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ENGINEERING DATA TRANSMITTAL

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1	SNF-5133		A 0	SSFC Design Report	ESQ	2	5	1
2	SNF-5191		A 0	SSFC Canister and Shield	ESQ	2	5	1
				Plug Fabrication				
				Specification				
3	SNF-5192		A 0	SSFC Insert Fabrication	Q	2	5	1
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16 KEY

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1	1	Design Authority D M Johnson	[signature]	1 24 00	R3-11	1	1	~~J E Kurtz~~ C A Bullock, RADCON	[signature]	1/26/00	X3-68
1	1	Design Agent J M Tanke	[signature]	1-24-00							
		Cog Eng									
1	1	Cog Mgr R L McCormack	[signature]	1/24/00	R3-11						
1	1	QA C R Hoover	[signature]	1/24/00	L6-58						
1	1	Safety L J Garvin	[signature]	1/19/00	R3-26						
1	1	Env J E Turnbaugh	[signature]	1/6/00	X3-79						

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5 Proj /Prog /Dept Div	6 Cog Eng	1 EDT	
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4	H-2-829991	1	~~A~~ 0	SSFC Drawing List	Q	24	5	1
5	H-2-829991	2	~~A~~ 0	SSFC Drawing Tree	Q	24	5	1
6	H-2-829992	1	~~A~~ 0	SSFC Assembly	ESQ	24	4	1
7	H-2-829992	2	~~A~~ 0	SSFC Assembly	ESQ	24	4	1
8	H-2-829993	1	~~A~~ 0	SSFC Shield Plug	ESQ	24	4	1
9	H-2-829993	2	~~A~~ 0	SSFC Shield Plug Port	ESQ	24	5	1
10	H-2-829993	3	~~A~~ 0	SSFC Shield Plug Plate	ESQ	24	5	1
11	H-2-829994	1	~~A~~ 0	SSFC Insert	Q	24	5	1

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	D M Johnson	Date 1-24-00
Project Title/Work Order: Shippingport Spent Fuel Canister Design Drawings Design Report, and Fabrication Specifications		EDT No 627800
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Shippingport Spent Fuel Canister Design Report Project W-518

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Abstract The SSFC Design Report Describes A spent fuel canister for Shippingport Core 2 blanket fuel assemblies The design of the SSFC is a minor modification of the MCO The modification is limited to the Shield Plug which remains unchanged with regard to interfaces with the canister shell The performance characteristics remain those for the MCO, which bounds the payload of the SSFC

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SHIPPINGPORT SPENT FUEL CANISTER

DESIGN REPORT

PROJECT W-518

January 2000

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Prepared for Fluor Daniel Hanford Inc

Prepared by Parsons Infrastructure & Technology Group Inc

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1 0 INTRODUCTION

The basic Multi Canister Overpack (MCO) is designed as a storage/process vessel that will be used to stabilize and store the spent fuel currently stored in the Hanford K Basins A portion of the MCOs will be modified to transport and store Shippingport fuel currently stored in underwater storage racks in Cell 4 at 221-T (T-Plant) The modified SSFC used for the Shippingport fuel will be referred to as the Shippingport Spent Fuel Canister (SSFC) The SSFC and fuel is to be transported to the Canister Storage Building (CSB) where the SSFC's will be placed inside storage tubes for storage of up to 75 years The Shippingport fuel will be loaded and sealed within the SSFC in an inert atmosphere prior to transport to the CSB

This design report is limited to the features and functions of the SSFC to be used for the transport and storage of the Shippingport fuel relative to the requirements set forth in the SSFC Performance Specification (Reference 6 1) The SSFC Performance Specification is a compilation of the applicable parts of the basic MCO Performance Specification (Reference 6 2) and the Scope of Work for the modification of the MCO for Shippingport fuel The only modifications made to the MCO were those required to accommodate the Shippingport fuel

The SSFC Performance Specification limits the evaluation to structural and some functional considerations Criticality, shielding, thermal/fluid, and interface considerations are not part of the evaluation, however, features are included in the design to accommodate evaluations performed by the buyer and indicated in the SSFC Performance Specification Components such as lifting interfaces, process interfaces, etc , are the responsibility of the Buyer The approach in this design report is to address how each requirement for the SSFC is met by the design In many areas this report references the appendices that contain the detailed analysis and design drawings The appendices only consider and address the differentiating requirements or features from the basic MCO design for the K-basin Where the features and evaluations have not changed or are bounded reference is made to the applicable analysis in the MCO Design Report (Reference 6 3)

The SSFC is designed to Section III of the ASME Boiler and Pressure Vessel Code as designated within the SSFC Performance Specification with the pressure boundary designed to Subsection NB of the ASME Code (Reference 6 4) Formal application of the ASME Code to the containment portion of the SSFC would be by the issuance of a Certified ASME Design Specification and related "Over Pressure Protection Report to cover a subset of the requirements of the SSFC Performance Specification However, as indicated in the Performance Specification and this report all the applicable load conditions for the SSFC are bounded by the similar load conditions for the MCO Therefore, the design specification and over pressure protection report that supports the basic MCO design that forms the basis for the SSFC bounds that of SSFC Hence a vessel meeting the MCO requirements would meet the requirements of the SSFC On this basis a vessel with an ASME stamp applied based on the MCO requirements would meet the need of a stamp for the SSFC The "N" certificate holder (fabricator) is responsible for issuing the ASME Design Report and applying the stamp Some load cases are specifically exempted from meeting ASME Code requirements by the SSFC Performance Specification

As shown in the attached appendices, the SSFC design is evaluated against the ASME Code and shown to be compliant using the principles and rules as set forth in the ASME Code Interpretations of the SSFC Performance Specification interfaces, and load application are stated in each appendix

The final cover cap closure weld addresses the ASME Code requirements by the use of ASME Code Case N-595 (Reference 6 5), which invokes appropriate stress reduction factors ASME Code Case N-595 requires that the final closure weld be liquid penetrant inspected at the root pass, after each 1/4 inch of weld material, and following the cover pass, to allow use of a stress reduction factor of 0 9 Finally helium leak testing is required to demonstrate containment integrity ASME Code Case N-595 also requires that the ASME Certified Design Specification (containing the Overpressure Protection Report) demonstrate that the Service Limits specified in the SSFC Design Specification will not be exceeded and hence no pressure relief is required nor will be permitted during storage

The redundant cover above the test plug in the cover cap is not considered part of the pressure boundary and correspondingly is not designed or evaluated to the ASME Code However, using ASME Code Case N-595 with the same conditions, the test plug cover weld is permitted to be a pressure retaining weld if it is inspected like the cover cap closure weld and appropriate stress reduction factors are utilized ASME Code Case N-595 does not require the test plug cover weld to be leak tested The SSFC Performance Specification does not apply ASME Code criteria to components that are not required for criticality or containment safety such as the insert

2 0 DESCRIPTION OF SYSTEM

2 1 General

The SSFC is designed to facilitate the removal, processing, and storage of the Shippingport fuel currently stored at the T-Plant The SSFC is a stainless steel canister approximately 24 inches in diameter and 166 inches long, with cover cap installed The shell and the collar that is welded to the shell are fabricated from Type 304/304L dual-certified stainless steel for the shell and Type F304/F304L dual-certified stainless steel for the collar The shell has a nominal thickness of 1/2 inch The top closure consists of a shield plug with a processing port, and a locking ring with jacking bolts to pre-load a metal seal under the shield plug

At the T-Plant, Shippingport fuel is loaded dry by lifting the fuel from the pool and letting it dry prior to placing it into the SSFC At the time of loading the SSFC with insert in place is within a TN-WHC transport cask on a transport trailer designed for the MCO transfers Four fuel assemblies are loaded into the SSFC, each being separated by the four cells of a cruciform-shaped canister insert Following fuel loading, a shield plug is installed to shield and seal the SSFC To energize the seal a locking ring is installed and jacking bolts are tightened to pre-load the metal closure seal Using the process port a vacuum is drawn to aid in the final drying of the fuel Following vacuum drying the SSFC is backfilled with an inert gas The shield plug provides biological shielding for workers during the vacuum/backfill process The process port cover may be installed or removed as needed per the SSFC operating procedures After the SSFC is inerted and the transfer cask sealed the SSFC is taken to the Canister Storage Building (CSB) At the CSB the SSFC is removed from the transfer cask and transferred to the weld station for installation of the cover cap It is then transferred to interim storage where it becomes one of two SSFCs stacked in a storage tube SSFCs will have a cover cap welded over the shield plug to provide a permanently welded closure

The drawings in Appendix 1 illustrate the details of all SSFC components

2 2 Interfaces

The SSFC, as described above, must interface with many exterior components and environments, including "hands-on capabilities for all operations These include

1 Transfer Cask
2 Shippingport Fuel and Insert
3 Remote operator for the Process Port/valve with the cap off
4 Remote operator for the Process Port/valve with the cap on for future sampling/testing if required
5 Remote operators for Process Port Cover
6 Locking and Lifting Ring installation/jacking bolts tightening equipment
7 Transfer equipment at CSB
8 CSB storage tubes
9 MCO Handling Machine
10 Closure Cap installation equipment
11 Non-destructive examination processes for the closure welds
12 Leak rate testing equipment
13 Repair equipment
14 Shield Plug installation equipment

The design ensures proper interface with the above components by compliance with the SSFC Performance Specification and the interface drawing provided by the Buyer (SK-1 80096)

2 3 SSFC Shell

The SSFC shell provides both confinement and containment of the fuel during both handling and storage The shell is constructed of Type 304L/304 dual-certified stainless steel The main section of the shell is fabricated from 24 inch diameter Schedule 80S SA-312 Type 304L/304 dual-certified stainless steel pipe, or rolled SA-240, Type 304L/304, dual-certified stainless steel plate The bottom of the shell is a SA 182, Type F304L machined stainless steel forging or may be machined from SA-240 Type 304L, stainless steel plate Completing the containment boundary at the top of the shell the SSFC collar is a SA 182 Type F304L/F304 dual-certified stainless steel machined forging with a double lead buttress thread and a seal surface for the primary seal and shield plug to rest

2 4 Cover Cap

The cover cap is a SA-182, Type 304L stainless steel forging that is placed on top of the SSFC at the CSB The purpose of the cover cap is to provide a welded closure that is capable of meeting the containment leakage rate criteria The closure weld is a full penetration weld just below the top of the locking ring on the collar of the SSFC shell This weld is a "field weld" that cannot be radiograpically inspected due to the configuration and contents of the SSFC However the weld is configured to allow for ultrasonic inspection and helium leak testing The weld will be qualified by the use of ASME Code Case N-595 that requires only liquid penetrant inspection and helium leakage rate testing

The exterior of the cover cap is machined to have the same lifting rim configuration as the locking ring so that the SSFCs can be handled after installation of the cover cap The cover cap has one mechanically sealed penetration that can be aligned over the process port on the shield plug The penetration permits operation of that shield plug port through the cover cap after its installation The penetration is a plug with a mechanical seal that will allow venting of the cover cap sampling of the atmosphere within the cover cap, as well as access for operation of the shield plug port This access could be used as needed although at this time there is no anticipated need for it The penetration has the capability to be seal welded shut prior to welding the cover cap in place Its orientation to allow operation of the port will be predetermined To ensure proper orientation, alignment marks will be used and/or a fixture employed that holds the orientation correctly while the cover cap is welded in place The cover plate on the process port, if used, provides a redundant closure for protection with a mechanical seal capable of a 150 psig design pressure

2 5 Shield Plug

The shield plug is a multi-functional component of the SSFC It provides a mechanical confinement and containment boundary until the cover cap is welded in place It also provides for axial shielding to allow personnel access to the top of the SSFC for securing the mechanical closure as well as performing the vacuum drying and processing functions The shield plug also retains the main seal that seals against the SSFC collar The shield plug for the Shippingport fuel has one port that connects to a penetration that allows for a vacuum to be drawn and the cavity to be backfilled with an inert gas There are four 3/4-10 UNC bolt holes equally spaced on top of the shield plug to allow attachment of a lifting and handling device for the shield plug

2 6 Shield Plug Port

The shield plug port, as described above, encompasses unique functions for the handling processing, and safety in the storing of the spent fuel A process plug is used in the shield plug port The process plug is a hollow cross-drilled and threaded plug that seals when fully engaged and allows flow when the plug is disengaged by unthreading approximately twelve turns Sealing properties are made possible due to a metal "C-seal" that has the capability of resealing over five times when the plug is tightened into place The seal is made from a structural hard metal such as Inconel that is plated with a soft metal such as silver or gold The seal and qualification testing for re-sealing capability are described in Appendix 14 The process plug has both a socket head and an external hex head This permits the plug to be operated with the cover cap either off or on when the cover cap penetration aligns with this port

The cover plate is a four-bolt blind flange with mechanical seals similar to the process plug The cover plate bolts are captured to allow for remote removal and installation of the cover The cover plate uses a similar metal 'C seal' that requires a relatively low sealing pressure The seal has the capability to "snap" onto the cover plate by being slightly oval thus facilitating remote removal and installation The metal seal that is used for the process plugs is an Inconel C seal with silver or gold plating, produced by EG&G Pressure Seals Use of this plating allows the seal to repeatedly seat at the high temperature limit of 132 °C (270 °F) per the SSFC Performance Specification, thereby meeting the specification's reseal requirements

2 7 Seal

The primary seal for the SSFC provides a seal between the shell and the shield plug This seal is manufactured by Helicoflex and is comprised of a high strength alloy spring covered with a 300 series stainless steel inner jacket and a silver outer jacket The seal is held in place with four stainless steel clips that are fastened to the shield plug When properly preloaded the seal will maintain a leak tight condition The seal is similar to the standard mechanical seals approved by the Nuclear Regulatory Commission (NRC) for dry fuel storage applications

2 8 Locking Ring

The pre-load on the seal is maintained by the use of a locking ring and jacking bolt arrangement The locking ring is a stainless steel forging with buttress threads This configuration allows the locking ring to be threaded into the SSFC collar after the shield plug is in place The locking ring serves two functions 1) it provides a grapple interface for handling the SSFC and 2) it provides support for the jacking bolts that pre-load the shield plug and the seal Eighteen SA-193, Grade B8S or B8SA 1½ inch set screws are threaded into the locking ring The screws serve as jacking bolts to pre load the seal and are sized to maintain the appropriate pre load throughout the operating pressure and temperature range (150 psig at 132 °C (270 °F)) A mechanical seal is not required to be maintained for the 450 psig design pressure At pressures or temperatures greater than the seal evaluation limit, loss of preload and subsequent loss of seal capability could occur due to either plastic or elastic deformation see Appendix 4 for details

