

SECTION C

Attachment C-A-A Fuel and Fuel Package Descriptions

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Table of Contents

<u>Section</u>	<u>Page</u>
1.0 Peach Bottom Unit 1.....	A-3
1.1 Introduction.....	A-3
1.2 Physical Description of Fuel.....	A-3
1.3 Packaging.....	A-11
1.4 As Stored Condition.....	A-24
1.5 Radionuclide Inventory.....	A-26
2.0 Shippingport L WBR.....	A-36
2.1 Introduction.....	A-36
2.2 Physical Description of Fuel.....	A-37
2.3 Packaging.....	A-52
2.4 As Stored Condition.....	A-53
2.5 Radionuclide Inventory.....	A-53
3.0 TRIGA Fuel Types.....	A-85
3.1 Introduction.....	A-85
3.2 Physical Description of Fuel.....	A-85
3.3 Packaging.....	A-94
3.4 As Stored Condition.....	A-94
3.5 Radionuclide Inventory.....	A-102
3.6 References.....	A-102

1.0 PEACH BOTTOM UNIT I

1.1 Introduction

The Peach Bottom Unit 1 reactor was a High Temperature Gas-cooled Reactor (HTGR) that utilized graphite, uranium carbide, and helium coolant to achieve power production at a rated capacity of 115 MW(t). It was located at Peach Bottom, Pennsylvania, and operated with two different cores (Core 1 and Core 2) from 1966 to 1974. The reactor contained 804 fuel elements per fuel core load. The total number of fuel elements irradiated in the core was 1,639, which exceeds the total capacity of the two different core loadings because replacement and test fuel assemblies were added during operation of the cores. The graphite-based fuel elements were 3.5 in. in diameter and 12 ft. in length, containing varying amounts of uranium and thorium. These heavy metals were present as carbon-coated uranium carbide and thorium carbide particles that had been formed into compacts by sintering with carbonaceous materials.

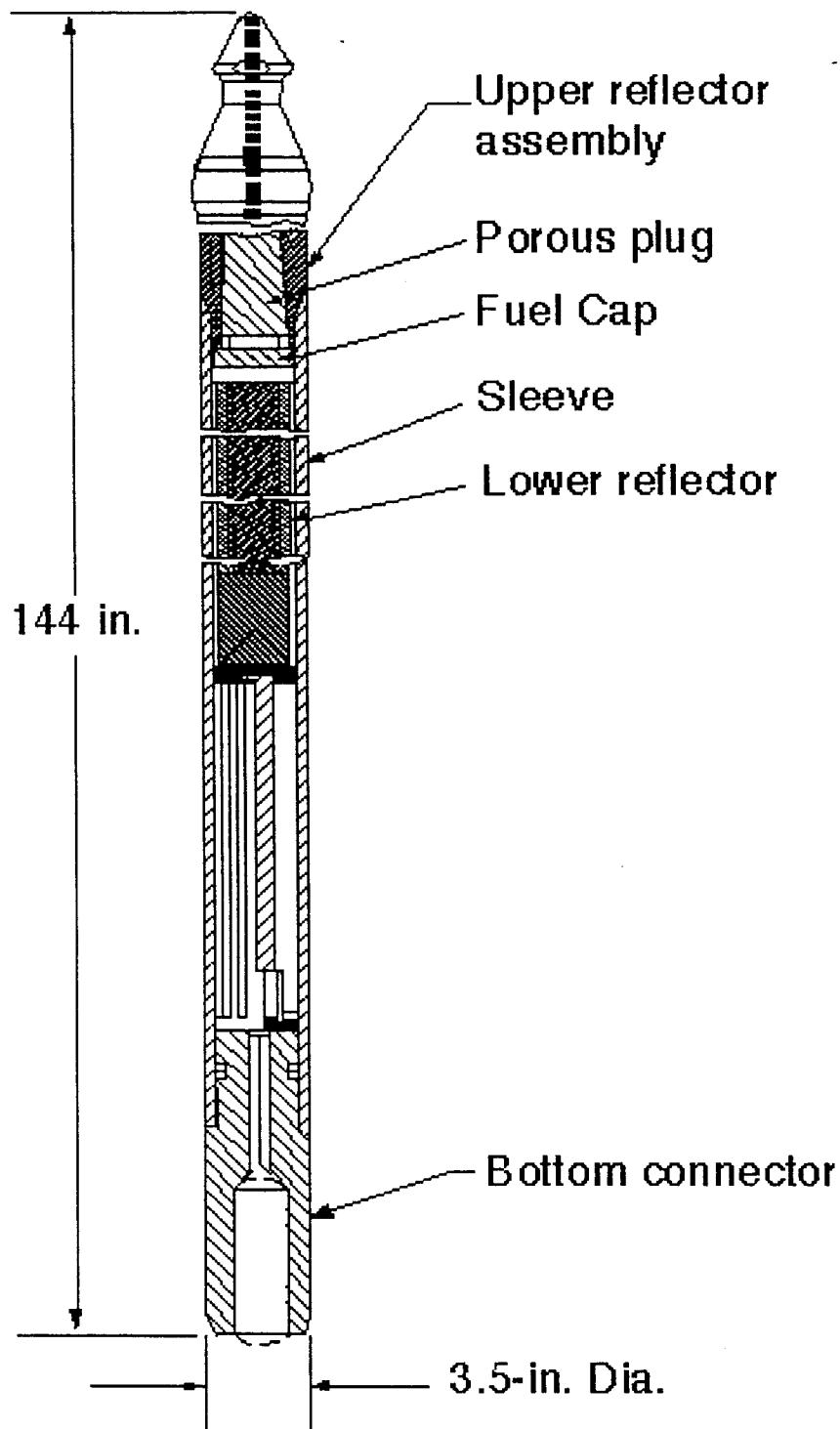
The design burnup of the fuel was ~73,000 MWd/MTIHM (megawatt days per metric tons initial heavy metal); however, excessive fuel failures during operation of Core 1 resulted in removal of that core at about half the design burnup. The fuel failure was attributed to the fuel particle coating system. This system was modified for the second core, which performed satisfactorily and reached design burnup. The reactor was shut down at this point. The total initial heavy metal loadings of the two cores were 1.686 and 1.419 MT of U + Th, respectively.

1.2 Physical Description of Fuel

The basic fuel element is a solid semi-homogeneous type in which graphite served as the moderator, reflector, cladding, fuel matrix, and structure. Each fuel element consists of an upper reflector assembly, a fuel bearing middle section, a lower reflector, and an internal fission product trap. The fuel materials, part of the lower reflector, and the fission product traps are contained in a sleeve of low-permeability graphite that joins the upper reflector on one end and a bottom connector fitting on the other (see Figure 1-1). A stainless steel screen installed at the bottom of each fission product trap retains any charcoal granules that might be released from the graphite body of the internal trap. Within the sleeve, the mixture of fissile and fertile materials making up the fuel is contained in annular compacts stacked on cylindrical graphite spines.

Three basic fuel element configurations were irradiated in both Peach Bottom reactor cores; standard fuel elements, instrumented fuel elements, and test elements. The external appearance of all configurations is the same. Each core contained a number of fuel elements that were instrumented with thermocouples and (in Core 1 only) acoustic thermometers. Thirty-six instrumented elements were included in the 804 fuel elements required for each core loading. In addition, 33 fuel test elements were irradiated in Core 2 to various exposures; the purpose of this was to measure the thermal, physics, fission product, and materials' behavior of commercial HTGR fuel concepts utilizing test assemblies in a representative commercial HTGR neutron spectrum and a helium coolant environment.

Most of the test elements were removed and destructively analyzed at either General Atomics (GA) or Oak Ridge National Laboratory (ORNL). Thus, only the standard and the instrumented elements will be discussed.



Peach bottom assembly

J96 0201

Figure 1-1. Standard Peach Bottom Unit 1 Assembly

1.2.1 Core 1 Standard Fuel Elements

The Core 1 standard fuel element has as its primary components a bottom connector, a sleeve, a screen, an internal fission product trap assembly, a lower reflector piece, fuel compacts, spines, burnable poison compacts (in selected elements), a fuel cap, and an upper reflector assembly. The bottom connector and the sleeve are joined by a silicon braze, and together they form the main barrier against fission-product leakage from the fuel element. The fuel cap is a graphite disk that slips loosely into the upper end of the sleeve. All three of these components (bottom connector, sleeve, and fuel cap) are made of graphite, which has a helium permeability of 3×10^{-3} cm²/s or less and an effective permeability to gaseous fission products of approximately 10^{-5} cm²/s at reactor conditions.

The screen, internal trap assembly, lower reflector piece, fuel compacts with spines, and fuel cap are stacked, in that order, within the sleeve. The bottom connector supports the weight of these components. The lower reflector piece is a 3-in.-long graphite cylinder made of reactor-grade graphite. The annular fuel compacts are stacked on the cylindrical graphite spine sections. These spine sections are approximately 30 in. long and about 1.75 in. in diameter. There are two types of spines: one made of solid graphite and one with a 0.89-in.-diameter hole designed to contain burnable poison compacts. The screen, which is used to retain any charcoal granules that might be released from the graphite body of the internal trap, is made of 18-8 stainless steel.

The upper reflector assembly is a machined graphite component that is threaded and cemented into the sleeve of the fuel element. The cement consists of furnace-cured carbonaceous material. The upper end of the reflector piece is machined to engage with the fuel handling machines. A 0.25 in.-diameter hole down the centerline of the reflector serves as an inlet channel for purge gas. A porous plug cemented and retained within the upper reflector provides a controlled pressure drop for inflowing purge gas.

The Core 1 fuel compacts consisted of carbides of uranium enriched to 93.15% ²³⁵U at the beginning of life (BOL) and thorium, uniformly dispersed as coated particles in a graphite matrix. The total carbon within the carbide substrates was between 11 and 16%, by weight, at BOL. The pyrolytic carbon-coated particles were between 210 and 595 mm in diameter, with coating thicknesses of 55 ± 10 μm . The size distribution of the particles was designed to ensure that the volume fraction of the coated particles did not exceed 30% of the total compact volume.

1.2.2 Four Types of Standard Fuel Elements

There are four basic types of fuel elements, which differ in their uranium, thorium, rhodium, and boron content. All other physical dimensions are the same for each element. To achieve the four different fuel element types each element was loaded with four distinctly different types of compacts. Each compact contained different levels of uranium, thorium, rhodium, carbon, and boron. The different fuel compacts are described in Table 1-1.

Table 1-1. Fuel Compact Loading (in grams)

Compact Type	A	B	C	D
Description	Standard	Heavy Rhodium	Light Rhodium	Heavy Thorium
Th ²³²	52.10	52.10	52.10	115.36
U ²³⁴ *	0.156	0.156	0.156	0.082
U ²³⁵	9.70	9.70	9.70	5.14
U ²³⁶ *	0.052	0.052	0.052	0.028
U ²³⁸	0.505	0.505	0.505	0.268
Rh ¹⁰³	0	1.028	0.342	0
Carbon	285.00	285.00	285.00	273.00

*²³⁴U and ²³⁶U loadings were not required. These were the maximum amounts expected in the fully enriched fuel material.

By stacking the four different types of compacts (Types A, B, C, or D) and the burnable poison compacts in different configurations inside each graphite fuel element, four distinct types of fuel elements were created. The four types of fuel elements, based on nuclear properties, which were required for the Peach Bottom Unit 1 reactor were designated as Types I, II, III, and IV. These four different element configurations are described in Table 1-2.

Table 1-2. Types of Fuel Elements Based on Nuclear Properties

Fuel Element Type				
Description	I Heavy Rhodium	II Light Rhodium	III Light Rhodium with burnable poison	IV Heavy Thorium; Light Uranium
Spine	Solid Graphite	Solid Graphite	Hollow with poison compacts	Solid Graphite
Compact Type:				
- In upper 9 inches	A	A	A	D
- In middle 54 inches	B	C	C	D
- In lower 27 inches	A	A	A	D
Number of types in a nominal core loading	54	588	60	102

1.2.3 Instrumented Elements

A total of 36 fuel elements were instrumented in the cores with two thermocouples each and (in

Core 1 only) eight of these elements containing acoustic thermocouples. The acoustic thermocouple is an instrument, which utilizes the proportionality between resonance frequency of a transmitted sound wave and the temperature of the helium gas in a cavity within the fuel element to determine the temperature. The axial and radial location of the thermocouples varied, depending upon the planned position of the specific fuel element location in the core. The number of instrumented elements in each fuel element type is described in Table 1-3.

Table 1-3. Number and Type of Instrumented Fuel Elements

Number of Instrumented Fuel Elements	Type of Fuel Element	Use of Thermocouples
8	I & II	Spine and sleeve temperature. Also an acoustic thermometer at center, hot spot height (Core 1 only).
3	I	Axial profile at center of core - Spine temperature.
5	I, II, III, & IV	Radial profile - Spine plus internal trap inlet temperature.
7	I, II, & III	Radial profile - Both TCs for spine temperature.
3	II	Both TCs for spine temperature.
2	IV	Low uranium loading - Both TCs for spine temperature.
2	I & II	Internal trap inlet and outlet temperature.
2	II & IV	Standoff and bottom reflector temperature.
3	II	Axial profile at edge of core - Spine temperature.
1	III	Boron loaded - Both TCs for spine temperature.

