: 3 hours
- Attach Drying/Inerting-Backfilling Equipment: 3 hours
- Perform Drying cycle: 6-12 hours (depending on equipment and dryness criteria, see Appendix B)
- Perform Inerting/Backfilling operation (including port seal weld and leak test): 6 hours
- Remove Drying/Inerting-Backfilling Equipment: 3 hours

These times will be refined as tooling and process steps are developed as part of the design and demonstration programs are finalized.

Appendix B

Drying Process

Time Estimate Factors:

Based on vendor experience, there are several factors and variables that need to be assessed before a meaningful time estimate for a drying scenario can be formulated. These factors include:

- physical condition of the fuel (i.e., cladding integrity),
- amount of crud material present on the fuel surfaces and associated fittings,
- water solubility of the crud material,
- surface area of the surfaces that moisture can adhere to after bulk water removal efforts are completed,
- temperature limitation on fuel cladding materials (if any),
- net free volume of the canister,
- canister processing port diameter,
- canister basket materials (including neutron absorber panels),
- canister internal characteristics (horizontal surface areas, bottom sump, other features that may hamper or otherwise impede efficient removal of water vapor),
- dryness acceptance criteria,
- distance between processing station and vacuum drying system,
- fuel heat load, and
- time limit for transitioning between bulk water removal and establishing vacuum condition.

Example Process:

Example summary of NAC's optimized drying process:

- Following placement of closure lid, drying system hoses are attached to the canister quick-disconnects
- Pressurized gas (helium, argon, nitrogen) is introduced thru the vent connector
- Water is blown out the drain connector
- Several bursts of gas are introduced to "burp" the canister at predetermined intervals according to pressure/temperature/heat load profiles (NAC Proprietary Information)
- Vacuum system is engaged, reducing pressure incrementally to 100 torr maintaining constant pressure for 30 minutes without pump operation
- Achieve 3 torr and backfill with 1 atmosphere cover gas.

Appendix C

Preliminary Detailed Process Steps

Preliminary Process Steps:

Below are preliminary list of detailed process steps envisioned for loading different types of fuel (from different facilities) into DOE SNF Standardize Canister in the CPP-603 IFSF. These steps will likely be revised as tooling, equipment, and demonstration processes are finalized or completed. The steps text is color coded per the categories in Section 3: Logistic in Red, Standard in Green, and New in Blue.

ATR Fuel in ATR4 Buckets From CPP-603

1. Bring Equipment (drying, welding, NDE, etc.) into Fuel Handling Cave via Transfer Pit and Transfer Car
2. Bring Empty DOE SNF Standardized Canisters and components (lid assembly, level divider plate and upper basket, spacers) into Fuel Handling Cave via Transfer Pit and Transfer Car
3. Bring criticality control inserts for ATR4 Buckets into Fuel Handling Cave via Transfer Pit and Transfer Car
4. Bring Top Spacers Inserts into Fuel Handling Cave via Transfer Pit and Transfer Car
5. Place Empty DOE SNF Standardized Canister (with first level basket) in Floor Well using Crane (CRN-GSF-401)
6. Lift Fuel Storage Canister from a Storage Rack location in the Fuel Storage Area using Crane (CRN-GSF-101)
7. Move Fuel Storage Canister to Shuttle Bin with Crane (CRN-GSF-101)
8. Move Fuel Storage Canister into Fuel Handling Cave with the Shuttle Bin
9. Open Fuel Storage Canister (lid set aside)
10. Remove ATR4 Bucket from Fuel Storage Canister with Crane (CRN-GSF-401)
11. Move ATR4 Bucket to south rack floor wells by lower window near Manipulators using Crane (CRN-GSF-401)
12. Load inserts into ATR4 Buckets with Manipulators and Crane (CRN-GSF-401)
13. Place ATR4 Bucket (with inserts) in DOE SNF Standardized Canister using Crane (CRN-GSF-401)
14. Repeat steps #9 – 12 until level filled
15. Place Top Spacer Inserts on top of Basket over ATR4 Buckets in DOE SNF Standardized Canister
16. Place Level Separator Plate/Upper basket in DOE SNF Standardized Canister
17. Repeat steps #9 – 13 until second level filled
18. Place Top Spacer Inserts on top of Buckets/Basket
19. Place Lid Assembly on DOE SNF Standardized Canister
20. Place Remote Shell Welding/NDE/Repair Equipment on DOE SNF Standardized Canister
21. Perform Welding & NDE operation
22. Perform (if needed) Repair operation(s) on any welds with unacceptable flaws
23. Remove Shell Welding/NDE/Repair Equipment
24. Attach Drying/Inerting-Backfilling Equipment to DOE SNF Standardized Canister
25. Perform Drying cycle
26. Add Water/Moisture Getter into DOE SNF Standardized Canister (if needed)
27. Perform Inerting-Backfilling operation (including leak test)
28. Place, weld, and NDE Vent Plug Cover (including leak test)
29. Remove Drying/Inerting-Backfilling Equipment
30. Move Crane (CRN-GSF-101) into Fuel Handling Cave thru Moveable Shield Doors
31. Place DOE SNF Standardized Canister in North Floor Well location using Crane (CRN-GSF-101)
32. Repeat steps until 5-9 of the North Floor Wells are filled with sealed DOE SNF Standardized Canisters

The steps text is color coded per the categories in Section 3: Logistic in Red, Standard in Green, and New in Blue.