2 9 Shippingport Fuel Canister Insert

The canister insert is designed to aid in the loading of four Shippingport fuel assemblies into an SSFC The canister insert is in the form of a cruciform that divides the SSFC cavity into four regions, or cells The canister insert rests on the bottom spacer plates and extends nearly the full length of the fuel assembly The canister insert serves no structural function its sole purpose is to position the fuel during loading operations The canister insert is placed into the SSFC when the SSFC is in the transfer cask The fuel is loaded into the SSFC while it and the insert are inside the cask

3 0 REQUIREMENTS

This section establishes the essential requirements necessary to define SSFC performance physical and quality characteristics environmental conditions and transportability The italicized text below delineates each requirement from the SSFC Performance Specification followed by a description about how the design complies

3 1 Design Life

The SSFC shall contain and confine the fuel assemblies throughout its design life of 40 years both before and after being subjected to the Design Basis Accidents (DBAs) described in Section 4 18 2 The SSFC shall not knowingly have design features that would prevent its design life from being extended to a total of 75 years

Refer to Section 4, Item 1 *The SSFC structural components are constructed from austenitic stainless steel with high resistance to corrosion from all aspects of the environment the system is expected to see over the specified lifetime There are no components making up the system that have any known mechanism that will cause the system not to sustain the required design lifetime None of the design basis accidents described is known to prevent the SSFC from completing the expected lifetime or extending it to 75 years*

3 2 SNF Confinement

The SSFC shall confine its contents during all normal operations and after being subjected to the DBAs described in Section 4 18 2 The SSFC shall be designed to facilitate confinement while process connections are being made and in conjunction with process piping during process operations

Refer to Section 4, Item 2 The SSFC is designed to confine its contents during all normal operation and during the design basis accidents described in Reference 6 1 Confinement is met by a Type 304L stainless steel shell that is closed with a mechanical seal between the shield plug and the shell The vessel is designed to and is to be fabricated in accordance with Section III Division 1 Subsection NB of the ASME Boiler and Pressure Vessel Code (Reference 6 4) as set forth in Reference 6 1 The process plug is designed to couple with an operator tool allowing it to be operated within a sealed environment and providing the requested confinement see the drawings in Appendix 1

3 3 SNF Containment

The SSFC shall maintain its containment capabilities during and after being subjected to the DBAs described in Section 4 18 2, except for the cask drops as noted in Section 4 18 2 During Hanford on-site transportation and process operations the total gaseous leakage across the SSFC pressure boundary including process connection seals but excluding controlled flow through any port, shall not exceed 1×10^{5} scc/sec This gaseous leakage rate is based on a clean seal and a clean sealing surface at the final mechanical closure boundary and associated process boundaries The SSFC when sealed by welding at the CSB weld station, shall be capable of not exceeding a maximum total leak rate of 1×10^{7} scc/sec

Refer to Section 4, Item 3 *The containment is provided by the same shell and seal system described above The port valve is designed to have a cover with a metal seal The seal is capable as is the main seal of meeting the 1 × 10^{-5} scc/sec criteria The shell is designed and analyzed for the design basis to comply with Reference 6 4 The shell is not required to meet Reference 6 4 requirements when it is in the cask for the horizontal and corner drop loads This is due to the cask being designed with a collar that provides a ring/point load to the shell The shell being fabricated from material with high elongation has the potential of deforming without breaching over this feature but would have localized stresses above the allowables*

During fabrication the shell is leak tested to 1 × 10^{-7} scc/sec to verify its containment capability The closure cap will be leak tested after installation The closure weld is designed to be capable of being inspected ultrasonically Qualification of this weld will be in accordance with ASME Code Case N-595 (Reference 6 5) allowing for liquid penetrant inspection only The SSFC could provide redundant seals with the port cover in place prior to the installation of the cover cap

3 4 Maintainability

The SSFC shall be designed to minimize the need for preventative maintenance throughout its design life

Refer to Section 4, Item 4 *As can be seen in the detailed drawing in Appendix 1 and discussed in the material evaluation of Appendix 2 the SSFC exterior is designed entirely out of austenitic stainless steel providing for a maintenance-free package during its expected lifetime for the specified environment The process plug and cover are designed for remote operation to facilitate maintenance on those components*

3 5 Human Factors

The SSFC components shall be designed to facilitate handling and assembly with the use of appropriate handling equipment The SSFC design shall also enable handling while wearing protective clothing used in radiation zones (e g coveralls gloves booties mask breathing apparatus etc)

Refer to Section 4, Item 5 *SSFC components can all be handled with remote equipment and by personnel in protective clothing Small components such as seals and bolts are captured or fastened to the larger components that can be handled with the aid of hoists cranes etc The SSFC shell can be handled by installing the locking ring and hoisting from the locking ring The shield plug can be handled by attaching a lifting device to the bolts holes provided in the top section The insert can be handled with the use of shackles and rigging The cover plate seal is snapped into place because the seal is elliptical The main seal is held into place by small clips*

3 6 Interchangeability

To the maximum extent possible (design goal) SSFC components with like functions shall be interchangeable (i e , any insert can be loaded into any SSFC shell any SSFC shield plug and locking ring can be used to close and seal any SSFC shell etc)

The SSFC shell, shield plug lifting ring, cover cap and the insert shall have unique identification numbers for tracking and accountability purposes

Refer to Section 4, Item 6 *All components are dimensioned as shown in the Appendix 1 drawings so that after welding and final machining they are all interchangeable The drawings and the SSFC Fabrication Specification (Reference 6 6) provide for the Buyer supplied numbering and marking system that allows for the required tracking and accountability*

3 7 Environmental Conditions

The SSFC shall be capable of performing its mission while subjected to the environmental conditions listed in Table 1

Refer to Section 4, Item 7 *The selection of materials in Appendix 2 and the applicable stress values used for the materials in the analyses performed in Appendices 4-12 ensure that the SSFC and the canister insert are fully functional for the environmental conditions stated above All containment seals including the process plug seal are also selected for these conditions*

Table 1 – External Environmental Conditions (as seen by SSFC)

Parameter	Condition
Hanford Site	
Temperature (Air)	Range -33 °C to 46 °C (27 °F to 115 °F) Rate of Increase 14 °C (26 °F) in 20 minutes Rate of decrease 13 °C (24 °F) in 1 hour
Relative Humidity	Range 5% to 100% Rate of Change Negligible
T-Plant Loading Location	
Temperature	10 °C to 75 °C (50 °F to 167 °F)
Transportation	
Temperature	0 °C to 75 °C (32 °F to 167 °F)
CBS (Storage)	
Temperature (Tube)	10 °C to 132 °C (50 °F to 270 °F)
Temperature Cycling	Refer to Chapter 4 of HNF-SD-TP-RTP 004 Rev 0 (WHC 1996a)
Relative Humidity	Refer to Chapter 8 of HNF-SD-TP-RTP 004 Rev 0 (WHC 1996a)

3 8 Transportability

After fabrication, SSFC components shall be transportable by highway from the fabricator facility to the location within the Hanford site where they will be warehoused until requested for the packaging and removal of the SNF

Refer to Section 4, Item 8 *The dimensions of the SSFC parts as shown in Appendix 1 permit transport from the fabricator facility to the warehouse site within Hanford Suggested packaging of the components for highway transport is provided in the SSFC Fabrication Specification*

3 9 SSFC Design Overview

The SSFC incorporates the MCO design baseline as represented by the MCO design report (HNF 1999b Reference 6 3) the MCO Fabrication Specification (Reference 6 16) and the MCO design drawings (latest revision as of the date of this performance specification (Reference 6 1) except where is impacted by the modified shield plug features for the SSFC Included in the baseline are

- Shell Subassembly
  - Canister Collar
  - Canister Shell
  - Bottom Plate Subassembly
    - Shell Bottom
    - Guide Cone
    - Support Plate
- Cover Plate Subassembly
  - Cover Plate, 4 Hole
  - Bolt
  - Seal
- Port 2 Style Process Valve
- EG&G Seal
- Radial Plug
- Locking Ring
- Set Screw
- Shield Plug/ Locking Ring Interface
- Helicoflex Seal
- Shield Plug/collar Interface
- Canister Cover Subassembly
  - Canister Cover
  - Test Plug
  - Plate
  - C-Seal

Any Changes to this MCO baseline other than those included in the scope of this design must be incorporated into the baseline for the SSFC

The SSFC design meets the above MCO baseline by using the components referenced above The MCO drawings are used for the above components as indicated on Drawing H-2 829991 which lists by drawing all components making up the SSFC

3 9 1 Code Requirements

The SSFC shall be designed in accordance with Divisions 1 11 13, and 15 of DOE Order 6430 1A, *General Design Criteria* (DOE 1989) Safety Class (SC) and Safety Significant Components (SS) providing fuel containment, confinement and criticality control shall be constructed to meet the rules of ASME Boiler and Pressure Vessel Code Section III Subsection NB (Reference 6 4) under the component safety group as guided by the NUREG/CR 3854 (Reference 6 7) The Nuclear Regulatory Commission (NRC) positions in Regulatory Guides 1 84 (Reference 6 9) and 1 85 (Reference 6 9) on ASME Code Cases shall be reviewed prior to using such Code Cases for safety class applications for the SSFC The Buyer shall approve use of additional, applicable ASME Code Cases All deviation from Subsection NB shall be documented and justified and approved by the Buyer

Refer to Section 4, Item 9 *The applicable sections of the ASME code that are applied to the various components of the system are shown in Table 2 – Safety Class Requirements Safety Class (SC) and Safety Significant (SS) require compliance with the principles and allowables of Section III Subsection NB of the ASME Code General Service (GS) components are required to be designed and fabricated to industrial codes according to HNF PRO-097 The SSFC SSC designations for components common to MCO components retain the SSC designations for the MCO so as to not perturb the existing fabrication requirements although it is likely that components of the SSFC will not exceed safety significant*

Section III Subsection NB of the ASME Code (Reference 6 4) is applied to the containment boundary The containment boundary is a SC item since its failure would result in a potential release of radioactive material

The SSFC is designed to the applicable technical requirements of the ASME Code as set forth in the SSFC Performance Specification (Reference 6 1) The SSFC vessel will be ASME Code stamped SS items are designed and fabricated to applicable sections of the ASME Code and as set by the SSFC Performance Specification GS items (e g canister insert) are evaluated to the applicable conditions specified by the SSFC Performance Specification (lifting and handling)

Table 2 – Safety Class Requirements

System or Component	Function	SSC Designation
Shell	Contain/Protect SNF	SC
Shield Plug	Contain SNF protect personnel	SC
Locking and Lifting Ring and Set Screws	Maintain pressure on main seal allows for lift of loaded SSFC	SC
Cover Cap	Seal SSFC	SC

System or Component	Function	SSC Designation
Canister Insert	Position fuel during loading process	GS
Plug Valve	Process port to accommodate gas flows in support of SSFC processing	SS
Seals excluding Main Shield Plug Seal	Containment	SS
Long Process Tube Screen	Keep particles > 2 mm diameter in the MCO if the shell is used for K basin fuel	SS
Main Shield Plug Seal	Seals SSFC shield plug to shell	SS
Cover Plates	Provides leak tight seal	SC
Cover Plate Bolts	Maintain Seal Pressure	SC
Additional Shield Plug Thickness	Provides additional shielding	GS

3 9 2 SSFC Design Criteria

The SSFC design shall implement the following criteria

1 ASME Section III Code stamp required

2 Design pressure for shell bottom plate and cover cap 450 psig (based on MCO conditions with K Basins spent fuel which exceed Shippingport PWR Core-2 blanket fuel assembly requirements)

3 Design pressure for shield plug closure assembly 150 psig (based on MCO conditions with K Basins spent fuel which exceed Shippingport PWR Core 2 blanket fuel assembly requirements)

4 Design temperature 132 °C

5 Processing operating pressure full vacuum internal with 60 psig external pressure at 75 °C

6 Processing operating pressure full vacuum internal with 0 psig external pressure up to 132 °C

7 Processing operating pressure 75 psig internal with 0 psig external pressure up to 132 °C (based MCO conditions with K Basins spent fuel which exceed Shippingport PWR Core-2 blanket fuel assembly requirements)

8 The SSFC assembly must be designed to accommodate 1 0 inch nominal differential thermal expansion in the axial direction between the fuel and SSFC shell Maximum allowed radial temperature gradient between the outside of the SSFC s shell and the center of the SSFC shield plug of 100 °C

Refer to Section 4, Item 10-20 *The design pressure of 450 psig and a design temperature of 132 °C is used for evaluation of the SSFC with the cover cap welded in place for all normal conditions and design basis conditions in Appendices 4-12 The design pressure of 150 psig and a design temperature of 132 °C is used for evaluation of the SSFC without the cover cap welded* *in place for all normal conditions and design basis conditions in Appendices 4 12 Appendix 12 demonstrates the SSFC s compliance with the applicable ASME Code requirements for the conditions stated above The mechanical seals used to seal the SSFC under these conditions are metallic seals Since these seals will not be leak tested immediately following installation operations personnel must adhere to the manufacturer s recommendation of not reusing the seal An ASME design specification that is a subset of the SSFC Performance Specification will be issued permitting an ASME Code Section III Subsection NB design report to be prepared allowing for the SSFC containment boundary to be fabricated to and stamped in accordance with the Section III of the ASME Code*

3 9 3 Maximum SSFC Assembly Weight

The gross weight of a SSFC (including fuel and insert) should not exceed 19 242 lbs This weight is based on maximum design weight of the MCO for other fuels Maximum weight based on the maximum weight Shippingport PWR Core 2 blanket fuel assembly loaded is 9 525 lbs

Refer to Section 4, Item 21 *Detailed weight calculations for each component of the SSFC are provided in Appendix 3 The summary of the expected weights shows that the nominal SSFC (without cover with Shippingport fuel) dry weighs approximately 9 095 lbs*

3 9 4 Height of the SSFC

The maximum height of the SSFC shall not exceed 160 inches (without final cover cap) at a temperature of 25°C When the final cover cap is welded in place the maximum height shall not exceed 167 30 inches

Refer to Section 4, Item 22 *The maximum height of the SSFC with the cover cap off is 160 inches The maximum height of the SSFC with the cover cap in place is less than 167 3 inches as shown in the Appendix 1 drawings*

3 9 5 Diameter of the SSFC

The nominal outside diameter of the SSFC is 24 inches In no case, including post accident conditions is the SSFC inside circumference below the bottom of the shield plug allowed to exceed 73 04 inches ($\pi \times$ 23 25 inches) The SSFC shell is allowed to have a 25 31 inch maximum as built outside diameter above the 148 inch elevation measured from the SSFC bottom These dimensional limits are applicable during normal operations and post accident conditions