1.2.4 Core 2 Fuel Elements

The Core 2 standard fuel elements were essentially the same as the Core 1 elements. The only design difference was in the coated particles and the external appearance of the fuel compacts. The coating of the Core 2 fuel and fertile particles consisted of an inner coating of low-density pyrolytic carbon surrounded by an outer isotropic layer of pyrolytic carbon ("BISO" particle). The total coating thickness was between 90 and 130 μm . coated particles were -340 and 630 μm in diameter, respectively, for the fissile and fertile particles. The Core 2 compacts were smooth and had slots on the ends.

1.2.5 Poisons

Burnable poison compacts, cylindrical in shape, were placed in hollow spines of some of the fuel elements (Type 3 fuel elements). Each compact contained 0.436 ± 0.030 g of natural boron in the form of zirconium diboride pressed into a graphite matrix. The maximum particle size of the zirconium diboride was 100 μm .

The physical properties of a typical standard and instrumented fuel element are summarized in Table 1-4.

Table 1-4. Physical Fuel Configuration

Assembly Shape	Right cylindrical rod
Assembly Dim.	3.5" O.D. x 12' long
Compact Shape	Flat annular cylinders (A doughnut shape)
Compact Dimension	2.7" O.D. x 2.98" long. Center hole ~ 1.75" dia.
Assembly "Cladding" Material	Low-permeable Graphite and nuclear-grade graphite
Compact "Cladding" Material	None (Graphite matrix was not designed to be a cladding)
No. of compacts/assembly	30 compacts
Enrichment	93.15%
Active fuel length	89"-90"
Fuel Meat	UC,ThC particles
Particle Cladding	Pyrolytically deposited carbon (PyC). Monocoated
Particle Cladding thickness	55 +/-10 μm
Particle Diameter	between 210 and 595 μm
Added material:	
Spines:	
- Solid spines, Dim.	~1.75" O.D. x ~30" long
- Hollow spines, Dim.	~1.75" O.D. x ~30" long (hole = 0.89" dia)
Burnable poison compacts	
- Shape	Solid cylindrical pellets
- Poison compact, Dim.	~0.89" O.D. x 2.0" long
- Poison material	ZrB ₂ particles pressed into a graphite matrix
- Poison particle diameter	~100 μm
- Stainless Steel Screen	18-8 SST
- Internal trap	Activated Charcoal
- Brazing ring	Silicon
- Thermocouple (Instrumented elements only)	Inconel sheath, tungsten-rhenium, chromel-alumel Nb-1% Zr sheath
- Bottom Connector (Instrumented)	Graphite, stainless steel, inconel

1.2.6 Current Location

The Peach Bottom 1 reactor was shut down on October 31, 1974, and all of the spent fuel was shipped to different facilities. The total inventory of spent fuel from the reactor consists of two cores (Core 1 and Core 2), some replacement elements, and a number of test elements. There

were 819 fuel elements (818 regular elements and one test element) irradiated in Core 1. There were 820 fuel elements (787 regular elements and 33 test elements) irradiated in Core 2. The total number of elements irradiated in both cores was 1639.

Most of the spent fuel (813 regular Core 1 and 787 regular Core 2 elements) is stored at Idaho National Engineering and Environmental Laboratory (INEEL). All the spent fuel shipped to General Atomic Corporation for destructive analysis was subsequently shipped to the INEEL for storage. Of the twelve known elements shipped to ORNL for examination two of these were destroyed in the course of examinations and the remaining ten are in retrievable underground storage. This leaves 25 Peach Bottom Unit I fuel elements unaccounted for.

1.3 Packaging

Because of the different storage locations and dates of transportation, the fuel elements from each core were packaged differently. A description of how the elements from each core were packaged is discussed below.

1.3.1 Core 1 Packaging

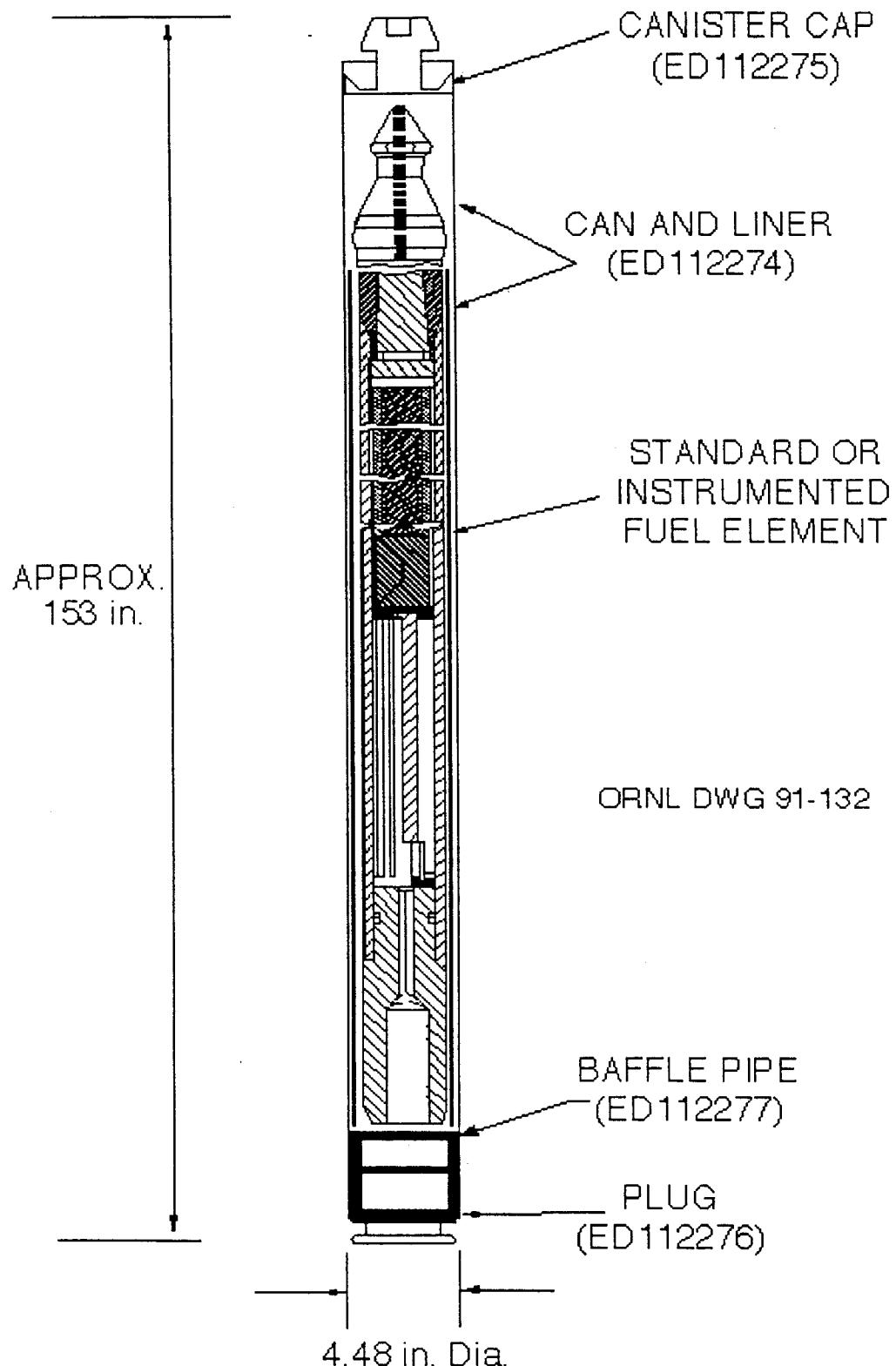
Core 1 is currently stored in open-field drywells at the CPP-749 Facility, and in the Fuel Element Cutting Facility (FECF) within CPP-603. These facilities are located within the Idaho Nuclear Technology and Engineering Center (INTEC) at the INEEL. The fuel was placed in sealed aluminum canisters with stainless steel liners at Peach Bottom after removal from the reactor. The failed fuel was removed from the core with a stainless steel failed fuel element tool, and both the tool and the element were placed in a sealed canister (see Figure 1-2). The sealed storage canisters were then back-filled with Helium and checked for leaks. If leaks were detected the entire canister and fuel element were then placed in a second aluminum storage canister called a salvage canister (see Figure 1-3). The typical loaded storage canisters weigh about 150 lb.

The canisters of fuel were shipped to the INEEL in the Peach Bottom fuel shipping cask. Eighteen elements at a time were positioned in the cask by means of a basket assembly with a length of 158.38" and a diameter of 25.5" (see Figures 1-4 through 1-9). At the INEEL, an entire handling basket (called Canister CAN-SFE-101) loaded with fuel canisters was lowered into a CPP-749 drywell. A loaded handling basket weighs a maximum of 5150 lb. Forty-six handling baskets are situated in individual drywells. Removal and canning of the failed Core 1 fuel resulted in a number of package types (fuel canisters) that were loaded into the handling baskets (see Table 1-5).

1.3.2 Core 2 Packaging

Core 2 fuel elements are currently stored in unsealed, carbon steel canisters at the Irradiated Fuel Storage Facility (IFSF) within CPP-603 (see Table 1-6). The Core 2 spent fuel was packaged for shipment using canisters of the same type as those used for Core 1. However, instead of placing the fuel into similar drywells used for the Core 1 fuel, all the Core 2 fuel was stored in the IFSF. Since the carbon steel storage canisters are only 11 feet in length, once the fuel was received at

the INTEC, the graphite fuel elements were removed from the aluminum canisters and the top reflector was cut from the tops of each element. The cropped elements were stored 11 to 12 elements per carbon steel canister (nominal count is 12 per canister) and the canisters were then placed into the IFSF (see Figure 1-10).



Peach Bottom Spent Fuel Storage Canister

Figure 1-2. Peach Bottom Spent Fuel Storage Canister

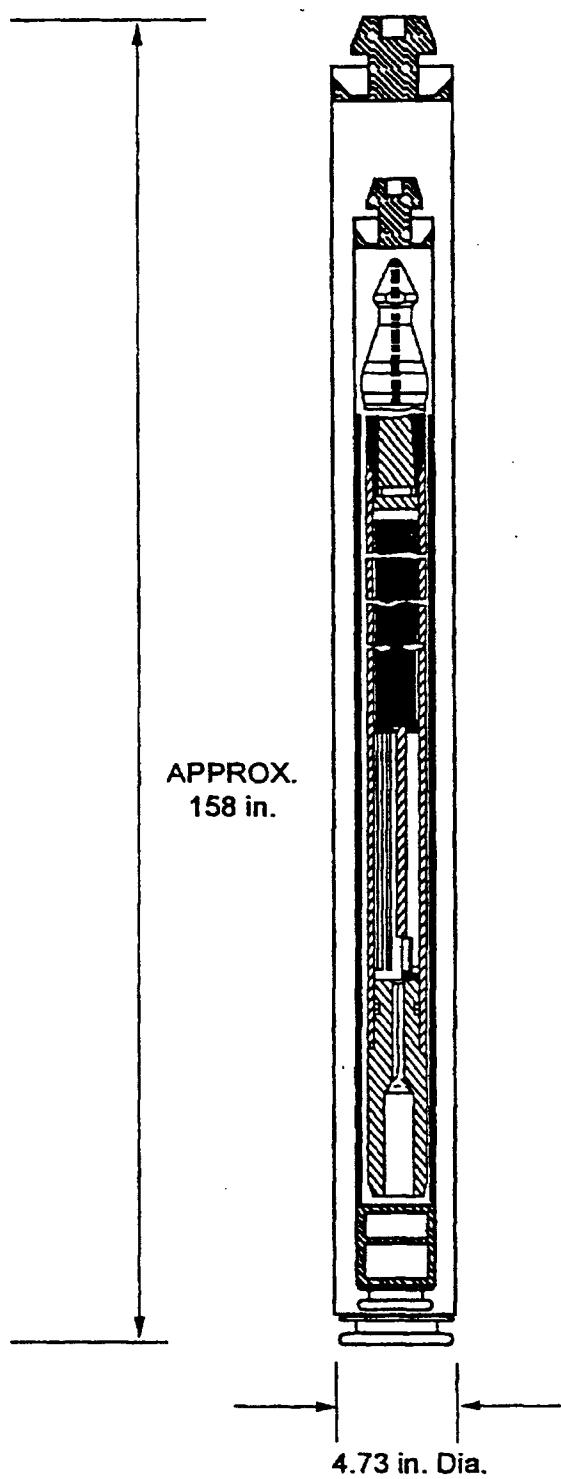
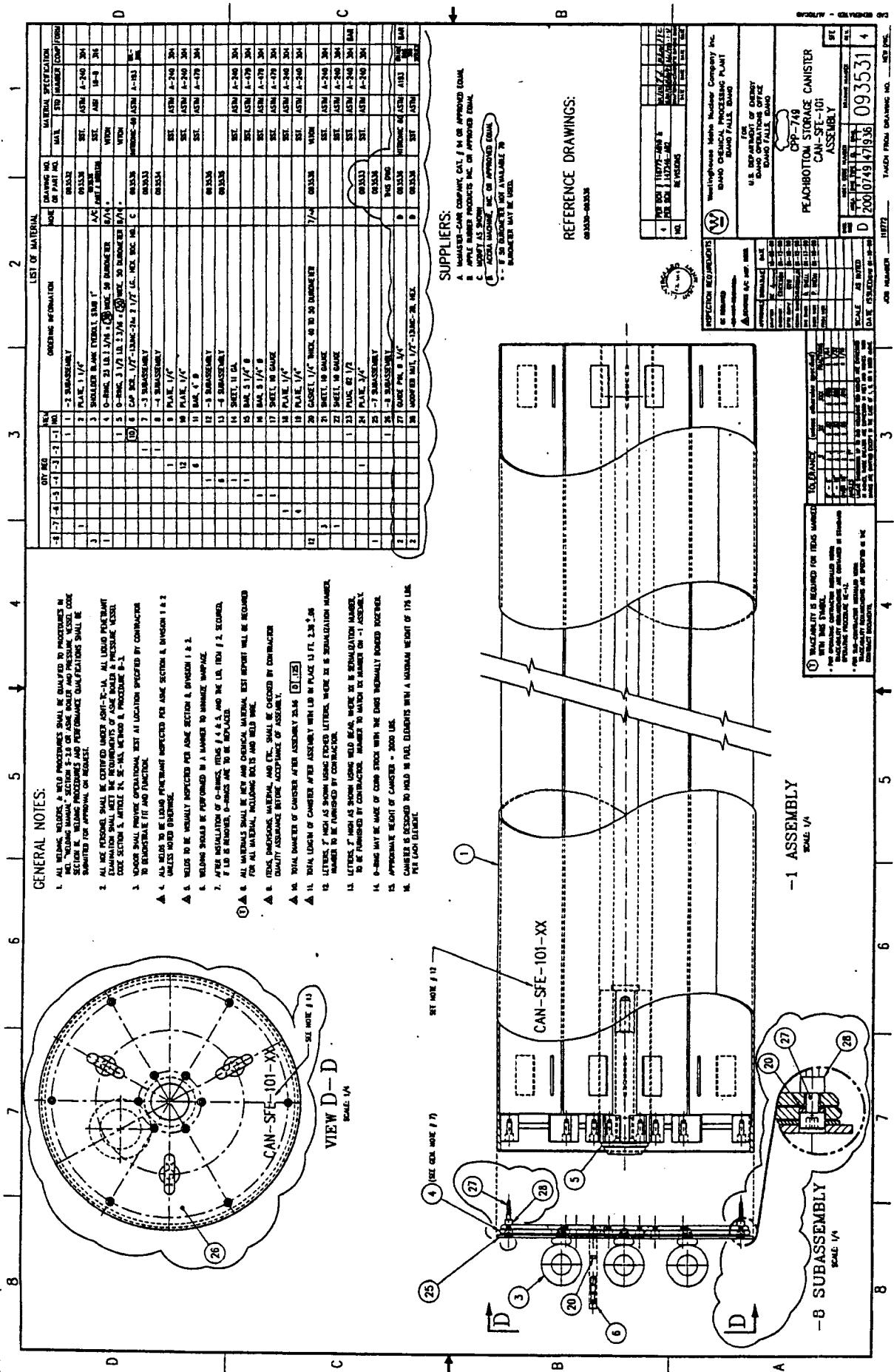