Peach Bottom Fuel From CPP-603

1. Bring Equipment (drying, welding, NDE, etc.) into Fuel Handling Cave via Transfer Pit and Transfer Car
2. Bring Empty DOE SNF Standardized Canisters and parts into Fuel Handling Cave via Transfer Pit and Transfer Car
3. Bring Top Spacer Inserts into Fuel Handling Cave via Transfer Pit and Transfer Car
4. Place Empty DOE SNF Standardized Canister (with first level basket) in Floor Well using Crane (CRN-GSF-401)
5. Lift Fuel Storage Canister from a Storage Rack location in the Fuel Storage Area using Crane (CRN-GSF-101)
6. Move Fuel Storage Canister to Shuttle Bin with Crane (CRN-GSF-101)
7. Move Fuel Storage Canister into Fuel Handling Cave with the Shuttle Bin
8. Open Fuel Storage Canister (lid set aside)
9. Remove Peach Bottom fuel element from Fuel Storage Canister with Tool & Crane (CRN-GSF-401)
10. Place Peach Bottom fuel element into DOE SNF Standardized Canister
11. Repeat steps #9 – 10 until DOE SNF Standardized Canister is filled
12. Place Top Spacers Inserts in basket over fuel in DOE SNF Standardized Canister
13. Place Lid Assembly on DOE SNF Standardized Canister
14. Place Remote Lid-Shell Welding/NDE/Repair Equipment on DOE SNF Standardized Canister
15. Perform Welding & NDE operation performed
16. Perform Repair operation on any welds with unacceptable flaws (if needed)
17. Remove Lid-Shell Welding/NDE/Repair Equipment
18. Attach Drying/Inerting-Backfilling Equipment to DOE SNF Standardized Canister
19. Perform Drying cycle
20. Add Water Getter into DOE SNF Standardized Canister
21. Perform Inerting/Backfilling operation (including leak test of Lid-shell weld)
22. Place Vent Plug Cover Plate over top vent plug
23. Weld and NDE Vent Plug Cover Plate (including leak test of Vent Plug Cover Plate seal weld)
24. Remove Drying/Inerting-Backfilling Equipment
25. Move Crane (CRN-GSF-101) into Fuel Handling Cave thru Moveable Shield Doors
26. Place DOE SNF Standardized Canister in North Floor Well location using Crane (CRN-GSF-101)
27. Repeat steps until 5-9 of the North Floor Wells are filled with sealed DOE SNF Standardized Canisters

The steps text is color coded per the categories in Section 3: Logistic in Red, Standard in Green, and New in Blue.

Peach Bottom Fuel From CPP-749/Generation I Vaults

1. Bring Equipment (drying, welding, NDE, etc.) into Fuel Handling Cave via Transfer Pit and Transfer Car
2. Bring Empty DOE SNF Standardized Canisters and parts into Fuel Handling Cave via Transfer Pit and Transfer Car
3. Bring Top Spacer Inserts into Fuel Handling Cave via Transfer Pit and Transfer Car
4. Place Empty DOE SNF Standardized Canister (with first level basket) in Floor Well using Crane (CRN-GSF-401)
5. Bring Peach Bottom Fuel Storage Canister from CPP-749 using Transfer Cask
6. Load Transfer Cask into Cask Transfer Car in PCS
7. Move Transfer Cask into Fuel Handling Cave with the Transfer Car
8. Open Transfer Cask (lid set aside)
9. Remove Peach Bottom fuel element from Transfer Cask with Tool & Crane (CRN-GSF-401)
10. Place Peach Bottom fuel element into DOE SNF Standardized Canister
11. Repeat steps #9 – 10 until DOE SNF Standardized Canister is filled
12. Place Top Spacers Inserts in basket over fuel in DOE SNF Standardized Canister
13. Place Lid Assembly on DOE SNF Standardized Canister
14. Place Remote Lid-Shell Welding/NDE/Repair Equipment on DOE SNF Standardized Canister
15. Perform Welding & NDE operation performed
16. Perform Repair operation on any welds with unacceptable flaws (if needed)
17. Remove Lid-Shell Welding/NDE/Repair Equipment
18. Attach Drying/Inerting-Backfilling Equipment to DOE SNF Standardized Canister
19. Perform Drying cycle
20. Add Water Getter into DOE SNF Standardized Canister
21. Perform Inerting/Backfilling operation (including leak test of Lid-shell weld)
22. Place Vent Plug Cover Plate over top vent plug
23. Weld and NDE Vent Plug Cover Plate (including leak test of Vent Plug Cover Plate seal weld)
24. Remove Drying/Inerting-Backfilling Equipment
25. Move Crane (CRN-GSF-101) into Fuel Handling Cave thru Moveable Shield Doors
26. Place DOE SNF Standardized Canister in North Floor Well location using Crane (CRN-GSF-101)
27. Repeat steps until 5-9 of the North Floor Wells are filled with sealed DOE SNF Standardized Canisters