Refer to Section 4, Item 23 *The inside circumference below the bottom of the shield plug is maintained to be less than 73 04 inches as shown in Appendix 5 and Appendix 11 These evaluations include the post-Level D events as defined in the SSFC Performance Specification The only event that has the potential of any significant distortion of the circumference of the shell is the side drop in the cask and is localized in the area of the collar in the cask. The distortion would be inward (localized denting) and hence the circumference requirement would not be violated*

3 10 SSFC Shell Design

The SSFC shell is identical to the MCO shell a cylindrical vessel that provides access to its cavity through its top end and receives a shield plug assembly at its top end for closing The SSFC shell has a bottom assembly that provides a permanently sealed closure on the shell bottom end The SSFC bottom assembly is nominally flat and includes an internal liquid collection sump at the SSFC centerline required for the MCO but not utilized for the SSFC The SSFC must permit or allow loading the canister insert within its cavity The empty shell must be designed to load into and out of the transport cask

Refer to Section 4, Item 16 *As shown in the Appendix 1 drawings the SSFC shell assembly consists of a forged bottom closure a cylindrical 1/2 inch thick wall shell and a forging collar at the top that mates with the shield plug and locking ring The top closure permits full access to the inside cavity for installation of the Shippingport fuel canister insert and fuel All welded components are made of Type 304L/304 dual certified stainless steel At the bottom of the cavity are 6 support plates in the form of a spider supporting the canister insert and maintaining a 1 00-inch minimum distance between the basket and the bottom head The empty shell can be loaded into the cask by assembling the locking ring in place and grappling the lift ring on the locking ring similar to what is done when handling a loaded MCO The SSFC may be up-righted with standard engineered lifting devices although a turning fixture may facilitate the up righting operation The SSFC should not be handled or lifted without the lifting ring in place The use of other fixtures to lift the SSFC increases the potential of damaging and distorting the collar area so that insertion of the locking ring could be very difficult The bottom forging of the SSFC is the same as for the MCO to allow the bottom section to be utilized as an MCO if needed However the water removal features of the MCO will not be utilized when the canister is used as an SSFC since no water is permitted and the fuel is dried prior to placing in the SSFC*

3 11 SSFC Closure Design

The SSFC shall be designed with a mechanical closure configuration The closure shall rely on a mechanical elastic/crushable metallic seal to maintain the containment and confinement requirement at the final closure interface The closure system shall utilize the shield plug/shell interface as the closure boundary where the crushable metallic seal shall be located The shield plug shall be held in place via a locking ring threaded into the SSFC shell The locking ring shall contain screws that will be tightened to force the shield plug down against the elastic/crushable metallic seal while pushing up on the locking ring

The SSFC shall be designed to incorporate a final welded closure cap over the shield plug The cap shall be welded to the SSFC shell, and the weld geometry shall permit a 100% ultrasonic examination of the weld The final seal/shell structure weldment should be ASME code qualified such that ASME N Stamp is preserved for the structure The cap shall be capable/configured for lifting the SSFC with the same equipment described in Section 4 13 of the SSFC Performance Specification (Reference 6 1) The cap shall be capable of withstanding the pressure rating of 450 psi at 132 °C, and shall meet the drop criteria for drop into the CSB tubes per Table 3(Based on MCO conditions with K Basins spent fuel) The SSFC design will verify that the increased decelerations during accidental drops due to the lighter SSFC payload will not increase the net effects on loads to components

The closure cap shall be capable of being fitted with a recessed threaded plug to be used for helium leak testing after welding The penetration in the cover cap shall be adequately sized and located to permit insertion of a tool to access the threaded plugs contained in the port This alignment is not required by anticipated SSFC operations but the option to provide the capability exists by nature of using the existing features of the design The weld joining the closure cap to the SSFC shell shall be helium leak tight to 1 × 10 7 scc/sec

Refer to Section 4, Item 17 *The SSFC closure consists of a shield plug locking ring and main seal as shown in the Appendix 1 drawings The shield plug assembly rests on a seal ledge on the inside of the SSFC collar The shield plug has a groove in the mating surface to the ledge that retains the main seal and prevents over crushing of the seal The locking ring assembly place that threads into the collar with a double lead buttress thread holds the shield plug in Once the locking ring is installed the eighteen 1½ inch diameter set screws are tightened generating a force between the shield plug and the locking ring The force seats the metal main seal and maintains a minimum sealing load on the seal during all loading conditions The evaluation of the setscrews and their required tightening is shown in Appendix 4 The locking ring is designed so that with a 1/8 inch gap between its bottom surface and the shield plug the top surface of the locking ring is 1/8 inch below the top surface of the shield plug The main seal is a Helicoflex seal The seal will be installed to the manufacture s recommendation and in a manner that has been verified to meet the leak tightness required This will require that the seal can only be installed once and not reused The seal will be helium leak tested at following shield plug installation at the T-Plant The details of the seal can be found in Appendix 13 of the MCO design report*

The closure cap consists of a Type 304L stainless steel forging that mates with the SSFC collar The closure weld is a full thickness weld that is not radiographically examined The weld can be ultrasonically examined The weld can be helium leak tested to demonstrate helium leak tightness to 1 × 10^{-7}scc/sec The recessed threaded plug has a metallic seal that allows leak testing of the final closure After the plug is helium leak tested to 1 × 10 7 scc/sec it can be further sealed off by welding of a cover plate over the plug The plug threads into a 1 7/8 inch opening that can be aligned over the port thereby allowing access to the inner cavity With the opening aligned the port may be operated through the opening At the time the decision is made whether the access will be allowed the cover plate for the port will be removed and the cover cap will be aligned to allow operation through the cover cap by either alignment marks or by the use of fixture during the installation of the cover cap Analysis of the weld and the lifting ring that is attached to the cover cap is found in Appendix 6 The lifting rim on the cover cap is the same diameter and thickness as the lifting ring on the locking ring Analysis is performed combining the lifting loads with the 450 psig internal pressure at 132 °C The loads and analyses performed for the MCO bound the loads seen by the SSFC

Appendix 5 evaluates the structure of the shell for the drop analysis The bounding analysis is shown in Appendix 5 for the MCO since the MCO weighs almost twice as much as the SSFC The SSFC when dropped from the same height will see less deformation since there is less energy that has to be absorbed Although the drops to be evaluated are not defined by height but rather by deceleration the MCO drop situations still bound If the same g s are applied there is *less force since the mass is considerably less Likewise if the scope was expanded requiring that the SSFC be able to withstand a drop from the same height it could be shown that the MCO conditions still bound The total energy would be less since the mass would be less With less energy to absorb there would be less deflection*

Discussion regarding the difference between MCO and SSFC weights is subsequently considered The weight summary provided in Table 2 of Appendix 3 reports a SSFC weight of 9 095 pounds From Appendix 5 of the MCO Design Report[1] the weight of the MCO used in the calculations is 19 703 pounds The accelerations noted in load cases 1 through 4 for CSB-related drops are based on an MCO drop weight of 19 703 pounds The impact limiters inside the CSB tubes control MCO/SSFC inertia loads by the buckling of tubes resulting in an effectively constant crush force Therefore using a simplistic quasi-static approach the SSFC will experience accelerations equivalent to approximately 19 703/9 095 = 2 166× the accelerations used in load cases 1 through 4 The net effect on loads to components however is unchanged For example Section 8 Closure Seal Leakage in Appendix 5 of the MCO Design Report[1] bases its calculations on an inertial load equal to 28g × 19 703 pounds (MCO weight) or 551 684 pounds Thus the inertia load reacted by the seal region is 551 684 pounds Since the SSFC weighs only 9 095 pounds its acceleration is 28g × 2 166 = 60 65g the resulting inertia load is 60 65g × 9 095 pounds (SSFC weight) or 551 612 pounds which is identical to the MCO inertia load In summary although SSFC accelerations are proportionally higher than MCO accelerations the net effect for component loads is unchanged and the results presented in Appendix 5 of the MCO Design Report[1] bound the SSFC

The adequacy of the shell to retain the contents of the SSFC can be addressed by relative strength and thickness (i e stiffness) of the interfacing components For the horizontal drop the mass of the fuel is distributed relatively evenly Also the fuel is relatively weak (i e flexible) in the horizontal direction providing for no identifiable mechanism that could puncture the stiff backed shell of the SSFC For the vertical drop the fuel is relatively strong (i e stiff) in the axial direction however the interfacing parts of the SSFC are either the 12-1/2 inch thick shield plug at the top or the 2 inch thick bottom plate that is protected by the insert s 3/4 inch thick bottom plate To develop the maximum loading the SSFC has to impact relatively flat (vertical) on a surface that in-turn provides even a stiffer backing for the end plates This greatly reduces any mechanism that could cause puncture Finally because of the relatively stiff backing in both the horizontal and vertical directions the SSFC material would have to flow rather than shear to puncture a failure mechanism that requires significantly greater force

3 12 Canister Insert (Fuel Basket) Design

The Shippingport fuel canister insert shall provide four compartments Each compartment shall hold a Shippingport PWR Core-2 blanket fuel assembly Each assembly is 142-5/16 inch long and a maximum of 7 1/2 inch square at the top 6 1/2 inches of length The remainder of the fuel assembly is 7-3/8 inch square The insert shell allows for 1/2 inch of bowing in the fuel assembly in any direction The insert is not required to provide any physical support of the fuel for criticality control or shielding purposes after loading The fuel is loaded into the SSFC with the insert in place The insert shall interface with the SSFC such that none of the features of the SSFC shell are plastically deformed under normal conditions nor changed by the insert's presence The insert shall be capable of being handled empty meeting safety factors of 3 on material yield and 5 on material ultimate strength The inserts shall allow for the fuel to be loaded in the upright position The insert shall be designed for fuel assemblies with the following physical characteristics

- Type of Assembly — Plate Type of Blanket Fuel
- Type of Blanket Fuel — High Density Natural UO_2 Wafers
- Composition of Fuel Assemblies
  - Fuel Cladding and Assembly Shell — Zircaloy-4
  - Top Extension Bracket — Type 304 Stainless Steel
  - Bottom Extension Bracket — Type 304 Stainless Steel
  - Bottom Extension Bracket Spring — Inconel-X
- Overall Length of Fuel Assemblies — 142 5/16 inches
  - Top Extension Bracket — 18-1/2 inches
    - Upper Square Section (7-1/2 inches × 7-1/2 inches) — 6 1/4 inches
    - Cylindrical Section (5-3/4 inches diameter includes transition) — 10 inches
    - Lower Square Section (7-3/8 inches × 7-3/8 inches) — 2 1/2 inches
  - Core Region (7-3/8 inches × 7-3/8 inches) — 104 1/2 inches
  - Bottom Extension Bracket — 19-5/16 inches
    - Upper Square Section (7 3/8 inches × 7 3/8 inches) — 2-27/32 inches
    - Cylindrical Section (5-3/4 inches diameter includes transition) — 8-29/32 inches
    - Lower Square Section (7-3/8 inches × 7-3/8 inches) — 7 9/16 inches
- Blanket Assembly Weight (each) — 1 180 pounds
- Blanket Assembly Bow (Reference 6 17) — <1/2 inches
- Calculated Maximum Heat per Assembly (Reference 6 18)
  - With Decay to 1999 — 165 watts
  - With Decay to 2001 — 158 watts
- Calculated Maximum Fuel Surface Temperature with Decay to 1999 (Reference 6 18)
  - In Air — 210 °C (410 °F)
  - In Helium — 169 °C (336 °F)
- Calculated Maximum Canister Temperature Based on 1999 Heat Load in Helium (60 °C (140 °F) Ambient) — 136 °C (277 °F)
- Maximum Canister Temperature Adjusted to 2001 Heat Load (158/165 watts × 136) — 130 3 °C (266 5 °F)
- Estimated Mid-Canister Average Temperature in Helium (60 °C (140 °F) Ambient) — 100 °C (212 °F)

The Shippingport Fuel Insert is a cruciform structure that divides the compartment into four equal cavities for loading the fuel At the bottom is a 3/4 inch base plate that distributes the fuel load to the six spacer plates at the bottom of the SSFC A hole in the bottom plate and bottom 3 inches of the cruciform is provided to allow for clearance around the guide cone that is in the bottom of the SSFC The canister insert is fabricated from Type 304L stainless steel that is compatible with both the Shippingport fuel and the SSFC shell The canister insert is fabricated of 1/4 inch thick plate plus the *bottom plate The canister insert is only 135 inches long to allow sufficient clearance at the top end of the fuel assemblies where they are slightly larger in case of fuel distortion A theoretical cavity size of 7 7/8 inch square is possible even with the maximum plate thickness and the smallest SSFC shell diameter This allows for 1/2 inch of bowing in any direction Since the canister insert is not carrying load during any of the normal or accident conditions a minimal amount of welding is specified to minimize the potential for distortion of the insert*

Figure 1 depicts the interface of the canister insert with the fuel and the SSFC Details of the canister insert are provided in the Appendix 1 drawings The canister insert has two lifting holes opposite each other to allow lifting of the insert for placement into the SSFC These lifting points are designed for handling and meet factors of safety stress allowables of three on yield and five on the ultimate strength of the material Appendix 7 provides the analysis of the lifting features of the canister insert The canister insert is not designed for handling of fuel outside the SSFC

3 13 SSFC Shield Plug Design

The SSFC shield plug will be a cylindrical forging designed to mate with the open end of the SSFC shell The SSFC assembly must be designed to have at least a one inch nominal free space between the bottom of the shield plug and the top of the SNF assemblies at 72 °F The shield plug will provide worker shielding on the top of the SSFC The shield plug shall feature an integrally machined axisymmetric lifting ring with a 12 ton lifting capacity when gripped with six equally spaced 1 97 inch tangential length by 0 66 inch radial contact length grippers The ring will facilitate handling of the SSFC package when unloading from the transport cask CSB storage tubes and CSB weld stations with the MHM