Figure 1-3. Failed Fuel Element in Storage Canister in Salvage Canister



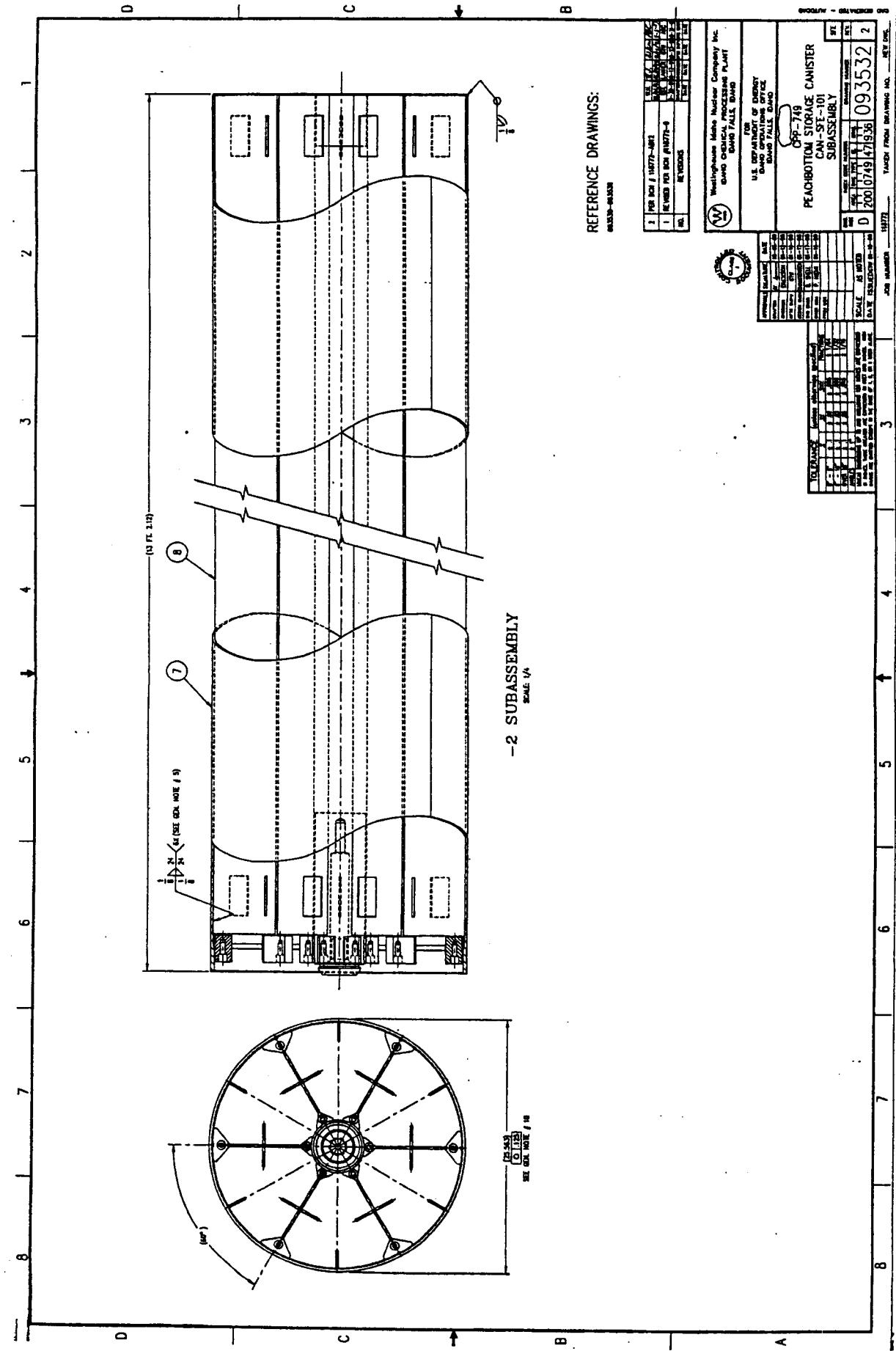


Figure 1-5. CPP-749 Peach Bottom Storage Canister CAN-SFE-101 Subassembly

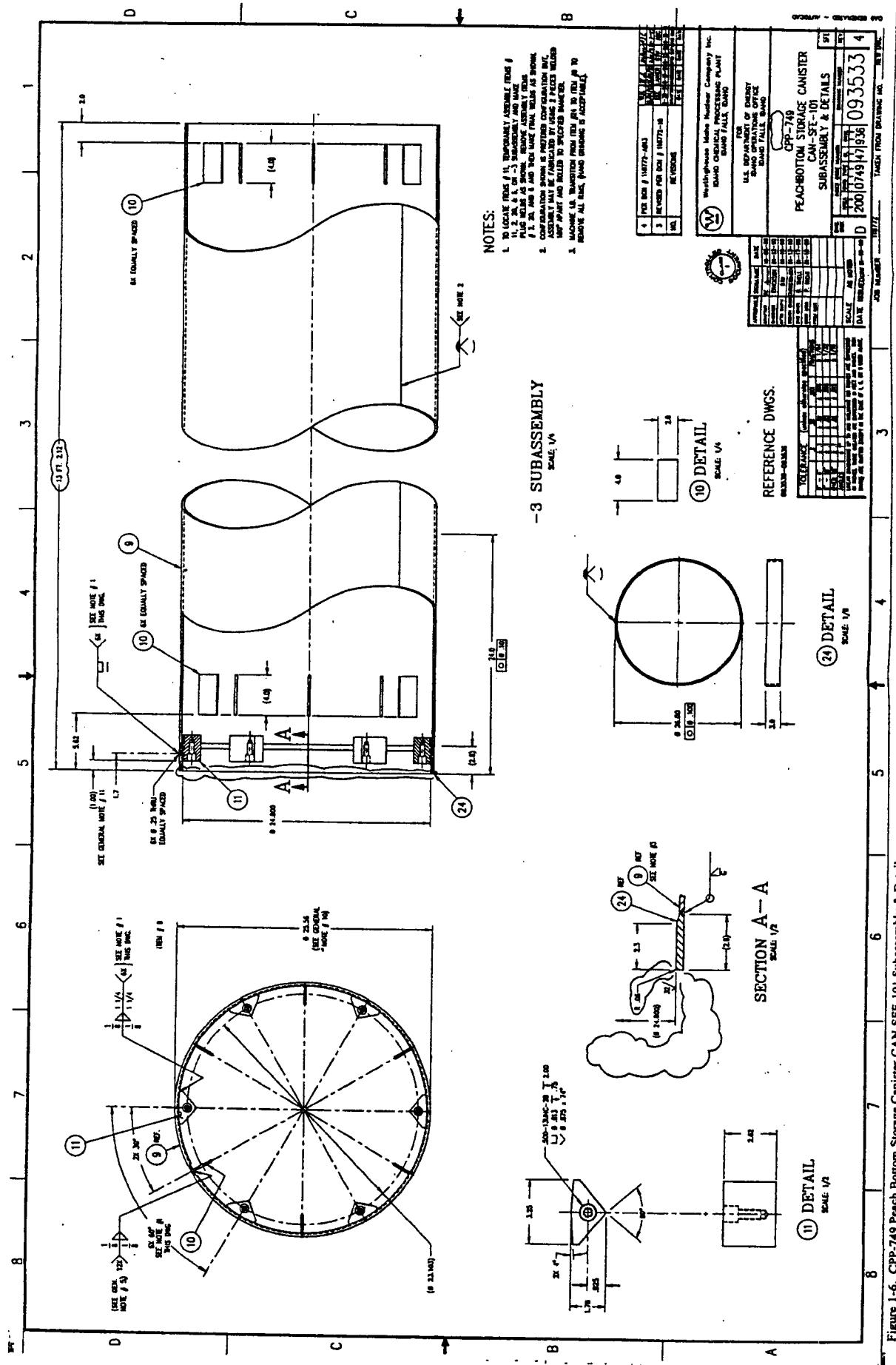


Figure 1-6. CPP-749 Peach Bottom Storage Canister CAN-SFE-101 Subassembly & Details

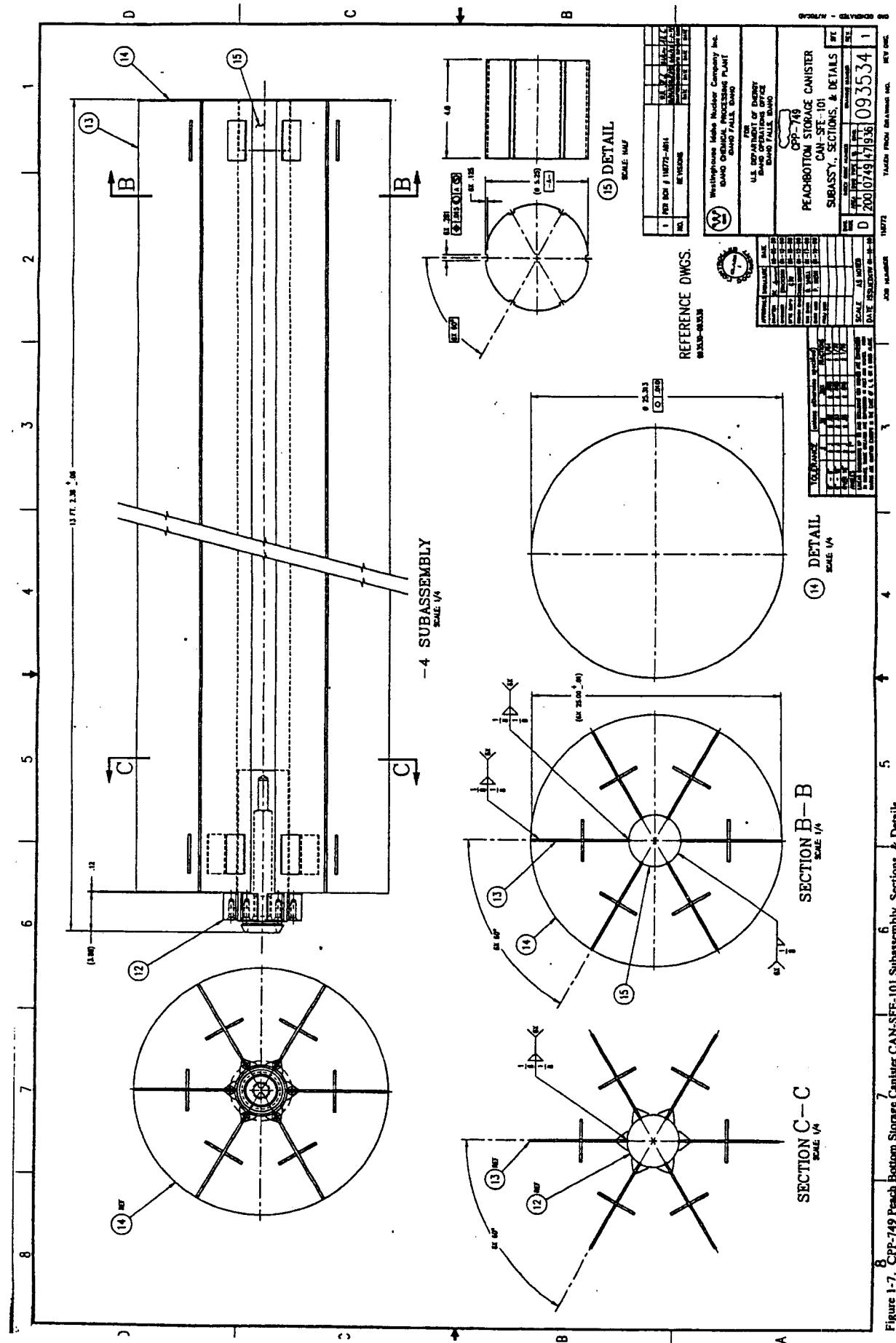


Figure 1-7. CPP-749 Peach Bottom Storage Canister CAN-SFE-101 Subassembly, Sections, & Details