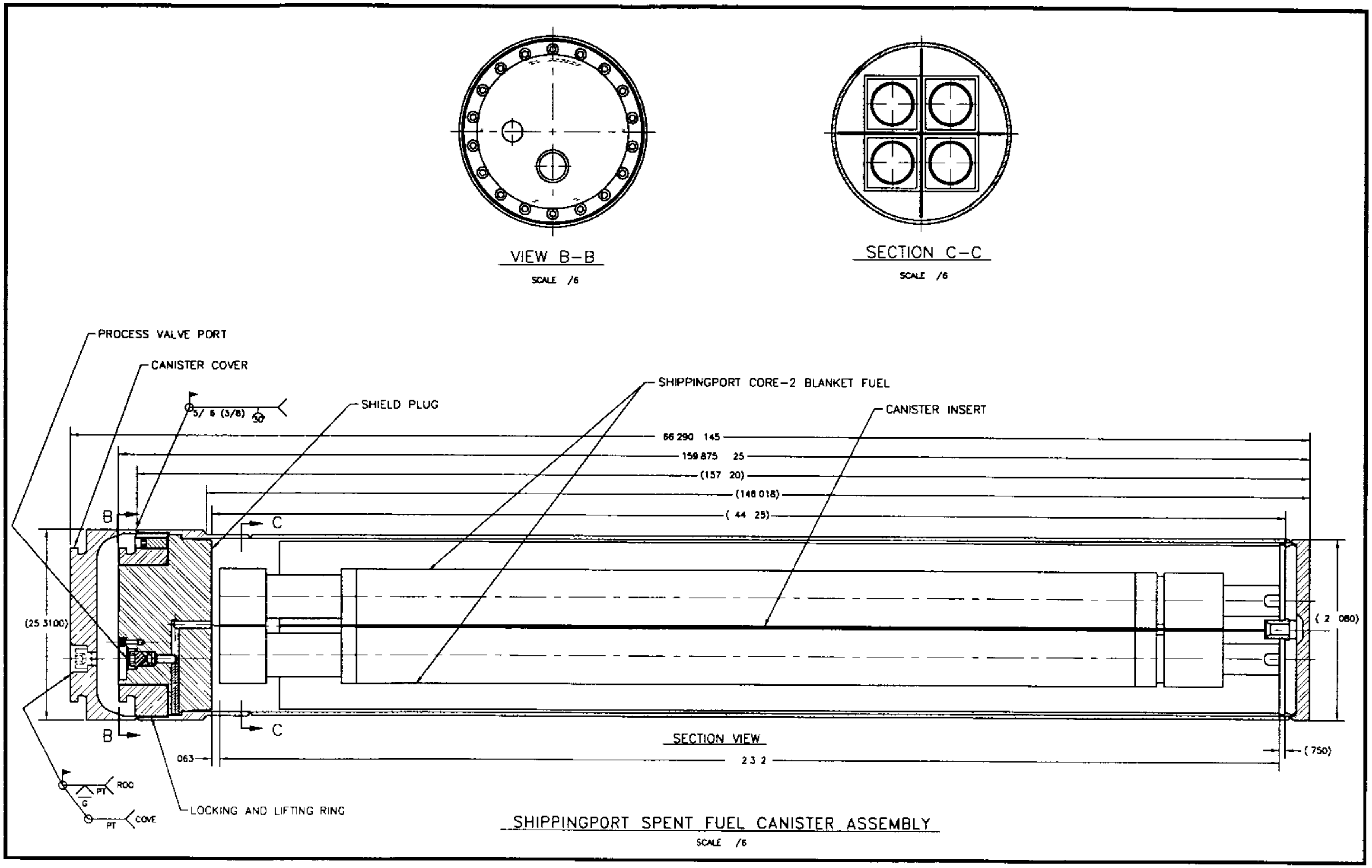

Figure 1 – SSFC Configuration

Refer to Section 4, Item 19 *The shield plug assembly consists of the shield plug shield plate process valve and cover plate The shield plug provides shielding at the top of the canister as well as providing part of the containment boundary for the contents of the SSFC A nominal one inch clearance at 72 °F is provided above the fuel or fragments The shield plug is held in place with a locking ring that has a lifting ring with a 12 ton capacity when gripped with six equally spaced grippers as specified The demonstration of this capacity is shown in Appendix 6 The shield plug for the SSFC has only one process valve or plug to allow a vacuum drying and helium backfilling of the cavity The one access port can be operated either by an external tool or an internal socket Placing a plate over the process plug can protect the process valve The cover plate for the process plug can be sealed to the shield plug using four bolts and a metal seal This identical interface allows for the operators to be sealed to the shield plug and then operate the process plug while maintaining containment The process valve itself is capable of being operated and than resealing*

The SSFC lifting ring design and cover cap lifting rim area must exhibit a safety factor of three on material yield and five on material ultimate strength

The lifting ring area of both cover cap and the lifting ring complies with the factors of safety for non-critical lifts as shown in Appendices 5 and 6 respectively

The shield plug will provide access to the interior of the SSFC via an offset penetration A description of the port penetration and associated equipment interface follows

Port connects to the inner cavity

- Approximately 0 6 inch inside diameter (ID) minimum diameter drilled vertical penetration and approximately 1 0 inch radial penetration and plug
- Port contains a process valve and
- The valve shall be operable by either an internal hex socket or an external hex

  As seen in the Appendix 1 drawings the port provides and offset access to the inner cavity of the SSFC The vertical portion of the penetration is approximately 0 6 inches in diameter and the horizontal portion is 1 0 inch in diameter A process valve that may be covered with blind flange accesses the port The process plug consists of a 1-7/8 inch threaded plug drilled in the center and then cross-drilled below the top of the threads As the plug is unthreaded it rises exposing the cross drilled holes and allowing flow The top has a hex head that can mate with a valve operator The seal is maintained with a C-seal at the top of the threads that has been proven to reseal in the excess of five times The torque required to seat the seal is evaluated in Appendix 10 and the seal data is provided in Appendix 14 The valve operator can use the same sealing surface as the cover plates to seal to the shield plug before operating the valve The valve has both an external hexagonal operator as well as an internal socket

The design of the penetration, port, and valve mechanism shall implement the following criteria

The process valve shall be capable of normal operation and achieve sealing criteria in Section 4 3 for five complete cycles

The process valve is identically designed as the process valves used in the MCO and the seals used have been demonstrated to reseal in the excess of five times as shown in Appendix 14

- Provisions for pressurizing the SSFC interior with an inert gas
- Provisions for purging gas from the SSFC interior

  The process valve port s cover plate seal surface allows sealing a mating fitting to the port The process valve can be operated with a tool to allow the pressurizing and purging of the SSFC if required The covers seals and attachment bolts are evaluated in Appendix 10

  Penetration connection and seal shall be leakage rate testable in accordance with ANSI N14 5 *Leakage Tests on Packages for Shipment of Radioactive Materials* (ANSI 1987)

  When assembled the entire SSFC can be leak tested in accordance with ANSI N14 5 (Reference 6 10) and ASME Section V Article 10 (Reference 6 11) by filling it through the process port with a detectable gas and then placing it in a chamber where a vacuum can be pulled and the gas can be detected Similarly a pressure drop or pressure rise can be used provided that sensitive enough instrumentation were used to detect the 1 × 10^{-5} scc/sec required leak rate

- Provisions to make or break all connections while continuing to maintain SNF containment with minimal spread of contamination

  By the use of the cover flange-sealing surface a valve operator tool designed by others could be used to make and break all connections while maintaining containment

- The penetration is to be sealable to the containment leak rate criteria after the process connection is terminated

  As documented in Appendix 14 of the MCO Design Report (Reference 6 3) the process valve seals are re-sealable to the containment leak rate criteria The seals have been tested after over five closures and found to meet the leak test requirements

- Connections shall be such as to facilitate their decontamination as per Section 4 17 of the SSFC Performance Specification

  The connections are angled to prevent the trapping of debris and are of a smooth finish to facilitate decontamination

- The port penetration and connection shall be accessible to the operator from the top face of the SSFC,

  The port penetration and process valve is accessible from the top per the Appendix 1 drawings

- Penetration and connection shall not appreciably reduce or impair SSFC shielding

  The penetration is offset to minimize any streaming that may occur The lower part of the penetration is positioned between fuel assemblies to minimize the streaming through the penetration The upper portion can be located between assemblies to reduce dosage at the time of assembly Also an additional two-inches of steel has been added to the shield plug to provide additional shielding The two inches of steel represents shielding that is additional to the requirements

- Provisions for removal or reinstallation of sealing mechanisms as required to cover shield plug appurtenances, these sealing mechanisms cannot extend above the top of the shield plug including fasteners,

  The process valve and the cover plate are designed to be replaced while regaining the same quality seal The sealing mechanisms including the bolts that hold the cover plate are compatible with remote operating equipment

- Provision to bleed down in a controlled way into the process piping internal SSFC pressure after process connections are made

  The process valve can be used to bleed down the SSFC internal pressure into the process piping with a correctly designed valve operator and pressure control device

  Penetration and connection shall be designed to facilitate remote operation via long handled tools via a manipulator and via manual means

  The penetration and connection are designed to facilitate remote operating as well as manual means Features such as captured bolts on the cover flanges standard hex head operators seals with ability to be retained ensure these operational processes

  Process connection shall be designed with a 1 5/16 inch hex head on the process valve and plug for the operator to engage

  As shown in the Appendix 1 drawings the process valves have a 1-5/16 hex cap for the operator to engage

In order to protect the shield plug appurtenances from damage during drops a minimum of 3/8 inch clearance shall be provided between the top of the installed process valve and the bottom of the cover plate

Refer to Section 4, Item 19 *A minimum of 3/8-inch clearance is provided between the top of the installed process plug and the bottom of the cover plate*

3 14 Materials, Processes, and Parts

The SSFC shell shall be fabricated from Type 304/304L stainless steel All components welded to the SSFC shell must be made of austenitic stainless steels compatible for welding to Type 304L stainless steel A mechanically attached shield plug and any components thereof must be made from Type 304L or Type 304N All materials shall be ASME/ASTM certified materials Provision shall be made to preclude metal to metal galling in threaded SSFC components Thermal and chemical compatibility of materials must be shown suitable

Refer to Section 4, Item 24 *The SSFC shell and shield plug assembly are fabricated out of 304L stainless steel and the locking ring is made of Type 304N stainless steel to insure compatibility Type 304/304L dual-certified stainless steel material is used for the collar and the shell to provide added strength and weldability The process plug is fabricated of Nitronic 60 stainless steel and the set screws Nitronic 60 is a stainless steel that is compatible with 304N and 304L material It has as good or better corrosion resistance in the environment described as the 304N or 304L materials No ferritic materials are used in the design All materials are specified as either ASME (SA) or ASTM (A) materials as shown in the Appendix 1 drawings*

Metal-to-metal galling is minimized by the use of harder material such as Nitronic 60 and 304N for the threaded fasteners and components The atmosphere is relatively non-aggressive since no free water or RCRA materials are permitted in the SSFC

3 15 SSFC Corrosion Control

Specifications generated for the SSFC and SSFC components shall require cleanliness during fabrication handling and storage before and during use Free water and RCRA materials are not permitted inside the sealed SSFC ASTM A 380-94 (Reference 6 12) and ASME NQA 1 (Reference 6 13), shall be invoked for cleanliness control The corrosive conditions for which the MCO has been designed bound the environment for the SSFC The MCO shall be designed and constructed to provide full service life under these corrosion conditions The mechanical seal required for final closure shall be of a material best suited for this application

The interfacing surfaces of the Shippingport fuel are Type 304 stainless steel and Zircaloy with the SSFC The fuel is loaded dry and maintained in an inert atmosphere The insert is also fabricated of Type 304 stainless steel

Refer to Section 4, Item 25 *Appendix A of the MCO Performance Specification (Reference 6 2) demonstrates the acceptability of austenitic stainless steel specifically Type 304L for the environment that is more severe than the SSFC will experience All major structural components of the SSFC are fabricated of austenitic stainless steel and hence have no significant corrosion impact on the design life of the SSFC see Appendix 2 of Reference 6 3 Cleanliness requirements as noted are included in the fabrication specification*

3 16 Welded Joints

All SSFC fabricator pressure boundary welds shall be made in accordance with ASME Code Section III requirements All welds shall be sufficiently smooth to enable easy decontamination Butt welds to be ground flush to within 0 03 inches of base metal Weld joint designs shall avoid potential contamination traps to the greatest extent practicable All SSFC pressure boundary welds and welds bearing the weight of the fully loaded SSFC must be designed for and pass 100% volumetric examination (radiographic or ultrasonic) per ASME requirements Exceptions for field welds only shall be properly documented justified and approved

The field weld joining the cover cap to the SSFC shell shall be designed to permit a 100% ultrasonic examination Flat surfaces behind the weld a minimum of 1 10 inches below and 1 325 inches above the weld centerline are required to facilitate this examination Additionally a 15 degree half-angle is required on the weld preparations for a 30 degree weld

Refer to Section 4, Item 26 *All SSFC pressure boundary welds are designed and produced to ASME Section III Division 1 Subsection NB (Reference 6 4) except the field closure weld which is a full thickness weld that cannot be 100% radiographically examined It is designed for 100% ultrasonic examination The acceptance of this weld is that it provides closure to a stabilized system and the quality is insured by welding qualification and the use of liquid penetrant inspection per Code Case N-595 (Reference 6 5) The margins of safety for the weld are provided in Appendices 5 and 11*

3 17 Decontamination Provisions

SSFC exposed surfaces shall facilitate their decontamination All exposed surfaces shall be smooth without cracks or crevices Blind or hidden corners or joints in areas potentially exposed to contamination that cannot be readily accessed by hand held spray devices shall be minimized

Refer to Section 4, Item 27 *All exposed surfaces are smooth with out cracks or crevices to facilitate decontamination Access to all surfaces is available as can be seen in the Appendix 1 drawings*

3 18 Safety Requirements

3 18 1 Safety Classification

SSFC components shall be classified by safety class in accordance with the requirements of HNF-PRO-704 *Safety Analysis Manual* (PHMC 1997) Appendix F SSFC components providing fuel containment shall be Safety Class items and comply with the requirements of HNF-PRO-704 All other SSFC components shall be Safety Significant or General Service items Safety Class items are

- SSFC Shell Assembly
- SSFC Shield Plug Assembly (excluding all port components)
- SSFC Shield Plug Cover plate and Cover Plate Bolts
- Cover Cap

The insert for the Shippingport fuel has a classification of General Service

Refer to Section 4, Item 28 *The various components of the SSFC are classified into safety classes in agreement to the above in Section 3 9 1 of this report The applicable code requirements are then applied The containment boundary components are designed and fabricated to ASME Code Section III Division 1 Subsection NB (Reference 6 4) The Shippingport Fuel canister insert is designed and fabricated to General Service/Quality Level 3*

3 18 2 Design Basis Accidents

All Safety Class items shall maintain containment and confinement during and after the Design Basis Accidents (DBAs) listed below All Safety Significant items whose failure could result in the failure of the Safety Class items above shall also be designed to withstand the DBAs listed below

NOTE The following design basis accident loadings are required to meet the Service Level D requirements of the ASME B & PV Code Section III Subsection NB for Safety Class items which provide fuel containment and confinement Items required to prevent failure of the Safety Class items are also required to meet the same Service Level D requirements (Service Level D allowable stresses may be exceeded for horizontal and corner drops while the SSFC is in the cask

- *Design Basis Fire* - Temperatures resulting from exposure to a design basis accidental fire on the outside of the transportation cask [from 10 CFR §71 73(3)] This basis fire shall result in exposure of the outside of the cask for not less than 30 minutes to a heat flux not less than that of a radiation environment of 800 °C with an emissivity coefficient of at least 0 9 For purposes of calculation the surface absorptivity must be either that value which the shipping cask may be expected to possess if exposed to a fire or 0 8 whichever is greater (This fire shall raise the SSFC shell temperature to 122 °C for 180 minutes after the fire The 132 °C design temperature bound the temperature associated with this fire) (Note No analyses required by the SSFC Design Agent)

  Design Basis Earthquake -- The design ground acceleration at the CSB is 0 35g Although this will be amplified due to the position of the SSFCs within the facility the design basis accident drop accelerations bound any imposed earthquake accelerations from the T Plant and CSB (Note No analyses required by the SSFC Design Agent)

- *Design Basis Tornado* - The CSB incorporates preventive and mitigative features regarding radionuclide releases from SSFCs due to tornadoes (as determined necessary by Probabilistic Risk Assessments) (Note No analyses required by the SSFC Design Agent)

  Design Basis Hydrogen Deflagration The SSFC shall maintain confinement during a design basis hydrogen deflagration event (Service Level D event) beginning at atmospheric pressure inside the SSFC at 75°C (Note No analyses required by the SSFC Design Agent)

- *Design Basis Drops* The following design basis drops for the MCO are the same drops that apply to the SSFC The MCO design basis accident drops have been determined to create accelerations listed in Table 3 MCO must survive while maintaining confinement containment (except for cask drops) and sub-criticality Temperature range for these drops is 25 °C to 132 °C and pressure range is 0 to 450 psig The accelerations listed in Table 3 are to be used for the design basis for the SSFC

  A two foot vertical drop of a sealed SSFC package onto flat reinforced concrete The SSFC lands on the bottom end and there is no credible possibility of a side slap down secondary impact of the SSFC

  A drop (worst case orientation) of the SSFC package inside the sealed transportation cask For an end drop scenario a secondary side slap down shall be considered The SSFC is physically constrained by the cask walls and remains in the cask Note for all drops when the SSFC is in the cask the SSFC does not need to maintain a leak tight seal The SSFC shall be able to retain all particulate greater than 2 mm in size or greater after the deformation occurs

  A vertical drop of the SSFC package into the transport cask Drop heights not to exceed 21 5 feet 'Piston effect' shall be included

  Vertical drops of SSFC package into a CSB storage tube with and without another SSFC already within the tube The tubes will contain impact limiters as required to reduce impact acceleration on the SSFC and internals Acceleration of each SSFC is limited to 35g within the CSB tubes

For all accelerations the fuel shall be modeled with the properties of stainless steel In cases where one component is dropped onto another (e g SSFC onto an SSFC in the storage tube and SSFC impacting the inside top or bottom of the cask) the eccentricity of the drop is negligible and does not require consideration

Table 3 – MCO and Component Accelerations (g's) Resulting from Design Basis Accident

Component		g's Piston Drop into Cask*	g's Two (2) Foot Drop	g's Drop into CSB Tube	g's Dropped with Cask[(1)]
Loaded MCO	Horizontal	N/A	N/A	N/A	101
	Vertical	25	54	35 (Spec) Lower MCO 28 (Spec) Upper MCO	27
	Corner	N/A	N/A	N/A	33 5 Lid Up 27 4 Lid Down

*g's computed assuming the MCO is slowed by piston like cushioning effect from air being squeezed through the 0 25 inch diametric clearance between the cask and the MCO and by the cushioning effect of adding water to the bottom of the cask (Alternate means of limiting the acceleration to <35g are being investigated)

[(1)] Reference SARP Tables B7 21 and B7 24 angle of impact for C/G drop in cask is 10 5 degrees off vertical

Refer to Section 4, Item 29 *In accordance with the requirements above the loads provided in Table 3 are evaluated in two ways The loads that are applied to the SSFC shell are evaluated in Appendix 5 These are all the loads that are applied to the containment boundary and have acceptance criteria coming from the ASME Code Section III Subsection NB (Reference 6 4) The horizontal loading and corner drop loads when the SSFC is in the cask are not evaluated to ASME Code criteria per the SSFC Performance Specification (Reference 6 1) The cask provides the containment in these load conditions Additionally there is a high probability of localized denting of the SSFC shell where it interacts with the ring inside the cask The localized denting in the sidewall will give stresses beyond those acceptable for Service Level D However due to the high elongation of the material and the limited amount of distortion (thickness of the ring) no expected breach of containment by the SSFC is expected Since this is an inward denting the circumference criteria for criticality is not expected to be violated For all other load conditions the criteria of ASME Code Section III Subsection NB was met The shell is also evaluated to demonstrate that the circumference restriction for criticality control purposes is not violated for any of the load conditions*

Since the insert provides no safety function during the design based accidents there is no evaluation of the insert done except for lifting and handling loads

3 18 3 Nuclear Criticality Safety

No structural integrity of the insert is required to maintain criticality safety The SSFC shell integrity shall be maintained during all events

Refer to Section 4, Item 30 *As stated above the SSFC shell is evaluated for all loadings specified in Table 3 The evaluation shows that none of the criticality or containment criteria stated above is violated Details can be found in Appendix 5*

3 18 4 Relieve Overpressure

No pressure relief is required for an SSFC containing Shippingport PWR Core 2 blanket fuel assemblies

No over pressure protection is needed in the design There is no mechanism that would cause the SSFC to exceed even a small fraction of the pressure retaining capability No water is permitted in the canister and there are no reactive substances in the basic fuel or permitted as adders The only source of pressure could come from fission gasses within the cladding or the heating of the initial gasses within the canister Assuming that the fission gases produced in this blanket fuel are similar in quantity as the fission gases that are produced in a highly burned PWR fuel assembly and 100% of the fission gases leak out (normal assumption is 30%) and the gases heat to the maximum fuel canister temperature the maximum pressure will be about 60 psig This is a small fraction of the 450 psig design pressure of the canister

3 19 Quality Assurance

3 19 1 General Requirements

The Design Agent shall formulate and execute quality assurance programs that provide the following assurances

- Performance requirements and design criteria are established documented and clearly understood
- Studies analyses and design decisions are fully documented

  Design meets performance requirements and design criteria

  Design is complete adequate and properly documented

  Traceability to the requirements of the contract technical specification is maintained

3 19 2 Responsibility for Quality Assurance

The Project shall be responsible for planning and documenting quality assurance audits including those under the direct responsibility of lower tier subcontractors

3 19 3 Quality Assurance Requirements

The quality assurance requirements included herein cover the new design work for the SSFC shield plug and the SNF canister insert The previously approved design of the MCO canister shell assembly and unaffected portions of the shield plug assembly are not considered to be new design Quality assurance requirements for fabrication of the modified shield plug and the unmodified components of the SSNF shall not conflict with contractual requirements for the MCO Fabrication Any changes in the fabrication quality assurance requirements for the MCO shall apply also to the SSFC

For the new design the *Quality Assurance Program Plan for Implementation of the OCRWM QARD for the Spent Nuclear Fuel Project (QAPP OCRWM-001) and* Quality assurance requirements from OCRWM QARD (Reference 6 19) shall be applied to design control, fabrication, inspection testing, handling, cleaning shipping, and storage, including documentation requirements for processes procedures training, qualification and other activities that may affect the ability of the SSFC to perform its intended function

3 19 3 1 Shippingport Spent Fuel Canister

Quality assurance requirements shall be applied to SSFC design and fabrication activities as follows

a **SSFC Design Activities**

SSFC design related activities shall be performed in accordance with the applicable sections of 10 CFR 71 *Packaging and Transportation of Radioactive Materials* Subpart H, *Quality Assurance*, as specified in the *Statement of Work for System Design and Specification for Multi-Canister Insert and Shield Plug Modifications* Contract No 004353 – Task Order No 01 This will satisfy OCRWM QARD requirements (Reference 6 20)

b **SSFC Fabrication** SSFC fabrication, including the supply of SSFC materials, shall be performed in accordance with the ASME Code, Section III, Division 1 NCA-4000 This satisfies OCRWM QARD requirements for fabrication (Reference 6 20)

* In accordance with the applicable Quality Assurance requirements specified in Section 9 of HNF-S-09453, including revisions and Section E Quality Assurance Inspection Requirements from the MCO fabrication contract document No 4700 including revisions

3 19 3 2 Shippingport Fuel Canister Insert

The SSFC insert design and fabrication shall meet the Quality criteria of GS/Quality Level 3

Refer to Section 4, Item 31 *A quality assurance program has been implemented in the design and fabrication requirements for the SSFC and its insert Per FDH direction a QA program having the applicable sections of 10 CFR 71 Subpart H program is required for the design of the SSFC and insert SSFC fabrication shall be in full compliance with the applicable codes that is Section III Division 1 Subsection NB of the ASME Code for the containment boundary The canister insert fabrication shall be performed in accordance with requirements of a GS/Quality Level 3 item Reference 6 6 SNF-5191 is the fabrication specification for the*

Shippingport Spent Fuel Canister Reference 6 15 SNF-5192 is the fabrication specification for the SSFC Insert These documents contain the applicable quality requirements

4 0 COMPLIANCE MATRIX

Design/Interface Parameter	Requirement	Source(s) (P S)*	How the Design Complies with the Performance Specification Requirement
1 Design Life	Maintain fuel elements for 40 years No known factors prevent the SSFC from being extended to 75 years	P S 4 1, Rev 0	Material and design have no known aspects that will prevent compliance Materials of construction were selected to resist corrosion
2 SNF Confinement	Confine contents during all normal operations and DBAs	P S 4 2, Rev 0	Confinement is demonstrated Appendices 4, 5, and 11
3 SNF Containment	Total gaseous leaks shall not exceed 1×10^5 scc/sec When sealed by welding shall be capable of not exceeding a maximum total leak rate of 1×10^7 scc/sec	P S 4 3 Rev 0	All seals and closure are designed with capabilities of leak tightness better than 1×10^5 scc/sec The welded portion of the containment boundary is tested to demonstrated leak tightness better than 1×10^7 scc/sec The field closure weld is leak tested The mechanical seal is designed to 150 psi The complete welded containment of the SSFC with the cover cap in place is designed to 450 psi
4 Maintainability	Designed to minimize the need for preventive maintenance	P S 4 4, Rev 0	No preventive maintenance is expected
5 Human Factors	Components shall be designed to facilitate handling and assembly with the use of appropriate handling equipment and also enable handling while wearing protective clothing used in radiation zones	P S 4 5, Rev 0	The components can be easily handled and assembled with the appropriate handling equipment
6 Interchangeability	To the maximum extent possible (i e , any insert can be loaded into any SSFC shell, any SSFC shield plug and locking ring can be used to close and seal any SSFC shell etc)	P S 4 6, Rev 0	All major components, SSFC shell assembly, Shield Plug Assembly, Process valve plugs, cover caps, locking rings and inserts are designed to be fully interchangeable
7 Environmental Conditions	Capable of performing its mission while subjected to the environmental conditions listed in Table 1	P S 4 7, Rev 0	The SSFC materials are fully compatible with the environmental conditions specified

Design/Interface Parameter	Requirement	Source(s) (P S)*	How the Design Complies with the Performance Specification Requirement
8 Transportability	Transportable by highway from the fabricator facility to the location within the Hanford site	P S 4 8, Rev 0	The dimensions of the components shown in Appendix 1 makes them all transport compatible
9 Code Requirements	ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, for the SSFC containment	P S 4 9 1, Rev 0	The SSFC containment meets the ASME Code requirements as specified in Section III, Subsection NB within the limits of the SSFC Performance Specification
10 Design Pressure	450 psig with the cover cap installed and 150 psig when sealed with the mechanical seal only	P S 4 9 2, Rev 0	The SSFC containment is designed for a 450 psig design pressure with cover cap installed and 150 psig with only the mechanical seal in place
11 Design Temperature	132 °C	P S 4 9 2 Rev 0	The SSFC containment and components are designed for temperatures up to 132 °C see Appendix 11
12 Processing Operating Pressure	Full internal, vacuum 60 psig external @ 75 °C	P S 4 9 2 Rev 0	The load conditions evaluated bound this condition see Appendix 11
13 Processing Operating Pressure	Full vacuum, internal 0 psig external @ 132 °C	P S 4 9 2, Rev 0	The load conditions evaluated bound this condition, see Appendix 11
14 Processing Operating Pressure	75 psig internal 0 psig external @ 132 °C	P S 4 9 2, Rev 0	The design pressure and pressure bound this condition see Appendix 11
15 Maximum ΔT between SSFC shell and shield plug center	100°C, thermal expansion of 1 0 inch in axial direction	P S 4 9 2, Rev 0	This load condition is evaluated in Appendix 11
16 SSFC Shell Design	Must be identical to the MCO	P S 4 10, Rev 0	See Appendix 1 for compliance Uses MCO drawings for fabrication

Design/Interface Parameter	Requirement	Source(s) (P S)*	How the Design Complies with the Performance Specification Requirement
17 SSFC Closure Design	Final welded closure cap Mechanical closure prior to welding cover cap in place	P S 4 11, Rev 0	See Appendix 1 for compliance
18 Spent Fuel Insert Design	The insert is designed to facilitate loading of four Shippingport Spent Fuel assemblies into the SSFC Handling features must be capable of meeting a factor of safety of 3 on yield stress and 5 on material ultimate stress	P S 4 12, Rev 0	See Appendix 1 for compliance with design requirements Appendix 7 provides the structural analysis of the insert
19 SSFC Shield Plug Design	Designed to mate with open end of the SSFC shell One inch minimum free space between the bottom of the shield plug assembly and the top of the SNF elements Feature an integrally machined axisymmetric lifting ring with a 12 ton lifting capacity 10 CFR 835, Subpart K DOE Order 5480 11 Paragraph 9a, HSRCM-1, Sections 111 and 311, HNF-IP-1043, Section 8 0, and NRC Regulatory Guide 8 8, Section C 2 b and C 2 f	P S 4 13, Rev 0	The SSFC Shield Plug assembly closes the fully open SSFC, provides shielding, and allows for a penetration to the internal cavity The features of the shield plug assembly and the clearances between the fuel and the assembly can be seen in Appendix 1 The shield plug is held in place with jacking bolts (set screws) between it and the locking ring The locking ring has an integral lifting ring that has in excess of a twelve ton capacity complying with Performance Specification requirements for lifting
20 Internal Process Filter	Not used on the SSFC		
21 Design Goal SSFC Weight	Goal weights for SSFC with fuel (dry) is not to exceed 9525 lbs	P S 4 9 3, Rev 0	The nominal weight with shield plug and cover, is 9,095 lbs
22 SSFC Height	160 inches without cap 167 30 inches with cap	P S 4 9 4, Rev 0	As seen in Appendix 1 Maximum height without cap is 160 inches Maximum height with cap is less than 167 3 inches