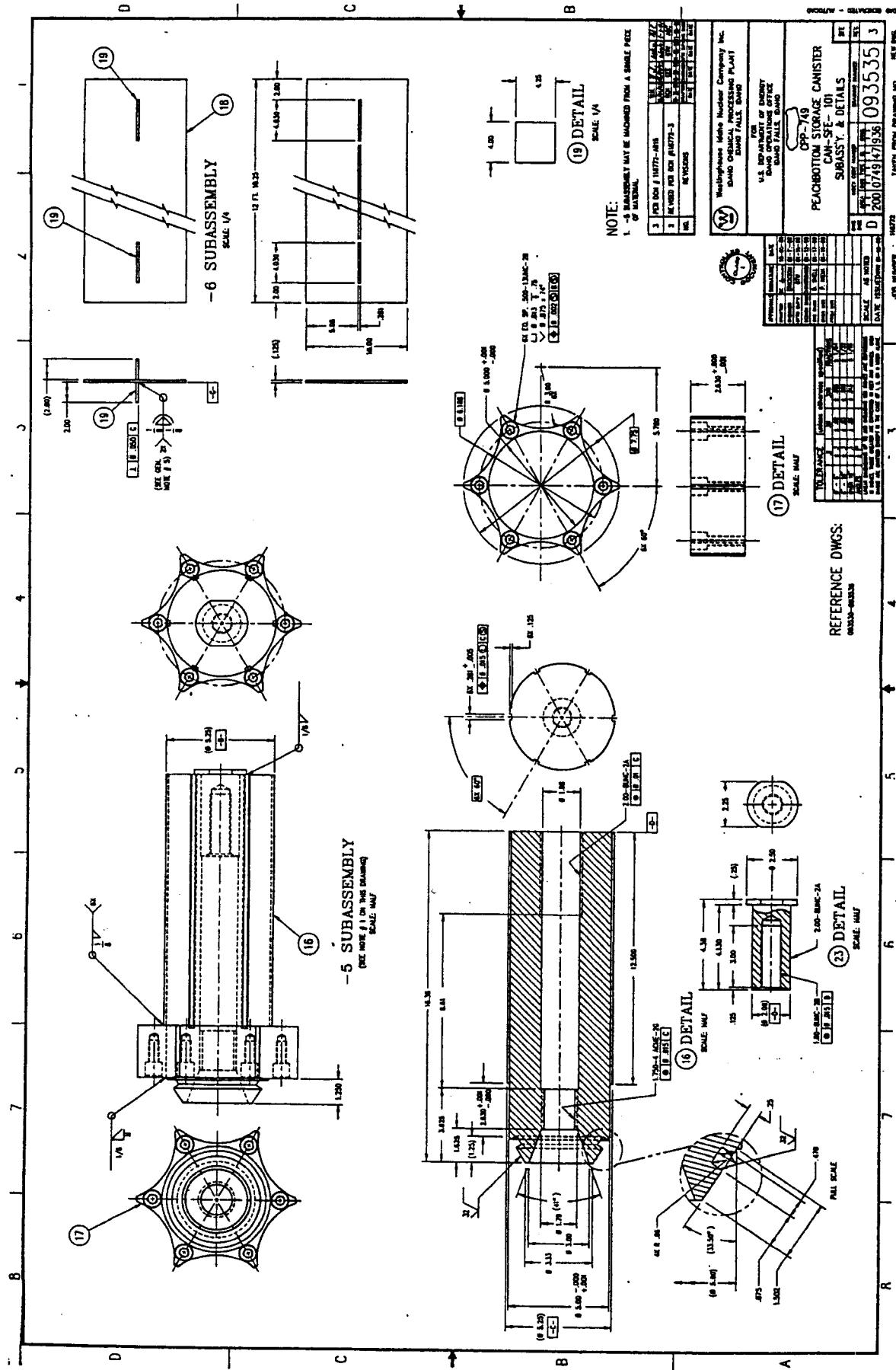
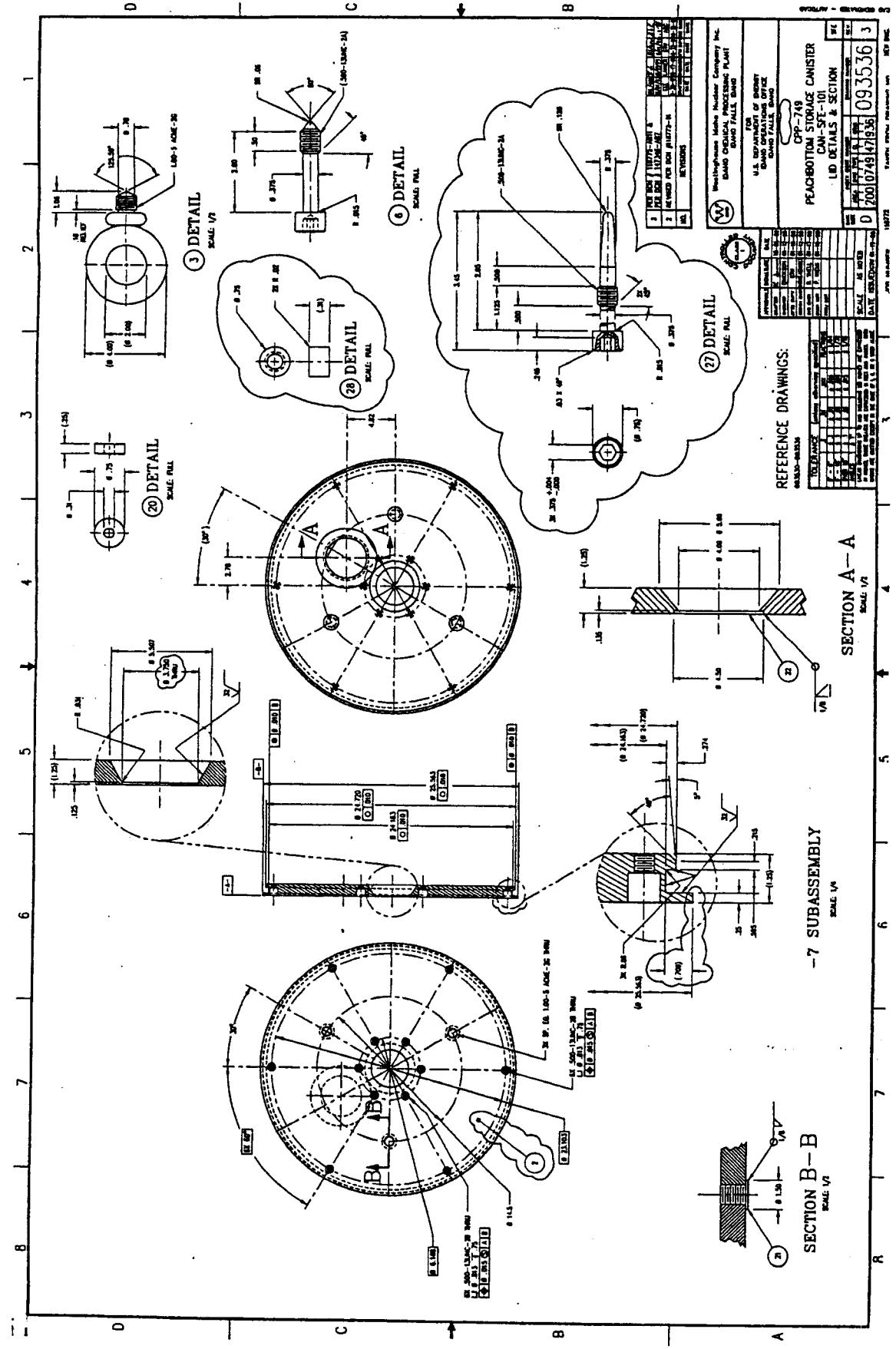


Figure 1-8. CPP-749 Peach Bottom Storage Canister CAN-SFE-101 Subassembly & Details - 1



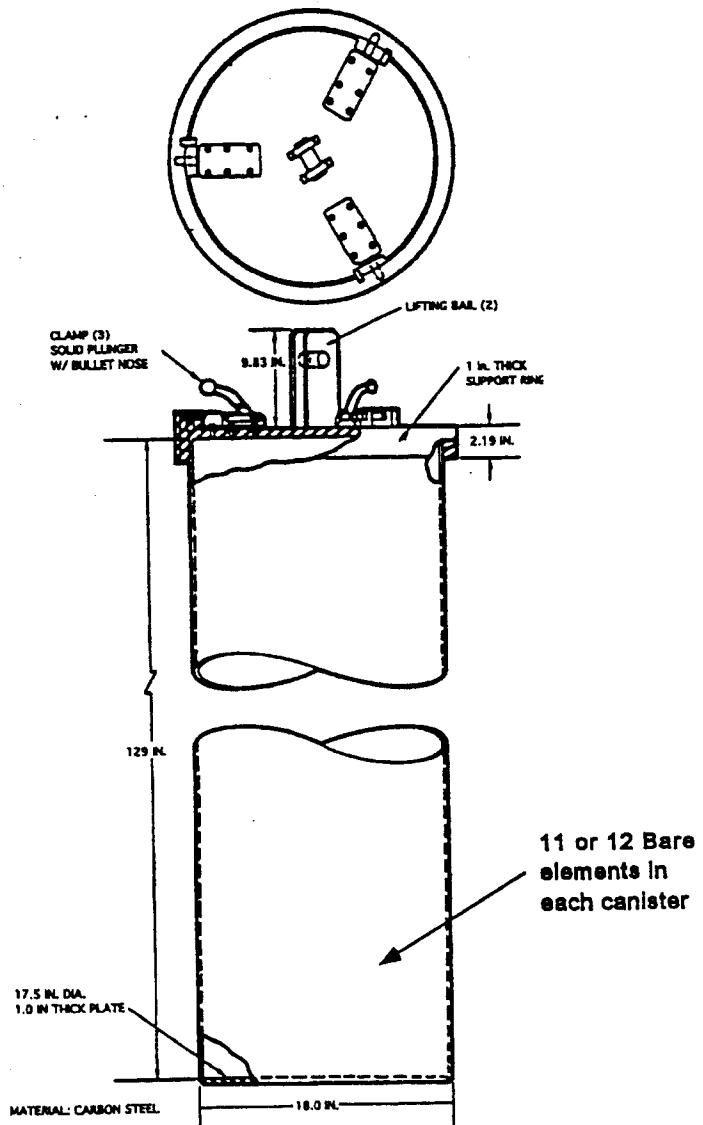


Figure 1-10. Core 2: IFSF Carbon Steel Canister

Table 1-5. Peach Bottom Unit 1 – Core 1 spent fuel package types stored in CPP-749

Fuel package type	No. of elements	Description
1	528	Type I or II fuel element, regular can and liner
2	58	Type I or II fuel element, failed sleeve, normal can, slit liner, spacer, type 2 removal tool
3	7	Fuel Package type 2 with a type I removal tool
4	1	Type II fuel element (No. 263) broken and stored in 2 containers Upper portion of element with 21 compacts is in a salvage can with unmarked salvage cap with partial type 2 removal tool, special spacer, component canister, 4.25 in. Spacer, and 50 lb of steel shot Lower portion of element with 9 compacts is in a regular canister (cap No. 120) with a 3.25 in. spacer and a special GA pulling tool
5	1	Type II fuel element (No. 451), failed sleeve, normal can, split liner, spacer, type I removal tool. Due to leaking canister, recanned in salvage canister with special vented cap, unmarked
6	1	Type II fuel element (No. 576), failed sleeve, type 2 removal tool, component canister and spacer in salvage canister, cap No. 8
7	1	Type 2 Fuel Package in a salvage canister (cap No. 851, fuel element No. 731).
8	1	Type 2 fuel element (No. 848) less upper reflector canned in salvage canister (component canister and 4 in. spacer inside). Salvage cap is unmarked
9	71	Type III fuel element, regular can and liner
10	8	Fuel Package type 2 with a type 3 fuel element
11	1	Fuel Package type 10 with a hollowed out cap (No. 90) due to a removal tool positioned too high (element No. 126)
12	1	Fuel Package type 10 recanned in salvage canister with cap C5 (element No. 306)
13	1	Type 10 Fuel Package (element No. 870) in can No. 14 (cap unmarked) with type 1 removal tool
14	98	Type IV fuel element, regular can and liner
15	5	Type 2 Fuel Package with acoustic thermometer installed
16	1	Type 15 Fuel Package (fuel element No. 807 in can 01, cap unmarked with a type I removal tool.