Design/Interface Parameter	Requirement	Source(s) (P S)*	How the Design Complies with the Performance Specification Requirement
23 SSFC Diameter	Nominal OD is 24 inches Above bottom, shield plug is 25 31 inches	P S 4 9 5, Rev 0	The nominal OD is 24 inches Above the 148 inch elevation the maximum OD is 25 31 inches Below 148 inches, the maximum circumference is less than 73 04 inches
24 Materials, Processes, and Parts	SSFC shell shall be fabricated from Type 304/304L stainless steel All materials shall be ASME/ASTM certified materials	P S 4 14, Rev 0	All welded components of the SSFC including the shell are fabricated from Type 304/304L stainless steel All materials are designated ASME (SA) or ASTM (A) as shown in Appendix 1
25 SSFC Corrosion Control	Cleanliness during fabrication, handling, and storage ASTM A 380-94 and ASME NQA-1 A mechanical seal is required for final closure	P S 4 15 Rev 0	Cleanliness is specified during fabrication handling, transportation and storage This is covered in the Fabrication Specification and the Warehouse Plan A mechanical closure is used with compatible materials to the shell that will assure its design life similar to the SSFC permitting redundant closure seals when the cover cap is welded in place
26 Welded Joints	ASME Section III, Division 1, NB-3350 Butt welds to be ground flush to within 0 03 inches of base metal All SSFC pressure boundary welds and welds bearing the weight of the fully loaded SSFC must be designed for and pass 100% volumetric examination per ASME requirements, except the field closure welds	P S 4 16, Rev 0	All pressure boundary welds are designed as per ASME Section III Division 1 NB-3350 welds All pressure boundary welds and those bearing the weight of the fully loaded SSFC meet the volumetric examination requirements of the ASME Code All welds are flush within 0 03 inches Field closure welds will be examined per the requirements of Code Case N-595

Design/Interface Parameter	Requirement	Source(s) (P S)*	How the Design Complies with the Performance Specification Requirement
27 Decontamination Provisions	All exposed surfaces shall be smooth without cracks or crevices	P S 4 17, Rev 0	As shown in Appendix 1 all exposed surfaces are smooth and without cracks or crevices
28 Safety Classification	HNF-PRO-704, Section 9 0, 10 CFR 71 73(3) Service Level D requirements of the ASME B & PV Code, Section III, Subsection NB	P S 4 18, Rev 0	The components are classified in accordance with the Performance Specification and comply with applicable sections of the ASME Code and Service Level conditions
29 DBA Fire, Earthquake and Drops	Temperature increase of 122 °C for 180 minutes after the fire Acceleration of CSB of 0 35*g* See Table 3 in Section 3 19 2	P S 4 18 2, Rev 0	The conditions resulting from the fire are bounded by other analyzed cases The loads for the drop conditions bound the earthquake conditions The SSFC is shown to meet the drop load conditions in Appendix 5 The canister insert is a non-safety item
30 Nuclear Criticality Safety	No structural or geometric requirements are required for maintaining criticality safety The shell integrity shall be maintained	P S 4 18 3, Rev 0	No evaluation of the fuel or insert is done The shell is demonstrated to maintain its integrity through out all postulated events See Appendix 5
31 QA	Applicable sections of 10 CFR 71, Subpart H, for design SSFC containment shall be fabricated in accordance with ASME Code, Section III SSFC canister insert fabrication in accordance with GS/Quality Level 3 Insert fabrication shall be accordance with applicable requirements of ASME NQA-1	P S 5 0, Rev 0	The QA requirements imposed by the Performance Specification were used in the design and are part of the fabrication specification

* "P S " denotes Performance Specification

5 0 SUMMARY OF COMPLIANCE WITH REQUIREMENTS

The design of the SSFC modified shield plug and fuel insert in combination with the MCO shell is in full compliance with the requirements of the SSFC Performance Specification (Reference 6 1) The compliance is demonstrated in the design drawings listed in Appendix 1 and in the evaluation of the design to the specified requirements in Appendices 2-17

6 0 REFERENCES

6 1 SNF-5190, *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0, 9/99

6 2 HNF-S-0426, *Performance Specification for the Spent Nuclear Fuel Multi-Canister Overpack*, Rev 5, 12/98

6 3 HNF-SD-SNF-DR-003, *Multi-Canister Overpack Design Report*, Rev 2, 2/99

6 4 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, *Rules for Construction of Nuclear Power Plant Components*, Division 1, Subsection NB, *Class 1 Components*, 1998 Edition

6 5 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, *Rules for Construction of Nuclear Power Plant Components* Division 1, Code Case N-595, *Requirements for Spent Fuel Storage Canisters* 1998 Edition

6 6 SNF-5191,*SSFC Fabrication Specification* Rev 0 9/99

6 7 NUREG/CR-3854, *Fabrication Criteria for Shipping Containers* UCRL-53544 March 1985

6 8 U S Nuclear Regulatory Commission Regulatory Guide 1 84 *Design and Fabrication Code Case Acceptability ASME Section III Division 1*, Revision 24, June 1986

6 9 U S Nuclear Regulatory Commission Regulatory Guide 1 85, *Materials Code Case Acceptability ASME Section III Division 1*, Revision 24, June 1986

6 10 ANSI N14 5, *American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment*, American National Standards Institute, Inc 1997

6 11 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section V, *Nondestructive Examination*, 1998 Edition

6 12 ASTM A 380-94, *Standard Practice for Cleaning and Descaling Stainless Steel Parts Equipment and Systems*

6 13 ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*, Subpart 2 1 *Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components for Nuclear Power Plants*

6 14 HNF-SD-SNF-TI-015 Rev 0, Spent Nuclear Fuel Project Technical Data book August 11, 1995

6 15 SNF-5192, S*SFC Insert Fabrication Specification*, Rev 0 9/99

6 16 HNF-S-0453, Rev 4, Multi-Canister Overpack Fabrication Specification Fluor Daniel Hanford, Richland, Washington

6 17 *Removal plan for Shippingport Pressurized Water Reactor Core 2 Blanket Fuel assemblies from T-Plant to the Canister Storage Building* WHC-SD-WM-ES 394, Rev 0, Westinghouse Hanford Company, Richland, Washington 1996

6 18 *Thermal Assessment of Shippingport Pressurized Water Reactor Blanket Fuel Assemblies within a Multi-Canister Overpack within the Canister Storage Building* HNF-4109, Rev 0, Numatec Hanford Corporation Richland, Washington

6 19 *Application of the Office of Civilian Radioactive Waste Management QA Requirements to the Hanford Spent Nuclear Fuel Project* HNF-SD-SNF-RPT 007, Rev 2C, Fluor Daniel Hanford, Inc , Richland, Washington

6 20 *Letter from Augenborg to Hanson* 99-AMW-027, DOE/RL, Richland, Washington.

7 0 APPENDICES

Appendix 1 – SSFC Drawings (references only)

H-2-829991	SH 1	Rev 0	Shippingport Spent Fuel Drawing List
	SH 2	Rev 0	
H-2-829992	SH 1	Rev 0	Shippingport Spent Fuel Canister Assembly
	SH 2	Rev 0	
H-2-829993	SH 1	Rev 0	Shippingport Spent Fuel Shield Plug Assembly
	SH 2	Rev 0	
	SH 3	Rev 0	
H-2-829994	SH 1	Rev 0	Shippingport Spent Fuel Insert Assembly

Appendix 2 – Material Evaluation

Appendix 3 – Weight Summary

Appendix 4 – SSFC Closure Bolt Pre-load Modeling and Response

Appendix 5 – SSFC Structural Drop Analysis

Appendix 6 – Stress Analysis of the Lifting Cap and Canister Collar

Appendix 7 – Stress Analysis for the Shippingport Spent Fuel Insert

Appendix 8 – Not used for Shippingport Spent Fuel Canister

Appendix 9 – Not used for Shippingport Spent Fuel Canister

Appendix 10 – Stress Analysis of Shield Plug Interface Components

Appendix 11 – SSFC Thermal Stress Evaluation

Appendix 12 – Not used for Shippingport Spent Fuel Canister

Appendix 13 – Main Seal Data (Same as MCO)

Appendix 14 – Seal Data for Process Valve Covers, and Filters (Same as MCO)

Appendix 15 – Not used for Shippingport Spent Fuel Canister

Appendix 16 – Not used for Shippingport Spent Fuel Canister

Appendix 17 – Warehouse Plan (Not used)

SSFC DRAWINGS

The drawings listed below reflect the specific details that make up the design of the Shippingport Spent Fuel Canister and Canister Insert Drawing H-2-829991 lists the applicable parts and drawings that are also common with the MCO Since all of the drawings have an individual document number, they are listed here as references only

H-2-829991	Sheet 1	Rev 0	*Shippingport Spent Fuel Drawing List*
	Sheet 2	Rev 0	
H-2-829992	Sheet 1	Rev 0	*Shippingport Spent Fuel Canister Assembly*
	Sheet 2	Rev 0	
H-2-829993	Sheet 1	Rev 0	*Shippingport Spent Fuel Shield Plug Assembly*
	Sheet 2	Rev 0	
	Sheet 3	Rev 0	
H-2-829994	Sheet 1	Rev 0	*Shippingport Spent Fuel Canister Insert Assembly*

PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

EVALUATION OF THE SSFC MATERIALS OF CONSTRUCTION

DOCUMENT REVISION	AFFECTED PAGES	REVISION DESCRIPTION	PREPARED BY INITIALS/DATE	CHECKED BY INITIALS/DATE	APPROVED BY INITIALS/DATE
0	ALL	INITIAL RELEASE	SAP 1 21 00	[illegible] 1/21/2000	[illegible] 1/21/2000

EVALUATION OF THE SSFC MATERIALS OF CONSTRUCTION

Comprehensive discussions evaluating the materials that are used to fabricate the MCO are provided in Appendix 2 of the MCO Design Report[1] That document provides discussions for the various major materials of construction (i e , carbon steel, stainless steel, copper, and aluminum) pertaining to brittle fracture resistance, thermal expansion coefficients, and galvanic compatibility All materials are shown to be acceptable

The calculated maximum values for heat, pressure, weight, radiological contents, and radiation dose for four Shippingport Core-2 blanket assemblies configured in a Shippingport Spent Fuel Canister (SSFC) are bounded by the design parameters of the MCO, as specified in the MCO Performance Specification[2] A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 660 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) However, linearly adjusting for a year 2001 maximum heat load of 632 watts, the maximum SSFC wall temperature is 136 °C × (632 W/660 W) = 130 3 °C (267 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F)

The canister insert comprises the only new component that is utilized for the payload of Shippingport Core-2 Blanket Assemblies, and is fabricated entirely of Type 304/304L stainless steel No new or different requirements are specified in the SSFC Performance Specification[3] Since Type 304/304L stainless steel is fully considered in the material evaluation provided in Appendix 2 of the MCO Design Report[1], its use as the material of construction for the canister insert is correspondingly acceptable

As discussed in Appendix 2 of the MCO Design Report[1], the Zircaloy-2 cladding and the stainless steel alloys each exhibit passive oxide layers on their surfaces Both exhibit similar galvanic corrosion potentials in seawater, thus, there should be no accelerated galvanic corrosion for this alloy combination The Shippingport Core-2 blanket assemblies utilize Zircaloy-4 for the cladding material Since Zircaloy-4 is more corrosion resistant than Zircaloy-2, the MCO evaluation is bounding

Whereas the material composition of both the SSFC and MCO are nearly identical, the operational loading process is different The MCO is designed for underwater loading, cold vacuum dried, and purged with inert gas The SSFC, however, is loaded dry and similarly purged with inert gas The dry loading process significantly reduces the possibility of corrosive interaction between materials making the SSFC a more stable configuration

The performance specification for the SSFC states that the environment for the MCO bounds that which the SSFC will be subjected to internally and externally Since the materials of construction are the same, the material evaluation performed in Appendix 2 of the MCO Design Report fully supports the SSFC

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[1] HNF SD SNF DR 003 *Multi Canister Overpack Design Report* Appendix 2 *Material Evaluation* Rev 2 2/99 and ECNs dated 7/99

[2] HNF S 0426 *Performance Specification for the Spent Nuclear Fuel Multi Canister Overpack* Rev 5 12/98

[3] SNF 5190 *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0 9/99

PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

CALCULATION TITLE

Shippingport Spent Fuel Canister (SSFC) Weight Summary

PROBLEM STATEMENT OR OBJECTIVE OF CALCULATION

1 Calculate the nominal and maximum weight of the Shippingport Spent Fuel Canister (SSFC) carrying a payload of four Shippingport Core-2 blanket assemblies

2 Calculate the axial center of gravity of the SSFC carrying a payload of four Shippingport Core-2 blanket assemblies

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LIST OF TABLES

1 0 INTRODUCTION

This calculation package provides the calculated weights and axial center of gravity of individual Shippingport Spent Fuel Canister (SSFC) components and a fully assembled SSFC, empty and loaded with four Shippingport Core-2 blanket assemblies

2 0 REFERENCES

1 SNF-5190, *Performance Specification for the Shippingport Spent Fuel Canister*, Rev 0, 9/99

2 HNF-SD-SNF-DR-003, *Multi-Canister Overpack Design Report*, Appendix 3, *Calculation Package – Weight Summary*, Rev 2, 2/99, and ECNs dated 7/99

3 *Shippingport Spent Fuel Canister Drawings*, H-2-829991, Rev 0, H-2-829992, Rev 0, H 2-829993, Rev 0, and *Shippingport Spent Fuel Insert Drawing*, H-2-829994, Rev 0

4 ASTM A480, *Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate Sheet and Strip*, Table A1 17, *Permissible Variation in Thickness for Plates*

3 0 ACCEPTANCE CRITERIA

Due to the nature of the calculation, acceptance criteria are not required

4 0 ASSUMPTIONS

With a few exceptions, the empty MCO used for the Mark 1A and Mark 1V payloads is identical to the empty SSFC used for the payload of four Shippingport Core-2 blanket assemblies The exceptions are noted as follows

1 *Shield Plug* the new shield plug utilizes one process port instead of four in the original design, since the components within each of these ports essentially fill the void, assume the shield plug weight and center of gravity does not change

2 *Internal Filter Guard Plate and Guard Plate Ring* the 1 50 inch thick internal filter guard plate is now a 2 00 inch thick shield plate, and the guard plate ring is no longer utilized, assume the shield plate weight is 2 00/1 50 = 4/3 times the weight of the internal filter guard plate from Reference 2 Note that this is the optional configuration The primary configuration is to make the shield plug 2 00 inch thicker resulting in the same net weight

3 *Dip Tube* the dip tube is not utilized for the SSFC

4 *Basket Stabilizer Extension* the basket stabilizer extension is not utilized for the SSFC