17	1	Type 1 Fuel Package (fuel element No. 808 and cap No. 252R) with acoustic thermometer installed.
18	18	Type 1 Fuel Package with thermocouple installed.
19	3	Type 2 Fuel Package with thermocouple installed.
20	3	Type 9 Fuel Package with thermocouple installed.
21	4	Type 14 Fuel Package with thermocouple installed.

Table 1-6. Storage Locations and Configurations

Core 1 Configurations	
Aluminum storage canisters	
- Standard storage canister	4.48" O.D. x ~153" long
- Salvage storage canister	4.73" O.D. x ~158" long
Aluminum Storage Baskets	25.5" O.D. x ~158" long (Elements longer than basket)
No. of Elements in Baskets	Nominally 18 elements
Core 1 Locations	
- CPP-749	814 canisters containing 813 elements in 46 aluminum storage baskets
- IFSF	4 overpack canisters containing 1-1/2 elements
Core 2 Configurations	
No storage canisters	All elements were de-canned (Bare fuel elements)
IFSF carbon steel canisters:	18.0"O.D. x 129.0" long
No. of Elements in IFSF canisters	Nominally 12 to 11 elements
Core 2 Locations	
- IFSF	787 elements in 70 IFSF storage canisters

1.4 As Stored Condition

1.4.1 Core 1

Core 1 contained fuel particles coated with a single layer of pyrolytic graphite. Dimensional changes caused by fast neutrons and damage due to fission product recoils resulted in cracking and distortion of the coatings on the fuel particles. The broken coatings, in the process of curling and changing dimensions, caused the compacts to distort and swell. The radial expansion produced in the compacts caused them to bind against the graphite sleeve, leading to fracture in some cases. A total of 90 elements in Core 1 developed cracked sleeves. Two elements were completely broken during core removal.

The fuel in the balance of the core remained intact and was removed and then packaged for disposal (see section 1.3.1). It can be assumed that most of the fuel particles have failed and most of the compacts have experienced swelling after their reactor experience.

Utilizing a small remote television camera and lights, visual inspections have been performed of the interior of the dry wells, the aluminum handling basket, and the aluminum fuel canisters containing the graphite fuels (see section 1.3) while in storage. Water has been seen to have entered the interior of the storage area causing corrosion of the basket bottoms, sides of the basket and fuel canisters, and the tops of the fuel canisters. Fairly large corrosion deposits were visually recorded on the bottoms of the handling baskets and the tops of the fuel canisters. The extent of the corrosion to the handling basket and canisters varied for each drywell storage location. However, it is assumed that all storage configurations have been corroded to some

extent.

Not all of the individual fuel canisters have been inspected, so the extent of the damage to both the fuel canister and the fuel elements have not been determined. Water may have entered through the corroded canisters and have come in contact with the graphite fuel elements. The possible degradation effect on the graphite material from the water has not yet been addressed. The Peach Bottom baskets and canisters showing corrosion are stored in first-generation vaults within CPP-749. To address this vulnerability, new second-generation vaults have been constructed and fuels within the first-generation vaults are being moved to the second-generation vaults. These transfers will be completed by fiscal year 2001.

To effect these transfers, a new support plate will be installed on the bottom of the existing Peach Bottom basket. The support plate prevents fuel cans from dropping through the bottom of the basket during handling should the corroded bottom fail. The support plate is connected to a rod that extends through the center tube of the basket. The support plate and rod are shown in Figures 1-11A and 1-11B. The connection is made remotely using the insertion tool to extend the rod through the penetration in the cask top lid, through the center position of the basket, to the new support plate below the basket, where it is threaded into place and torqued. This new rod also has a threaded lifting fixture at the top. A lifting rod can then be connected to the rod for restoring the fuel. The basket will continue to be relied upon to provide lateral support for the canned elements. The support plate (PLT-DSW-902-XX) has a diameter of 25-in. It is fabricated of $\frac{3}{4}$ -in. Type 304 stainless steel plate. The support rod is fabricated of $\frac{3}{4}$ -in Nitronic 60 with a length of 153.5 inches.

The Fuel Examination and Cutting Facility (FECF) at the CPP-603 Underwater Fuel Storage Facility contains two canned Peach Bottom Fuel Elements.

One is a complete fuel element (element E05-05) which is fully intact except for some small coring taken on the fuel sleeve. Element E05-05 contains about 260 grams of U-235. This element, which is 12-feet long, is contained in a 13-foot long fuel can and is lying horizontally in the FECF. The fuel can, based on information from drawings, is constructed of aluminum alloy 6061, and has an OD of 4.75" and .065" wall thickness.

A second fuel element (element C05-05) was disassembled for examination and only partial compacts, which contain a total of about 225 grams of U-235, are contained in a 3' 5" can (same material and diametrical dimensions as the longer can) stored in a rack in the FECF. This element and element E05-05 were removed from the Peach Bottom Reactor core after 168 equivalent full power days of operation. Upon removal from the core, element C05-05 was determined to have a circumferential crack in the sleeve. The sleeve fracture was determined to be from radial growth in some of the fuel compacts.

The conceptual fuel-handling plan for the two Peach Bottom elements is to section the intact element, and repackage the elements into four overpack cans in the FECF for placement into the IFSF.

1.4.2 Core 2

Core 2 operated close to its full design lifetime of 900 equivalent full-power days (EFPD). The design of a new coated fuel particle resolved the problem experienced in Core 1, and all elements were in good condition after removal from the reactor. The fuel elements were canned and shipped to the INEEL. Upon receipt, the elements were removed from the cans and 18" of the reflector removed so that the elements would fit into the IFSF storage locations. Eleven to twelve bare elements are stored in each IFSF storage canister. The IFSF consists of a carbon steel storage rack into which 18" in diameter 11 feet long carbon steel canisters are placed. The carbon steel canisters have lids with lifting bails that reduce air exchange and particulate leakage. The IFSF is a vented and filtered fuel storage facility. There is no attempt to condition the atmosphere either before it enters from outside the facility or once it is inside the storage area. Therefore, the humidity is only regulated by the external and internal environments of the facility and storage canisters.

External visual examinations of the IFSF canisters in FY 1997 revealed no pertinent corrosion on the exterior of any IFSF canisters currently holding the Core 2 elements. No internal inspections of the storage canisters or fuel elements have occurred since the elements were placed into storage. The current assumption at the INTEC concerning the storage facility and canisters is that little to no corrosion will exist since the fuels were received dry (they were never wet during reactor service) and have been stored dry since the time of receipt.

1.5 Radionuclide Inventory

Core 1 was irradiated to 451 EFPD, and Core 2 to 897 EFPD, as compared with the design core lifetime of the fuel of 900 EFPD. The heavy-metal content of each fuel element has been calculated. The sums of all the calculated amounts for the 819 fuel elements irradiated in Core 1 and the 820 elements discharged as Core 2 are presented in Table 1-7, even though only 813 and 787 elements are presently located at the INEEL. The postirradiation uranium loadings for each of the Cores 1 and 2 fuel assembly packages are discussed in Tables 1-8 and 1-9, respectively. The radionuclide content of a typical Peach Bottom Core 2 spent fuel element with a fuel burnup of 73,000 MWd/MTIHM and a cooling time of 120 days is presented in Tables 1-10 and 1-11. The Core 2 data presented in Tables 10 and 11 envelope the Core 1 data. The radionuclide contents shown are given in a safety analysis report on the INEEL irradiated fuels storage facility and are based on 2.5 years of reactor operation at 114 MW(t). Using the radionuclide contents at a cooling time of 120 days as input, a series of calculations was made by means of the ORIGEN-2 code to determine the radioactivity (curies) and thermal power (watts) per fuel element at total decay times of 120 days to one million years. The initial cooling period of 120 days was included in the total decay time. The present heat generation rate is estimated to be 3.7 watts/assembly. Radiation levels from the fuel canisters is expected to be in the several rem/hour range. The source of the radiation is a combination of the residual fission and activation products, as well as Tl-208, a decay product from the uranium-232 in the fuel meat.

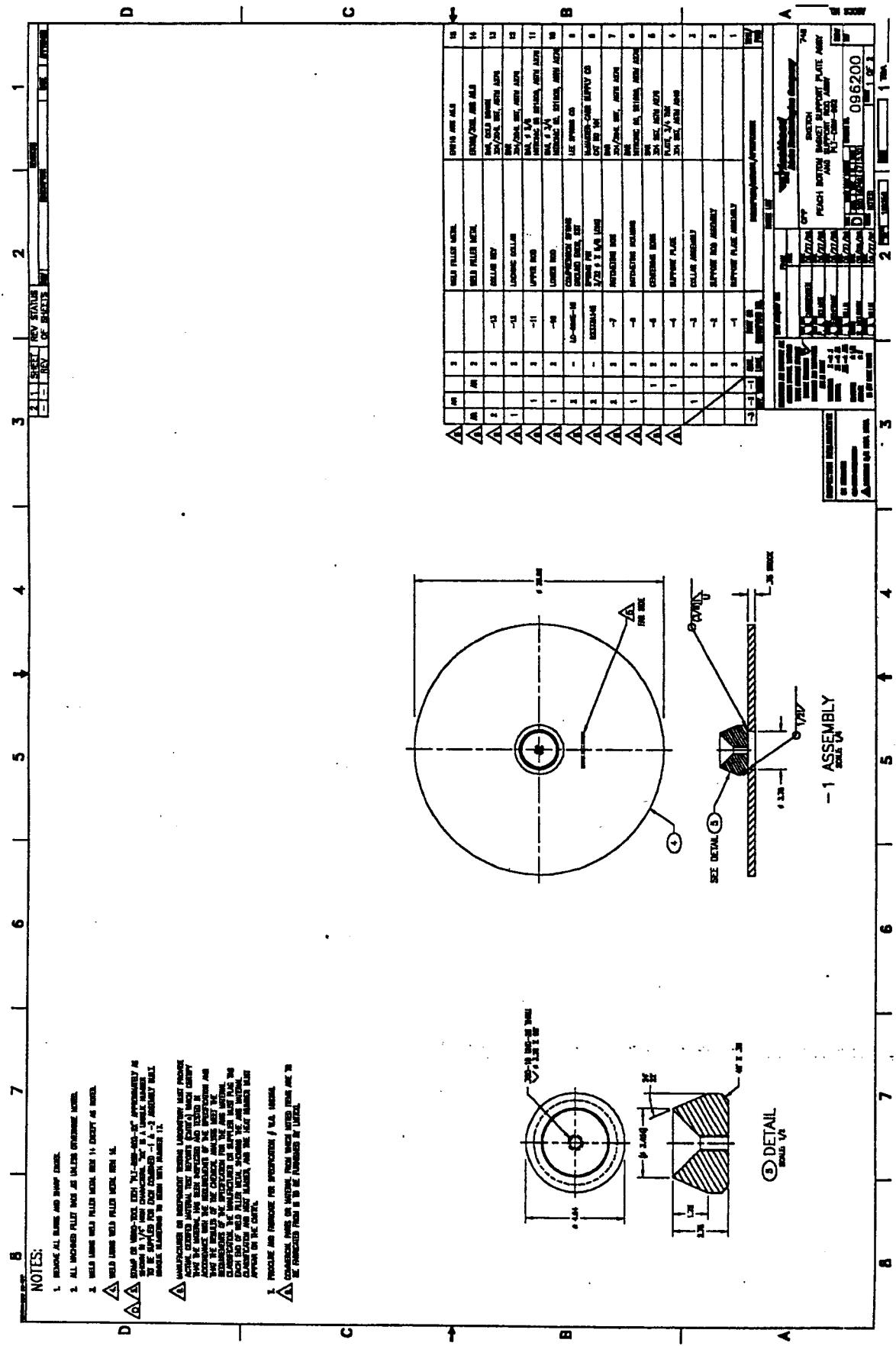


Figure 1-11A. CPP-749 Peach Bottom Basket Support Plate Assembly

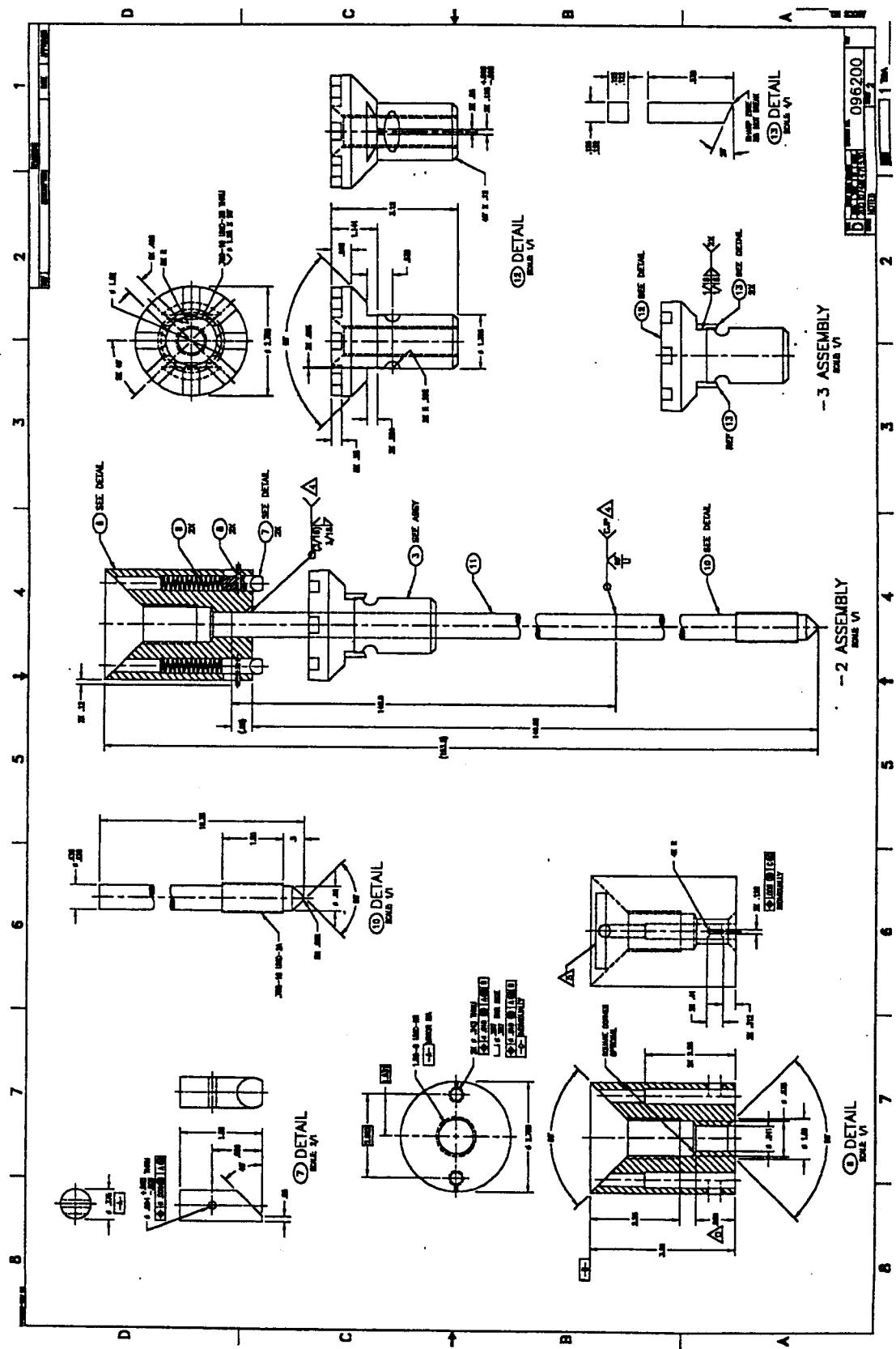


Figure 1-11B. CPP-749 Peach Bottom Reactor Support Rod Assembly

Table 1-7. Postirradiation heavy metal loadings

Nuclide	Mass per core, kg	
	Core 1	Core 2
Th-232	1,439.31	1,172.54
U-232	0.0015	0.0075
U-233	20.52	25.95
U-234	2.96	4.55
U-235	156.52	66.96
U-236	14.27	21.12
U-238	12.32	9.25
Pu-239	0.411	0.2
Pu-240	0.083	0.069
Pu-241	0.063	0.112
Pu-242	0.008	0.054
Np-237		1.625
Total U	206.59	127.83
Uranium assays		
U-235, wt %	75.76	52.38
U-233, wt %	9.94	20.30
U-232, ppm	7.08	58.55

Table 1-8. Peach Bottom Unit I - Core 1 summary of postirradiation uranium loadings by fuel assembly package

Package Type	No. Of Elements	Total U Average (g) Maximum (g)	U-232 Average (ug) Max. (ug)	U-233 average (g) Maximum(g)	U-234 Average (g) Maximum (g)	U-235 average (g) Maximum (g)	U-236 average (g) Maximum (g)	U-238 average (g) Maximum (g)
1	528	268.68 303.81	1645 2081	23.99 27.10	3.71 3.89	206.46 268.84	18.46 20.76	16.06 17.10
2	58	267.46 283.83	1697 2081	24.39 27.10	3.73 3.89	204.46 226.93	18.94 20.76	16.04 16.27
3	7	279.24 287.79	983 960	17.94 19.04	3.47 3.49	227.35 230.81	14.08 14.52	16.39 16.50
4	1	256.77 256.77	1594 1594	20.42 20.42	3.71 3.71	197.31 197.31	19.06 19.06	16.27 16.27
5	1	290.85 290.85	820 820	18.24 18.24	3.44 3.44	229.11 229.11	13.75 13.75	16.31 16.31
6	1	255.9 255.9	1699 1699	21.36 21.36	3.75 3.75	194.85 194.85	19.62 19.62	16.21 16.21
7	1	278.49 278.49	1191 1191	22.71 22.71	3.53 3.53	219.96 219.96	16.25 16.25	16.14 16.14
8	1	297.20 297.20	285 285	11.00 11.00	3.36 3.36	257.31 257.31	8.60 8.60	16.93 16.93
9	71	269.79 295.62	1594 2050	23.67 27.04	3.68 3.96	208.20 258.37	18.15 20.33	16.08 16.71
10	8	268.25 274.76	1836 2050	25.70 27.04	3.77 3.86	203.54 213.19	19.27 20.33	15.96 16.05
11	1	272.57 272.57	1646 1646	25.21 25.21	3.69 3.69	209.35 209.35	18.31 18.31	16.00 16.00
12	1	274.64 274.64	1498 1498	24.36 24.36	3.63 3.63	212.99 212.99	17.61 17.61	16.05 16.05
13	1	285.85 285.85	749 749	17.82 17.82	3.42 3.42	235.34 235.34	12.87 12.87	16.40 16.40
14	98	150.41 155.48	3009 3262	34.81 36.28	3.19 3.34	91.69 96.02	11.90 17.33	8.81 8.86
15	5	268.15 277.75	1715 2013	24.53 25.57	3.73 3.84	205.07 218.51	19.79 20.25	16.03 16.13
16	1	298.17 288.17	651 651	16.82 16.82	3.40 3.40	239.07 239.07	12.35 12.35	16.53 16.53
17	1	277.75 277.75	1279 1279	23.04 23.04	3.55 3.55	218.51 218.51	16.51 16.51	16.13 16.13
18	18	270.69 283.63	1550 2013	23.62 25.61	3.66 3.84	209.37 226.63	17.95 20.25	16.09 16.24
19	3	277.57 278.54	1228 1297	22.79 23.00	3.54 3.57	219.63 219.94	16.46 16.90	16.14 16.14
20	3	268.61 284.63	1378 1559	21.33 22.54	3.61 3.68	210.09 227.42	17.35 18.55	16.23 16.26
21	4	150.60 155.48	2933 3240	34.56 36.17	3.16 3.18	92.24 96.02	11.81 11.96	8.82 8.83

Table 1-9. Peach Bottom Unit I - Core 2 summary of postirradiation uranium loadings by fuel assembly package

Heavy Metal (g)	Types 1, 2, and 3	Type 4
U-233		
Average	33.0	37.8
Maximum	35.2	39.1
U-235		
Average	90.0	36.0
Maximum	189.0	108.4
U-total		
Average	167.0	105.0
Maximum	228.7	108.4
Thorium	1310	2524
Pu-239	0.27	0.08
Pu-240	0.09	0.03
Pu-241	0.15	0.05
Pu-242	0.07	0.03
Pu-total	0.59	0.18

Peachbottom Core 1 has 21 different fuel package types (see Table 1-5). Peachbottom Core 2 has two basic initial uranium and thorium loadings, thus the difference in the appearance between the Post Irradiation tables for Core 1 and Core 2.

(Source: GA Technologies Report, ORNL/Sub/86-22047/2, GA-C18525, "Characterization of Peach Bottom Unit 1 Fuel", October 1986)

Table 1-10. Radioactivity of Peach Bottom-1 reactor spent fuel based on one fuel element; burnup is 73,000 MWd/MTIHM (curies per element)

Actinides and Daughters

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
TL209	0.000E+00	5.872E-07	8.484E-06	8.707E-05	8.356E-04	5.539E-03	6.294E-03	1.252E-04
PB209	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.868E-02	2.564E-01	2.914E-01	5.795E-03
PB210	0.000E+00	2.764E-13	7.880E-10	4.989E-07	8.303E-05	3.298E-03	2.547E-02	4.272E-03
PB214	0.000E+00	4.08SE-11	8.484E-09	9.0IBE-07	8.305E-05	3.299E-03	2.548E-02	4.273E-03
BI210	0.000E+00	2.764E-13	7.881E-10	4.989E-07	8.303E-05	3.29SE-03	2.547E-02	4.272E-03
BI213	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.86SE-02	2.564E-01	2.914E-01	5.795E-03
BI214	0.000E+00	4.08SE-11	8.484E-09	9.018E-07	8.305E-05	3.299E-03	2.548E-02	4.273E-03
Po210	0.000E+00	6.573E-14	7.881E-10	4.989E-07	8.303E-05	3.298E-03	2.547E-02	4.272E-03
Po213	0.000E+00	2.660E-05	3.843E-04	3.944E-03	3.785E-02	2.509E-01	2.851E-01	5.670E-03
Po214	0.000E+00	4.087E-11	8.482E-09	9.016E-07	8.303E-05	3.29SE-03	2.547E-02	4.272E-03
Po218	0.000E+00	4.089E-11	8.486E-09	9.019E-07	8.307E-05	3.300E-03	2.548E-02	4.274E-03
AT217	0.000E+00	2.719E-05	3.92BE-04	4.031E-03	3.86E-02	2.564E-01	2.914E-01	5.795E-03
RN222	0.000E+00	4.089E-11	8.486E-09	9.019E-07	8.307E-05	3.300E-03	2.548E-02	4.274E-03
FR221	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.86E-02	2.564E-01	2.914E-01	5.795E-03
RA225	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.868E-02	2.564E-01	2.914E-01	5.795E-03
RA226	0.000E+00	4.089E-11	8.486E-09	9.019E-07	8.307E-05	3.300E-03	2.548E-02	4.274E-03
AC225	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.868E-02	2.564E-01	2.914E-01	5.795E-03
TH229	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.86E-02	2.564E-01	2.914E-01	5.795E-03
TH230	0.000E+00	2.811E-07	4.060E-06	4.264E-05	4.427E-04	4.232E-03	2.526E-02	4.270E-03
PA233	2.200E+04	4.045E+01	4.175E-07	1.597E-05	1.066E-04	1.342E-04	1.303E-04	9.737E-05
U233	4.201E-01	4.303E-01	4.303E-01	4.301E-01	4.284E-01	4.119E-01	2.779E-01	5.531E-03
U234	4.651E-02	4.652E-02	4.676E-02	4.835E-02	4.977E-02	4.852E-02	3.760E-02	2.931E-03
U236	0.000E+00	4.572E-10	6.583E-09	6.752E-08	6.459E-07	4.197E-06	6.405E-06	6.237E-06
U237	0.000E+00	4.751E-04	3.080E-04	4.046E-06	6.187E-25	0.000E+00	0.000E+00	0.000E+00
NP237	0.000E+00	2.417E-09	4.175E-07	1.597E-05	1.066E-04	1.342E-04	1.303E-04	9.737E-05
PU238	9.501E+00	9.451E+00	8.802E+00	4.323E+00	3.533E-03	0.000E+00	0.000E+00	0.000E+00
PU239	2.690E-02	2.690E-02	2.690E-02	2.683E-02	2.614E-02	2.017E-02	1.510E-03	8.322E-15
PU240	2.300E-02	2.300E-02	2.298E-02	2.276E-02	2.069E-02	7.967E-03	5.716E-07	0.000E+00
PU241	2.000E+01	1.937E+01	1.256E+01	1.649E-01	2.522E-20	0.000E+00	0.000E+00	0.000E+00
AM241	0.000E+00	2.118E-02	2.460E-01	5.818E-01	1.387E-01	7.482E-08	0.000E+00	0.000E+00
Subtotal	2.203E+04	6.982E+01	2.214E+01	5.631E+00	9.782E-01	2.574E+00	2.903E+00	9.775E-02