5 *Internal Filter Assembly and Partial Manifold* the internal filter assembly and partial manifold are not utilized for the SSFC

Per Reference 1, the nominal weight of a Shippingport Core-2 blanket assembly is 1,180 pounds The maximum weight is conservatively assumed to be 105% of nominal, or 1,239 pounds, the center of gravity of a Shippingport Core-2 blanket assembly is assumed to be at the geometric center where the length is 142 31 inch With an axial offset of 3 75 inch (1 76 inch for the SSFC bottom, 1 24 inch for the basket support plates, and 0 75 inch for the canister insert bottom plate), the fuel assembly's axial center of gravity is 3 75 + ½(142 31) = 74 91 inch above the SSFC bottom surface

Per Reference 2, the weight density of stainless steel is assumed as 0 286 lb/in^3

Center of gravity calculations are based on nominal weight

5 0 CALCULATIONS AND RESULTS

5 1 Weights and Axial Centers of Gravity for SSFC Components

Applicable component weights and centers of gravity from Reference 2 are summarized in Table 1

TABLE 1 – Weight and Center of Gravity Summary of Applicable Components from Reference 2

Component Description	Nominal Weight (lbs)	Maximum Weight (lbs)	Axial Center of Gravity① (in)
Canister Collar	199	207	149 27
Locking and Lifting Ring	403	417	155 69
Canister Cover	509	521	163 49
SSFC Shell	1,472	1,517	72 50
SSFC Shell Bottom	256	260	1 04
Dip Tube Guide Cone	3	4	4 12
Shield Plug (with process plugs and cover plates)	816	824	153 58
Internal Filter Guard Plate (weight × 4/3)	212	219	144 37
Summary	**3,870**	**3,969**	**113 33**

Notes

① The axial center of gravity is relative to the bottom outside surface of the SSFC

5 2 Weight and Axial Center of Gravity for the Canister Insert

Per Reference 3 the canister insert is a cruciform structure fabricated from 1/4 inch thick stainless steel The bottom of the canister insert is a 22¼ inch diameter, 1/2 inch thick, stainless steel plate

A 2 626 diameter hole through the bottom plate, 3 0 inch deep into the cruciform structure, provides a pocket for the dip tube guide cone

5 2 1 Weight and Axial Center of Gravity for the Cruciform Structure

The following physical characteristics apply to the cruciform structure

- *Thickness* 0 25 inch, +0 05, -0 06 inch (dimensions per Reference 3, tolerances per Reference 4)
- *Width* 22 25 inch, +0 00, -0 06 inch (dimensions and tolerances per Reference 3)
- *Length* 134 25 inch, ±0 13 inch (dimensions and tolerances per Reference 3)
- *Notch Width* 1 5 inch, ±0 06 inch (dimensions and tolerances per Reference 3)
- *Notch Length* 3 0 inch, ±0 06 inch (dimensions and tolerances per Reference 3)

Ignoring the two, 1 0 inch diameter lifting holes, the nominal weight is

$$W_{CSn} = (0\ 286)(0\ 25)\{[22\ 25 + (22\ 25 - 0\ 25)](134\ 25) - 4(1\ 5)(3\ 0)\} = 423\ \text{lb}$$

The maximum weight is

$$W_{CSm} = (0\ 286)(0\ 30)\{[22\ 25 + (22\ 25 - 0\ 30)](134\ 38) - 4(1\ 44)(2\ 94)\} = 508\ \text{lb}$$

The notches have a negligible effect on the axial center of gravity Thus, with an axial offset of 3 75 inch (1 76 inch for the SSFC bottom,1 24 inch for the basket support plates, and 0 75 inch for the bottom plate), the cruciform's axial center of gravity is

$$Z_{CS} = 3\ 75 + \frac{134\ 25}{2} = 70\ 875\ \text{in}$$

5 2 2 Weight and Axial Center of Gravity for the Bottom Plate

The following physical characteristics apply to the cruciform structure

- *Thickness* 0 75 inch, +0 09, -0 06 inch (dimensions per Reference 3, tolerances per Reference 4)
- *Outside Diameter* 22 25 inch, +0 00, -0 06 inch (dimensions and tolerances per Reference 3)
- *Inside Diameter* 2 626 inch, ±0 015 inch (dimensions and tolerances per Reference 3)

The nominal weight is

$$W_{BPn} = (0\ 286)(0\ 75)\left(\frac{\pi}{4}\right)\left[(22\ 25)^2 - (2\ 626)^2\right] = 82\ \text{lb}$$

The maximum weight is

$$W_{BPm} = (0\ 286)(0\ 84)\left(\frac{\pi}{4}\right)\left[(22\ 25)^2 - (2\ 611)^2\right] = 92\ \text{lb}$$

With an axial offset of 3 00 inch (1 76 inch for the SSFC bottom and 1 24 inch for the basket support plates), the bottom plate's axial center of gravity is

$$Z_{BP} = 3\ 00 + \frac{0\ 75}{2} = 3\ 375\ \text{in}$$

5 2 3 Weight and Axial Center of Gravity for the Canister Insert Assembly

The nominal weight is

$$W_n = W_{CSn} + W_{BPn} = 423 + 82 = 505\ \text{lb}$$

The maximum weight is

$$W_m = W_{CSm} + W_{BPm} = 508 + 92 = 600\ \text{lb}$$

The axial center of gravity is found by dividing the sum of the product of the weight and center of gravity for each component by the total weight of the assembly, as follows

$$Z = \frac{W_{CSn} Z_{CS} + W_{BPn} Z_{BP}}{W_n} = \frac{(423)(70\ 875) + (82)(3\ 375)}{505} = 59\ 91\ \text{in}$$

5 3 Weight and Axial Center of Gravity for the Empty and Loaded SSFC

Weight and axial center of gravity for the empty and loaded SSFC are summarized in Table 2

TABLE 2 – Weight and Center of Gravity Summary for an Empty and Loaded SSFC

Assembly Description	Nominal Weight (lbs)	Maximum Weight (lbs)	Axial Center of Gravity① (in)
Empty SSFC (without Canister Insert, Table 1)	3,870	3,969	113 33
Canister Insert	505	600	59 91
Empty SSFC Summary	**4,375**	**4,569**	**107 14②**
Shippingport Core-2 Blanket Assembly (each)	1,180	1,239	74 91
Shippingport Core-2 Blanket Assembly (×4)	4,720	4,956	74 91
Loaded SSFC Summary	**9,095**	**9,525**	**90 41②**

Notes

① The axial center of gravity is relative to the bottom surface of the SSFC

② The axial center of gravity is found by dividing the sum of the product of the weight and center of gravity for each component by the total weight of the assembly

PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

EVALUATION OF THE SSFC CLOSURE BOLT PRELOAD

DOCUMENT REVISION	AFFECTED PAGES	REVISION DESCRIPTION	PREPARED BY INITIALS/DATE	CHECKED BY INITIALS/DATE	APPROVED BY INITIALS/DATE
0	ALL	INITIAL RELEASE	SAP 1 21 00	[illegible] 1/21/2000	[illegible] 1/21/2000

EVALUATION OF THE SSFC CLOSURE BOLT PRELOAD

Comprehensive analyses of MCO closure bolt preload are provided in Appendix 4 of the MCO Design Report[1]

The calculated maximum values for heat, pressure, weight, and radiological contents for four Shippingport Core-2 blanket assemblies configured in a Shippingport Spent Fuel Canister (SSFC) are bounded by the design parameters of the MCO, as specified in the MCO Performance Specification[2] A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 632 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F)

No new or different requirements are specified in the SSFC Performance Specification[3] regarding closure bolt preload Thus, since the design parameters used for the evaluations in Appendix 4 of the MCO Design Report[1] are bounding, no additional analyses are necessary for the SSFC The following paragraph confirms the bounding nature of the MCO calculations

A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 660 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) However, linearly adjusting for a year 2001 maximum heat load of 632 watts, the maximum SSFC wall temperature is 136 °C × (632 W/660 W) = 130 3 °C (267 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F) Since all the analyses performed in Appendix 4 of the MCO Design Report[1] determine margins of safety based on 132 °C (270 °F), additional evaluations are not necessary

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[1] HNF SD SNF DR 003 *Multi Canister Overpack Design Report* Appendix 4 *MCO Closure Bolt Preload Modeling and Response* Rev 2 2/99 and ECNs dated 7/99

[2] HNF S 0426 *Performance Specification for the Spent Nuclear Fuel Multi Canister Overpack* Rev 5 12/98

[3] SNF 5190 *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0 9/99

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PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

EVALUATION OF THE SSFC FOR STRUCTURAL DROPS

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EVALUATION OF THE SSFC FOR STRUCTURAL DROPS

Although the handling and loading scenarios are different for the SSFC as compared to the MCO, the Design Basis Accident (DBA) conditions are the same since the actual conditions for the MCO have the potential of being more severe Comprehensive analyses of MCO structural drops are provided in Appendix 5 of the MCO Design Report[1] That calculation documents the evaluation of the MCO shell and the filter guard plate under different drop loads, considering the following load cases

1 54*g* bare bottom-end drop without the lifting cap, 150 psi internal pressure 132 °C (270 °F) temperature

2 54*g* bare bottom-end drop with the lifting cap, 450 psi internal pressure, 132 °C (270 °F) temperature

3 28*g* CSB tube drop of a fully loaded MCO onto another MCO without a modified lifting cap, 150 psi internal pressure, 132 °C (270 °F) temperature

4 28*g* CSB tube drop of a fully loaded MCO onto another MCO with a modified lifting cap, 450 psi internal pressure, 132 °C (270 °F) temperature

Further, the analyses determined that the 54*g* bare bottom-end drops (Cases 1 and 2) bound the 25*g* vertical "piston drop" into the cask, the 27*g* vertical drop with cask, bottom-end down, and the 35*g* vertical drop into CSB tube, and the 28*g* CSB tube drops (Cases 3 and 4) bound the 27g vertical drop with the cask

Finally, drops of the MCO within the cask were evaluated for the following cases

5 101g horizontal side drop, and

6 27g end drop, and

7 33 5g and 27 4g corner drops

The calculated maximum values for heat, pressure, weight, radiological contents, and radiation dose for four Shippingport Core-2 blanket assemblies configured in a Shippingport Spent Fuel Canister (SSFC) are bounded by the design parameters of the MCO, as specified in the MCO Performance Specification[2] A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 660 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) However, linearly adjusting for a year 2001 maximum heat load of 632 watts, the maximum SSFC wall temperature is 136 °C × (632 W/660 W) = 130 3 °C (267 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F) Since all the analyses performed in Appendix 5 of the MCO Design Report[1] determine margins of safety based on 132 °C (270 °F), no additional evaluations are necessary

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[1] HNF SD SNF DR 003 *Multi Canister Overpack Design Report* Appendix 5 *Multi Canister Overpack (MCO) Structural Drop Analysis* Rev 2 2/99 and ECNs dated 7/99

[2] HNF S 0426 *Performance Specification for the Spent Nuclear Fuel Multi Canister Overpack* Rev 5 12/98

No new or different requirements are specified in the SSFC Performance Specification[3] regarding the structural drops Thus, since the design parameters used for the evaluations in Appendix 5 of the MCO Design Report[1] are bounding, no additional analyses are necessary for the SSFC The following paragraphs confirm the bounding nature of the MCO calculations

Discussion regarding the difference between MCO and SSFC weights is subsequently considered The weight summary provided in Table 2 of Appendix 3 reports a SSFC weight of 9,095 pounds From Appendix 5 of the MCO Design Report[1], the weight of the MCO used in the calculations is 19,703 pounds The accelerations noted in load cases 1 through 4 for CSB-related drops are based on an MCO drop weight of 19 703 pounds The impact limiters inside the CSB tubes control MCO/SSFC inertia loads by the buckling of tubes, resulting in an effectively constant crush force Therefore, using a simplistic, quasi-static approach, the SSFC will experience accelerations equivalent to approximately 19,703/9,095 = 2 166× the accelerations used in load cases 1 through 4 The net effect on loads to components, however, is unchanged For example, Section 8, *Closure Seal Leakage*, in Appendix 5 of the MCO Design Report[1] bases its calculations on an inertial load equal to 28*g* × 19,703 pounds (MCO weight), or 551,684 pounds Thus, the inertia load reacted by the seal region is 551,684 pounds Since the SSFC weighs only 9,095 pounds, its acceleration is 28*g* × 2 166 = 60 65*g*, the resulting inertia load is 60 65*g* × 9 095 pounds (SSFC weight) or 551 612 pounds which is identical to the MCO inertia load In summary, although SSFC accelerations are proportionally higher than MCO accelerations, the net effect for component loads is unchanged and the results presented in Appendix 5 of the MCO Design Report[1] bound the SSFC

Load cases 5 through 7 are based on accelerations derived from the cask Since the weight of the SSFC has a negligible effect on the cask's impact response, the results presented in Appendix 5 of the MCO Design Report[1] bound the SSFC The only applied load to the SSFC comes from its own mass interacting with the cask, actual applied loads will be smaller due to the reduced mass of the SSFC as compared to the MCO

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[3] SNF 5190 *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0 9/99

PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

EVALUATION OF THE SSFC LIFTING CAP AND CANISTER COLLAR

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EVALUATION OF THE SSFC LIFTING CAP AND CANISTER COLLAR

Comprehensive analyses of the MCO lifting cap and canister collar are provided in Appendix 6 of the MCO Design Report[1]

The calculated maximum values for heat, pressure, weight, and radiological contents for four Shippingport Core-2 blanket assemblies configured in a Shippingport Spent Fuel Canister (SSFC) are bounded by the design parameters of the MCO as specified in the MCO Performance Specification[2] A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 660 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) However, linearly adjusting for a year 2001 maximum heat load of 632 watts, the maximum SSFC wall temperature is 136 °C × (632 W/660 W) = 130 3 °C (267 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F)

No new or different requirements are specified in the SSFC Performance Specification[3] regarding the lifting cap and canister collar Thus since the design parameters used for the evaluations in Appendix 6 of the MCO Design Report[1] are bounding, no additional analyses are necessary for the SSFC The following paragraphs confirm the bounding nature of the MCO calculations

Appendix 6 of the MCO Design Report[1] considers two loading conditions 1) a lifting load, and 2) a pressure load The lifting cap and canister collar are shown to be acceptable for a 12 ton (24,000 pound) design lifting load, a 450 psi internal pressure load, and a combination of both loading conditions From Table 2 in Appendix 3 of the SSFC Design Report[4], the maximum weight of the loaded SSFC is 9,525 pounds, but the 12 ton (24,000 pound) lifting requirement remains the same Since the lifting load evaluated in Appendix 6 of the MCO Design Report[1] is identical, the resulting margins of safety related to the lifting load condition will be identical