Fission Products

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
KR 85	5.000E+01	4.788E+01	2.676E+01	7.946E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 89	1.170E+03	4.039E+01	1.023E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 90	3.931E+02	3.868E+02	3.122E+02	3.666E+01	1.823E-08	0.000E+00	0.000E+00	0.000E+00
Y 90	3.931E+02	3.869E+02	3.123E+02	3.666E+01	1.823E-08	0.000E+00	0.000E+00	0.000E+00
Y 91	1.730E+03	9.468E+01	1.155E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ZR 95	2.100E+03	1.474E+02	5.035E-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95	3.980E+03	3.216E+02	1.118E-13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95M	0.000E+00	1.093E+00	3.735E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 103	4.801E+02	6.337E+00	4.083E-25	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 103M	4.801E+02	5.713E+00	3.681E-25	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 106	4.001E+02	2.521E+02	5.174E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 106	4.001E+02	2.521E+02	5.174E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127	2.200E+01	4.531E+00	3.785E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127M	2.200E+01	4.626E+00	3.864E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129	3.101E+01	1.281E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129M	3.100E+01	1.968E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I 129	0.000E+00	1.808E-07	1.819E-07	1.819E-07	1.819E-07	1.811E-07	1.811E-07	1.741E-07
CS 137	6.001E+02	5.908E+02	4.799E+02	5.999E+01	5.583E-08	0.000E+00	0.000E+00	0.000E+00
BA 137M	6.001E+02	5.589E+02	4.540E+02	5.675E+01	5.282E-08	0.000E+00	0.000E+00	0.000E+00
BA 140	1.500E+00	3.039E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA 140	2.000E+00	3.497E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE 141	6.351E+02	3.404E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 143	1.900E+01	6.858E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE 144	5.061E+03	2.783E+03	9.190E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144	5.061E+03	2.783E+03	9.190E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144M	0.000E+00	3.340E+01	1.103E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM 147	1.500E+03	1.256E+03	1.165E+02	5.486E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SM 147	0.000E+00	5.979E-09	3.392E-08	3.678E-08	3.678E-08	3.678E-08	3.678E-08	3.678E-08
SM 151	1.300E+01	1.293E+01	1.207E+01	6.034E+00	5.890E-03	0.000E+00	0.000E+00	0.000E+00
Subtotal	2.518E+04	9.974E+03	1.717E+03	1.962E+02	5.890E-03	2.186E-07	2.179E-07	2.109E-07

Table 1-11. Decay heat of Peach Bottom-1 reactor spent fuel based on one fuel element; burnup is 73,000 MWd/MTIHM (watts per element)

Actinides and Daughters

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
TL209	0.000E+00	9.757E-09	1.410E-07	1."7E-06	1.388E-05	9.203E-05	1.046E-04	2.080E-06
PB209	0.000E+00	3.126E-08	4.517E-07	4.635E-06	4.449E-05	2.949E-04	3.351E-04	6.664E-06
PB210	0.000E+00	6.404E-17	1.825E-13	1.156E-10	1.923E-08	7.641E-07	5.901E-06	9.897E-07
P8214	0.000E+00	1.304E-13	2.706E-11	2.876E-09	2.649E-07	1.052E-05	8.125E-05	1.363E-05
B1210	0.000E+00	6.374E-16	1.817E-12	1.150E-09	1.915E-07	7.605E-06	5.874E-05	9.851E-06
B1211	0.000E+00	3.572E-20	9.967E-17	6.212E-14	1.099E-11	9.483E-10	2.573E-08	3.666E-08
B1213	0.000E+00	1.143E-07	1.651E-06	1.695E-05	1.626E-04	1.078E-03	1.225E-03	2.436E-05
B1214	0.000E+00	5.239E-13	1.087E-10	1.156E-08	1.064E-06	4.228E-05	3.265E-04	5.476E-05
PO210	0.000E+00	2.107E-15	2.526E-11	1.599E-08	2.662E-06	1.057E-04	8.166E-04	1.370E-04
PO213	0.000E+00	1.346E-06	1.945E-05	1.996E-04	1.915E-03	1.270E-02	1.443E-02	2.869E-04
PO214	0.000E+00	1.898E-12	3.938E-10	4.186E-08	3.855E-06	1.531E-04	1.183E-03	1.984E-04
PO218	0.000E+00	1.482E-12	3.075E-10	3.26BE-08	3.010E-06	1.196E-04	9.234E-04	1.549E-04
AT217	0.000E+00	1.160E-06	1.676E-05	1.720E-04	1.651E-03	1.094E-02	1.243E-02	2.473E-04
RN222	0.000E+00	1.355E-12	2.812E-10	2.989E-08	2.752E-06	1.093E-04	8.444E-04	1.416E-04
FR221	0.000E+00	1.049E-06	1.516E-05	1.556E-04	1.493E-03	9.897E-03	1.125E-02	2.237E-04
RA225	0.000E+00	1.906E-08	2.754E-07	2.827E-06	2.713E-05	1.798E-04	2.043E-04	4.064E-06
RA226	0.000E+00	1.181E-12	2.450E-10	2.604E-08	2.398E-06	9.527E-05	7.358E-04	1.234E-04
AC225	0.000E+00	9.496E-07	1.372E-05	1.408E-04	1.351E-03	8.958E-03	1.01SE-02	2.024E-04
TH229	0.000E+00	8.317E-07	1.202E-05	1.233E-04	1.183E-03	7.845E-03	8.914E-03	1.773E-04
TH230	0.000E+00	7.956E-09	1.149E-07	1.207E-06	1.253E-05	1.198E-04	7.147E-04	1.208E-04
PA233	4.994E+01	9.182E-02	9.477E-10	3.625E-08	2.418E-07	3.046E-07	2.958E-07	2.210E-07
U233	1.221E-02	1.251E-02	1.251E-02	1.250E-02	1.245E-02	1.197E-02	8.079E-03	1.608E-04
U234	1.340E-03	1.340E-03	1.347E-03	1.393E-03	1.434E-03	1.398E-03	1.083E-03	8.443E-05
U235	0.000E+00	4.659E-13	6.710E-12	6.906E-11	6.83BE-10	6.029E-09	2.274E-08	2.407E-08
U236	0.000E+00	1.239E-11	1.783E-10	1.829E-09	1.750E-08	1.137E-07	1.735E-07	1.690E-07
NP237	0.000E+00	7.388E-11	1.276E-08	4.881E-07	3.257E-06	4.101E-06	3.983E-06	2.976E-06
PU238	3.149E-01	3.132E-01	2.917E-01	1.433E-01	1.171E-04	1.555E-35	0.000E+00	0.000E+00
PU239	8.291E-D4	8.291E-04	8.289E-04	8.267E-04	8.036E-04	6.216E-04	4.652E-05	2.565E-16
PU240	7.163E-04	7.162E-04	7.155E-04	7.087E-04	6.442E-04	2.481E-04	1.780E-08	0.000E+00
PU241	6.201E-04	6.004E-04	3.893E-04	5.113E-06	7.819E-25	0.000E+00	0.000E+00	0.000E+00
AM241	0.000E+00	7.036E-04	8.171E-03	1.933E-02	4.608E-03	2.485E-09	0.000E+00	0.000E+00
Subtotal	5.027E+01	4.217E-01	3.158E-01	1.789E-01	2.794E-02	6.699E-02	7.397E-02	2.379E-03

Fission Products

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
KR 85	7.490E-02	7.172E-02	4.008E-02	1.190E-04	6.370E-30	0.000E+00	0.000E+00	0.000E+00
SR 89	4.045E+00	1.396E-01	3.537E-21	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 90	4.562E-01	4.490E-01	3.624E-01	4.254E-02	2.116E-11	0.000E+00	0.000E+00	0.000E+00
Y 90	2.178E+00	2.144E+00	1.731E+00	2.032E-01	1.011E-10	0.000E+00	0.000E+00	0.000E+00
Y 91	6.214E+00	3.400E-01	4.149E-18	0.000E+00	0.00DE+00	0.000E+00	0.000E+00	0.000E+00
ZR 95	1.064E+01	7.464E-01	2.550E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95	1.909E+01	1.543E+00	5.362E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95M	0.000E+00	1.519E-03	5.190E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 103	1.606E+00	2.120E-02	1.366E-27	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 103M	1.105E-01	1.315E-03	8.472E-29	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 106	2.379E-02	1.499E-02	3.076E-05	4.070E-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 106	3.837E+00	2.418E+00	4.962E-03	0.000E+00	0.000E+00	0.D00E+00	0.000E+00	0.000E+00
TE 127	2.971E-02	6.118E-03	5.111E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127H	1.184E-02	2.488E-03	2.07BE-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129	1.108E-01	4.578E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129M	5.436E-02	3.451E-04	1.220E-33	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I 129	0.D00E+00	8.363E-11	8.416E-11	8.416E-11	8.416E-11	8.413E-11	8.379E-11	8.053E-11
CS 137	6.638E-01	6.535E-01	5.308E-01	6.635E-02	6.175E-11	0.000E+00	0.000E+00	0.000E+00
BA 137H	2.356E+00	2.195E+00	1.783E+00	2.228E-01	2.074E-10	0.000E+00	0.000E+D0	0.000E+00
BA 140	5.023E-03	8.479E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA 140	3.353E-02	5.863E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE 141	9.29SE-01	4.984E-03	1.821E-33	0.00GE+00	0.000E+00	0.000E+00	0.00GE+00	0.000E+00
PR 143	3.540E-02	1.27SE-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.G0E+00
CE 144	3.357E+00	1.846E+00	6.096E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144	3.720E+01	2.046E+01	6.755E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144M	0.000E+00	1.143E-02	3.773E-06	0.D00E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM 147	5.381E-01	4.506E-01	4.179E-02	1.968E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SM 147	0.000E+00	8.187E-11	4.645E-10	5.036E-10	5.036E-10	5.036E-10	5.036E-10	5.036E-10
SM 151	1.524E-03	1.517E-03	1.415E-03	7.075E-04	6.906E-07	5.423E-37	0.000E+00	0.D00E+00
Subtotal	9.360E+01	3.352E+01	4.502E+00	5.357E-01	6.916E-07	5.877E-10	5.874E-10	5.841E-10

2.O SHIPPINGPORT LWBR

2.1 Introduction

This report summarizes the pertinent information for the fuel used in the Shippingport Light Water Breeder Reactor (LWBR) core installed into the Shippingport reactor vessel. To date, the Shippingport fuel has been identified in a variety of different ways (see Table 2-1).

Table 2-1. Shippingport Designations and Definitions

Name Used	Definition
Shippingport	Shippingport reactor
Shippingport PWR	Shippingport Pressurized Water Reactor
Shippingport PWR-C1 or -C2	Shippingport PWR-Core 1 or Core 2
Shippingport PWR-C1-S1 or -S2 or...	Shippingport PWR-Core 1- Seed 1 or Seed 2 or...
Shippingport LWBR	Shippingport Light Water Breeder Reactor (same Rx, different core and design)

The Shippingport Atomic Power Station, located on the south bank of the Ohio River in Shippingport Borough, Beaver County Pennsylvania, was the first large-scale, central station application of nuclear power for civilian use in the United States. The station was jointly owned by U.S. DOE and the Duquesne Light Company, which operated the reactor since its initial startup in December 1957 and final shut down in 1983. During this operating period two pressurized water reactor (PWR) cores and one Light Water Breeder Reactor (LWBR) core saw service. PWR Core 1 operated until February 1964, having been partially refueled three times (4 different Seed cores used). Following plant modifications, Core 2 was installed and began power operation in May 1965. Core 2 underwent one partial refueling in 1969 (2 different Seed cores used), and continued in operation until February 1974 when the plant was shut down for repair of the turbine generator. At that time preparations began for refueling with the LWBR core, which began power operation in calendar year 1978 and operated until 1983.

All cores (including the seed and blanket assemblies from the two PWR cores) were sent to the Navy's Expended Core Facility (ECF) in Idaho for analysis. After analysis at the ECF the remaining fuel rods, assemblies, and scrap were sent to the INEEL or Hanford depending upon the type of material. Generally, the INEEL received the seed assemblies from the PWR reactors and the entire LWBR core, while Hanford received the blanket assemblies from the two PWR cores.

After the Shippingport PWR program was completed in 1974, work was begun to modify the Shippingport reactor vessel to accommodate a completely different type of core; a Light Water Breeder Reactor (LWBR). This new LWBR used an ^{233}U -Thorium fuel cycle that required a completely redesigned fuel form from the PWR fuel types. After appropriate modifications were made to the vessel to accommodate these different fuel forms, the LWBR reactor began operation in 1978 and operated to 1983 when the entire facility was shutdown permanently. The entire core was de-fueled, sent to the Navy's Expended Core Facility (ECF) in Idaho for analysis, and subsequently dried and shipped to the INTEC for extended storage.

2.2 Physical Description of Fuel

The Shippingport LWBR core was designed to simulate the interior of a large LWBR core environment and to permit net breeding in the entire core. To maximize the ^{232}Th conversion to ^{233}U and minimize the neutron loss to surrounding water, a unique "Seed and Blanket" concept was designed; the seed assembly was inserted into the middle of an annular blanket assembly. The core held twelve of these fuel "modules" (they were designed in a hexagonal shape) which contained a central movable seed region surrounded by a stationary blanket region. These twelve fuel modules were, in turn, surrounded by 15 reflector modules and finally by a stainless steel fill material (required due to the physical constraints of placing a hexagonal shaped core into a circular vessel) (Figures 2-1A and 2-1B). Some of the physical attributes of the LWBR fuel modules are described in Table 2-2.

Table 2-2. Shippingport LWBR Fuel Description

LWBR Core	Seed Module	Blanket Type I	Blanket Type II	Blanket Type III	Reflectors Type IV & V
Fuel Meat	$^{233}\text{UO}_2\text{-ThO}_2$	$^{233}\text{UO}_2\text{-ThO}_2$	$^{233}\text{UO}_2\text{-ThO}_2$	$^{233}\text{UO}_2\text{-ThO}_2$	ThO_2
Fuel Meat Form	Ceramic pellet				
Cladding	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4
Dimensions	See Figures 2-4, & 2-6through 2-8				
Enrichment	4.3 - 5.2 wt %	1.2 - 2.0 wt %	1.6 - 2.8 wt %	1.6 - 2.8 wt %	None
No. Of Elements	12	3	3	6	9 & 6 (IV & V)

2.2.1 Fuel Module Design

Of the 12 fuel modules used in the LWBR core there were three central fuel modules (identical and symmetrical to each other) and nine outer modules (not identical or symmetrical) surrounding these central modules. Each fuel module contained a central, axially movable, hexagonal seed and a stationary, annular hexagonal blanket (see Figure 2-2). The three central modules possessed standard blankets while the outer nine modules had power-flattening blanket configurations which used a larger outer blanket region that was fueled with a slightly higher uranium-233 content than the blanket regions of the inner modules. Use of this more highly loaded blanket region produced a relatively uniform power distribution within the interior of the core, thereby better simulating the breeding environment of a large (1000 MW(e)) core (see section 2.2.3).