Since all the analyses performed in Appendix 6 of the MCO Design Report[1] determine margins of safety based on 132 °C (270 °F) no additional evaluations are necessary

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[1] HNF SD SNF DR 003 *Multi Canister Overpack Design Report* Appendix 6 *Stress Analysis of the Lifting Cap and Canister Collar* Rev 2 2/99 and ECNs dated 7/99

[2] HNF S 0426 *Performance Specification for the Spent Nuclear Fuel Multi Canister Overpack* Rev 5 12/98

[3] SNF 5190 *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0 9/99

[4] SNF 5133 *Shippingport Spent Fuel Canister (SSFC) Design Report* Appendix 3 *Shippingport Spent Fuel Canister (SSFC) Weight Summary* Rev 0 9/99

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PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

CALCULATION TITLE

Stress Analysis of the SSFC Canister Insert

PROBLEM STATEMENT OR OBJECTIVE OF CALCULATION

1 Analyze stresses when lifting an empty canister insert at an ambient temperature of 20 °C (68 °F)

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LIST OF FIGURES

1 0 INTRODUCTION

This calculation package provides a stress analysis of the canister insert's lifting features

2 0 REFERENCES

1 SNF-5190, *Performance Specification for the Shippingport Spent Fuel Canister*, Rev 0 9/99

2 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section II, *Part A – Ferrous Material Specifications*, and *Materials*, Part D – *Properties*, Tables Y-1 and U, 1998 Edition, American Society of Mechanical Engineers, New York, New York

3 *Shippingport Spent Fuel Canister Drawings*, H-2-829991, Rev 0, H-2-829992, Rev 0, H-2-829993, Rev 0, and *Shippingport Spent Fuel Insert Drawing*, H-2-829994, Rev 0

4 Joseph H Faupel Franklin E Fisher, *Engineering Design*, Second Edition, John Wiley & Sons Inc , New York, New York, 1981

5 SNF-5133, *Shippingport Spent Fuel Canister Design Report*, Appendix 3, *Shippingport Spent Fuel Canister (SSFC) Weight Summary*, Rev 0, 1/00

3 0 ACCEPTANCE CRITERIA

Per Section 4 12 of Reference 1, the lifting features shall be capable of lifting the weight of the canister insert without exceeding one-third of the yield tensile strength or one-fifth of the ultimate tensile strength of the materials of construction

From Reference 2 and Reference 3, for a temperature of 20 °C (68 °F), the yield and ultimate tensile strength of dual-certified, Type 304/304L stainless steel is 30,000 psi and 75,000 psi respectively The allowable tensile stress is the lesser of one-third of the yield tensile strength, 1/3 × 30,000 = 10,000 psi, or one-fifth of the ultimate tensile strength, 1/5 × 75,000 = 15,000 psi Thus, the allowable tensile stress, σ_a = 10,000 psi The allowable shear stress is taken as 60% of the allowable tensile stress, or $\tau_a = 0\ 6 \times \sigma_a$ = 6,000 psi

4 0 ASSUMPTIONS

The canister insert is handled empty via two, 1 00 inch diameter holes Assumptions are as stated in Section 5 0, *Calculations and Results*

5 0 CALCULATIONS AND RESULTS

Per the Reference 3 drawings, the lifting features on the canister insert are two 1 00 inch diameter holes, both inset 1 00 inch from the top edge

5 1 Lifting Hole Tear-Out

Per Equation D26 of Reference 4, the force to *tear-out* a hole is determined from the following equation

$$P = 2Lt\tau_a$$

where, from Figure 1

$$L = d - R(\cos 40^o)$$

For d = 1 00 inch and R = 0 50 inch, L = 0 617 inch The force to tear-out the lifting hole, where t = 0 25 inch and τ_a = 6,000 psi, is P = 1,851 pounds

From Table 2 of Reference 5, the maximum weight of the canister insert is W = 600 pounds The tear-out load margin of safety for the two lifting points is

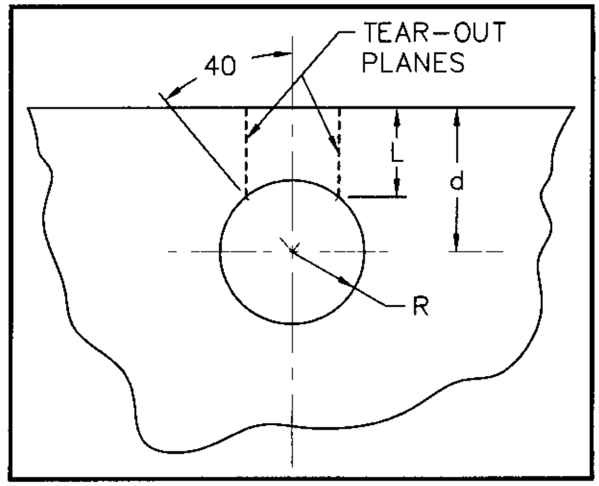

FIGURE 1 – Hole Tear-Out Geometry

$$M S = \frac{2P}{W} - 1 = +\underline{5\ 17}$$

5 2 Lifting Hole Bearing Stress

The bearing stress is calculated by conservatively assuming the lifting device contacts the hole over the 80° arc For a thickness, t = 0 25 inch, and hole radius, R = 0 50 inch, the bearing area is

$$A = 2\pi Rt\left(\frac{80^\circ}{360^\circ}\right) = 0\ 175\ in^2$$

For an allowable yield tensile stress, σ_a = 10,000 psi the allowable bearing load, $P_B = \sigma_a A$ = 1,750 pounds Again, from Table 2 of Reference 5, the maximum weight of the canister insert is W = 600 pounds The bearing load margin of safety for the two lifting points is

$$M S = \frac{2P_B}{W} - 1 = +\underline{4\ 83}$$

5 3 Canister Insert Longitudinal Weld Stress

As shown in the Reference 3 drawings, the cruciform structure is fabricated from three, 0 25 inch thick, 134 25 inch long, plates Two, 11 00 inch wide plates are welded normal to the center of a 22 25 inch wide plate to form the cruciform shape (when viewed from the end) Each narrow plate is attached with 1/8 inch bevel 1-10 skip welds (1 0 inch of weld for every 10 0 inch of length) on both sides Further, a 2 0 inch long continuous groove weld occurs on both sides of each end for loading continuity The effective length of the groove welds is determined from the following equation

$$L_W = 2(2\ 0) + \frac{134\ 25 - 2(2\ 0)}{10} = 17\ 0\ \text{in}$$

The determination of L_W is made by conservatively discarding the fractional portion of the length from the above equation Considering 1/8 inch groove welds (t_W = 0 125 inch) on both sides of the plate, the total weld area available to resist shear is

$$A_W = 2L_W t_W = 4\ 25\ \text{in}^2$$

From Table 2 of Reference 5, the maximum weight of the canister insert's longitudinal plates is W = 600 pounds Since one quarter of the weight is carried by each set of welds the shear stress in the welds is

$$\tau = \frac{W}{4A_W} = 35\ 3\ \text{psi}$$

With an allowable shear stress, τ_a = 6,000 psi, the resulting margin of safety is very large

5 4 Canister Insert Bottom Plate Weld Stress

As shown in the Reference 3 drawings, the bottom plate is attached via eight, 1/8 inch fillet welds (t_W = 0 125 × (sin 45°) = 0 088 inch), each 11 0 inch long (L_W = 44 0 inch) The total weld area available to resist shear is

$$A_W = 8L_W t_W = 7\ 7\ \text{in}^2$$

From Section 5 2 2 of Reference 5, the maximum weight of the canister insert's bottom plate is W = 92 pounds The shear stress in the welds is

$$\tau = \frac{W}{A_W} = 11\ 9\ \text{psi}$$

With an allowable shear stress, τ_a = 6,000 psi the resulting margin of safety is very large

PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

EVALUATION OF THE SSFC SHIELD PLUG INTERFACE COMPONENTS

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EVALUATION OF THE SSFC SHIELD PLUG INTERFACE COMPONENTS

Comprehensive analyses of MCO shield plug interface components are provided in Appendix 10 of the MCO Design Report[1]

The calculated maximum values for heat, pressure, weight, and radiological contents for four Shippingport Core-2 blanket assemblies configured in a Shippingport Spent Fuel Canister (SSFC) are bounded by the design parameters of the MCO, as specified in the MCO Performance Specification[2] A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 660 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) However, linearly adjusting for a year 2001 maximum heat load of 632 watts, the maximum SSFC wall temperature is 136 °C × (632 W/660 W) = 130 3 °C (267 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F)

No new or different requirements are specified in the SSFC Performance Specification[3] regarding the shield plug interface and components Thus, since the design parameters used for the evaluations in Appendix 10 of the MCO Design Report[1] are bounding no additional analyses are necessary for the SSFC The following paragraphs confirm the bounding nature of the MCO calculations

Appendix 10 of the MCO Design Report[1] considers three loading conditions 1) a pressure load combined with a preload torque on the cover plate bolts and process valves, 2) thermal expansion differences at a design temperature of 132 °C (270 °F), and 3) a critical drop loading (horizontal) of 101*g* The SSFC differs from the MCO in that only a single process valve port penetration is provided in the shield plug (versus four penetrations for the MCO) However, since the SSFC port configuration is identical to the MCO port configurations, loading of the port is correspondingly identical to the cases considered in Appendix 10 of the MCO Design Report[1] Note that calculations involving the process filter assemblies and associated guard plate components that are provided in Appendix 10 of the MCO Design Report[1] are not applicable to the SSFC since these components are not utilized

For loading condition (1), the shield plug interface and components are shown to be acceptable for the 450 psi internal pressure load combined with a preload torque on the cover plate bolts and process valves at a design temperature of 132 °C (270 °F) Similarly, for loading condition (2), thermal expansion at a design temperature of 132 °C (270 °F) is shown to be acceptable for the shield plug interface and components Finally for loading condition (3), the effect of the critical side drop loading of 101*g* is determined to be acceptable at a design temperature of 132 °C (270 °F)

Since all the analyses performed in Appendix 10 of the MCO Design Report[1] determine margins of safety based on 132 °C (270 °F), no additional evaluations are necessary

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[1] HNF SD SNF DR 003 *Multi Canister Overpack Design Report* Appendix 10 *Stress Analysis of the Shield Plug Interface Components* Rev 2 2/99 and ECNs dated 7/99

[2] HNF S 0426 *Performance Specification for the Spent Nuclear Fuel Multi Canister Overpack* Rev 5 12/98

[3] SNF 5190 *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0 9/99

PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

EVALUATION OF THE SSFC FOR THERMAL STRESSES

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EVALUATION OF THE SSFC FOR THERMAL STRESSES

Comprehensive analyses of MCO for thermal stresses are provided in Appendix 11 of the MCO Design Report[1]

The calculated maximum values for heat, pressure, weight, and radiological contents for four Shippingport Core-2 blanket assemblies configured in a Shippingport Spent Fuel Canister (SSFC) are bounded by the design parameters of the MCO, as specified in the MCO Performance Specification[2] A conservative value for the SSFC wall temperature, based on a mis-loaded canister with 660 watts being generated versus a nominal load generating 400 watts, is 136 °C (277 °F) However, linearly adjusting for a year 2001 maximum heat load of 632 watts, the maximum SSFC wall temperature is 136 °C × (632 W/660 W) = 130 3 °C (267 °F) Administrative controls ensure mis-loading will not occur and the SSFC wall temperature will not exceed 132 °C (270 °F)

No new or different requirements are specified in the SSFC Performance Specification[3] regarding the MCO thermal stresses calculations Thus, since the design parameters used for the evaluations in Appendix 11 of the MCO Design Report[1] are bounding, no additional analyses are necessary for the SSFC The following paragraphs confirm the bounding nature of the MCO calculations

Appendix 11 of the MCO Design Report[1] considers five loading conditions 1) a 25 psig external pressure load at a temperature of 75 °C (167 °F), 2) a full internal vacuum at a temperature of 132 °C (270 °F), 3) an internal pressure of 150 psig at a temperature of 132 °C (270 °F), 4) lifting of the MCO at a temperature of 132 °C (270 °F) with an internal pressure of 450 psig, and 5) a 100 °C (212 °F) thermal gradient between the outside of the MCO shell and the center of the MCO shield plug

For all five loading conditions, margins of safety for the MCO are determined using the design stress, S_M As can be seen in Tables 1 and 2 of Appendix 11 of the MCO Design Report[1], the allowable stress intensity limits for the Type 304/304L stainless steel components are not affected by a variation over the temperature range of interest, hence no additional evaluations are necessary For loading condition 4, a comprehensive discussion of lifting of the SSFC at a temperature of 132 °C (270 °F) is provided in Appendix 6, *Evaluation of the SSFC Lifting Cap and Canister Collar*

In summary, the analyses provided for the MCO configuration in Appendix 11 of the MCO Design Report[1] completely bound the SSFC configuration

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[1] HNF SD SNF DR 003 *Multi Canister Overpack Design Report* Appendix 11 *Multi Canister Overpack Thermal Stress Analysis* Rev 2 2/99 and ECNs dated 7/99

[2] HNF S 0426 *Performance Specification for the Spent Nuclear Fuel Multi Canister Overpack* Rev 5 12/98

[3] SNF 5190 *Performance Specification for the Shippingport Spent Fuel Canister* Rev 0 9/99

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PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

MAIN SEAL DATA

CARBONE LORRAINE

Product	Helicoflex Seals
Model/Part No	H-305236 REV NC (includes U260418 Retainer clip and screw)
Address	Helicoflex 2770 The Boulevard P O Box 9889 Columbia, SC 28209
Telephone	(803) 783-1880
Fax	(803) 783-4279
Contact	Michel LeFrancois

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PROJECT	CLIENT
Shippingport Spent Fuel Canister (SSFC)	Fluor Daniel Hanford, Inc

SEAL DATA FOR PROCESS VALVE, COVERS, AND FILTERS

EG&G PRESSURE SCIENCE, INC (PSI)

Product, Model Number, and Part Number (P/N) Information

Boss Seal, C-Seal 02 062 OD Face Type, Internal Pressure	PSI P/N 13632
C-Seal, 3 520 OD Face Type, Internal Pressure	PSI P/N 13503
C-Seal 1 156 OD Boss Type, Internal Pressure with Split Liner for MS 33649-12 Fitting	PSI P/N 801A91-0012-A (INCO 718)
Boss Type C Seal, 1 843 OD Face Type Internal Pressure with Split Liner	PSI P/N 14119

Address	EG&G Pressure Science 11642 Old Baltimore Pike Beltsville, MA 20705-1294
Telephone	(301) 937-9654
Fax	(301) 937-7027
Contact	Jeff Layer

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