In the seed and blanket regions, the fuel pellets contain a solid state solution of uranium-233 and thorium; both in oxide form; urania (UO_2) and thoria (ThO_2). In the seed region, the uranium-233 loading is about 5 to 6 weight percent (wt %) of uranium oxide in the thoria. In the blanket,

the uranium-233 loading is about 1.2 to 3 wt % uranium oxide. In the reflector region and in short regions at the top and bottom of the seed and blanket, the pellets contain only thorium yielding both a radial and an axial blanket, respectively. In all of the fuel regions of the core the ceramic pellets are nominally 97 percent of their maximum achievable theoretical density.

LWBR used a variety of rods in the construction of the various module types used in the core. The rods were fabricated by stacking different numbers and variations of $^{233}\text{UO}_2$ - ThO_2 binary and/or ThO_2 ceramic pellets into individual Zircaloy-4 tubes. By using different rods in the fabrication of the various module types, the neutron flux could be specifically altered to both control the reactions of the core and minimize the loss of neutrons from the core interior (see Variable Geometry Control in the Shippingport LWBR). The types of rods used in the LWBR include standard seed rods, standard blanket rods, Power-Flattening (PF) rods, and reflector rods. The LWBR core contained 17,288 individual rods. Of those, 16,721 are part of this Project. The different rod configurations in the specific fuel module types are described in Table 2-3.

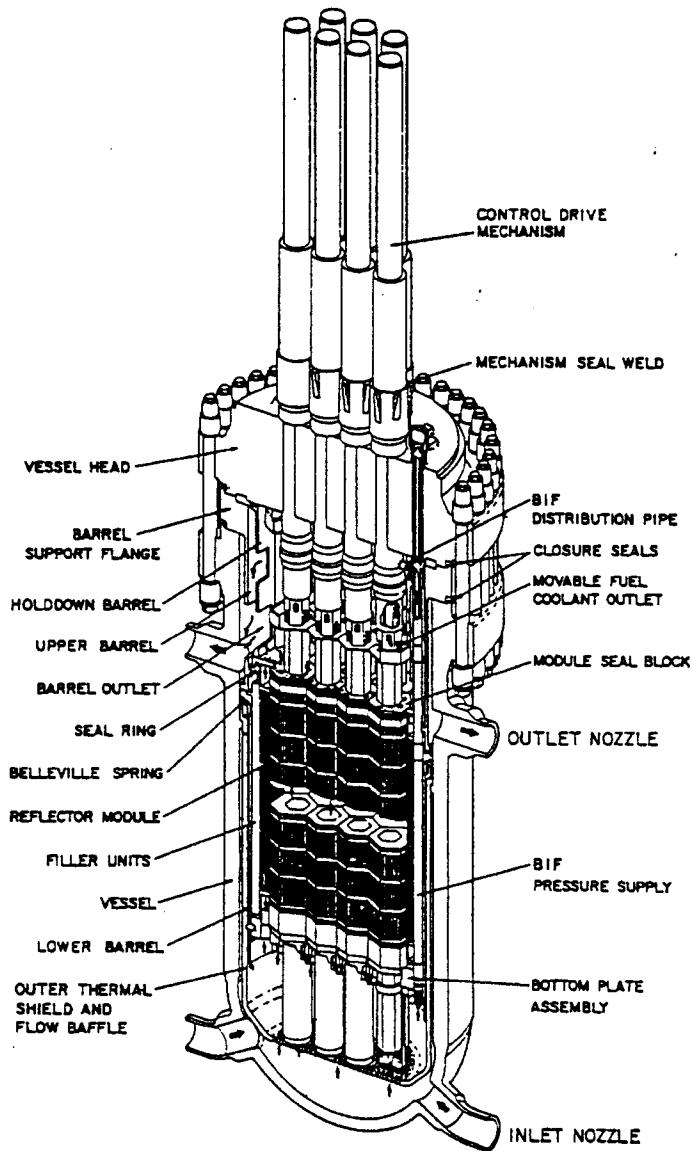


Figure 2-1A. LWBR Core Cutaway View

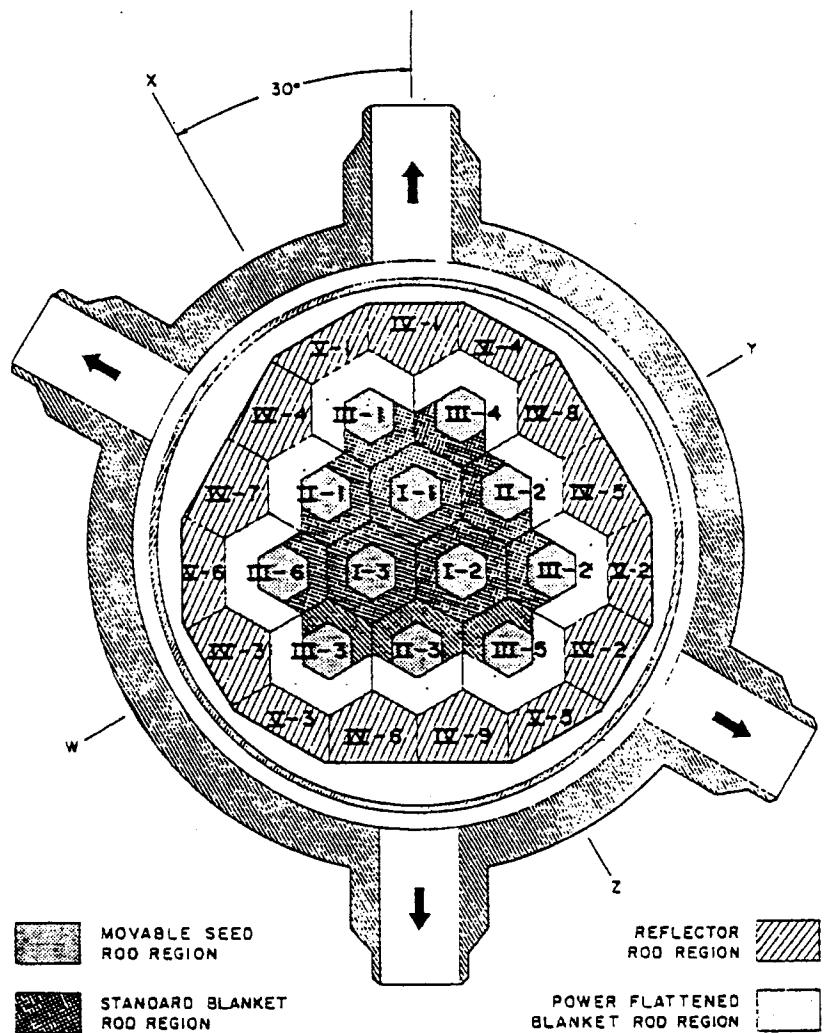
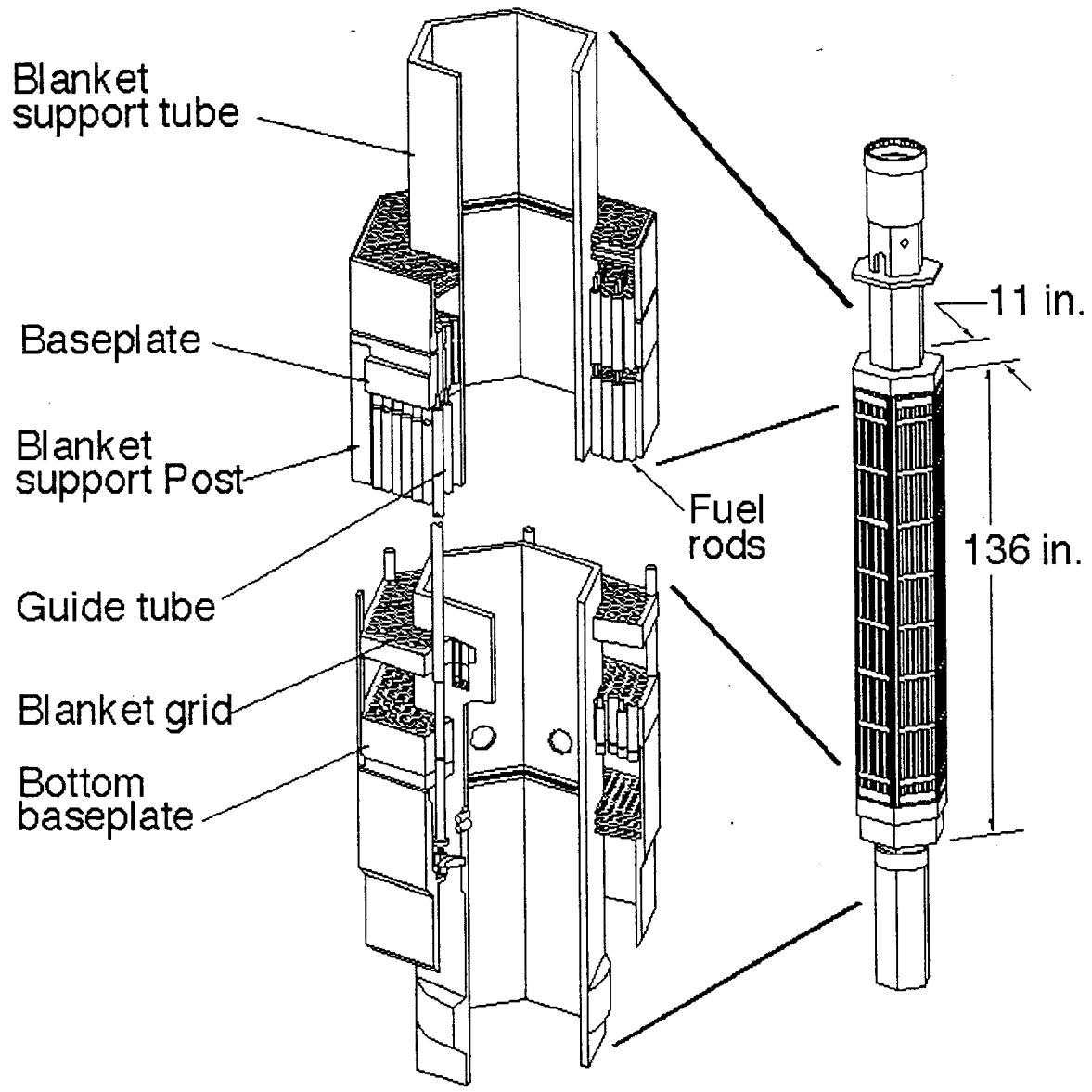


Figure 2-1B. LWBR Core Cross Section View



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Figure 2-2. Typical LWBR Assembly (both seed and blanket modules)

Table 2-3. Shippingport LWBR Fuel Rods and Modules

Seed Module	Blanket (Type I)	Blanket (Type II)	Blanket (Type III)	Reflector (Type IV)	Reflector (Type V)
619 seed rods 0.306" O.D. rods 104" long	444 standard rods	261 standard rods	187 standard rods	228 reflector rods	166 reflector rods 0.832" O.D. rods
		303 PF rods	446 PF rods		
	0.571" O.D. rods	0.571 " O.D. rods	0.571 " O.D. rods	0.832" O.D. rods	104" long
		0.527" O.D. rods	0.527" O.D. rods		
	104" long	104" long	104" long	104" long	
53,400 MWD/MTU	22,800 MWd/MTU	25,200 MWd/MTU	22,800 MWd/MTU	4,100 MWd/MTU	4,100 MWd/MTU

All the rods used the same basic fuel pellet compositions; $^{233}\text{UO}_2$ - ThO_2 binary, ceramic pellets or ThO_2 ceramic pellets. However, the physical configurations of the two types of pellets contained within the individual rods were varied greatly (see Figures 2-3, 2-5A and 2-5B). Additionally, the physical shapes of the different module types were varied to assist with the power-flattening capabilities of the reactor as well as assisting in physically emplacing the hexagonally shaped modules into the circular shaped reactor vessel (see Figure 2-4). The different types of fuel rods are shown in Figures 2-6 through 2-8.

2.2.2 Reflector Modules Description

Surrounding the 12 hexagonal fuel modules in the LWBR core was an annular region, about 8 inches thick, made up of 15 reflector blanket modules. These modules did not contain uranium-233 fuel initially, but instead contained thoria (ThO_2) pellets in 0.832" O.D. Zircaloy-4 tubes. The purpose of the reflector blanket region was to limit neutron losses from the core to less than about 0.8 percent of all neutrons. Use of this peripheral reflector blanket in the small LWBR Core assured an unambiguous quantitative demonstration of breeding within the entire core. The composition, physical geometry, and rod configuration are included in the above tables.

The difference between Type IV and Type V reflector modules is strictly one of geometry. Two distinct geometries were needed to physically fit the hexagonally shaped modules into the existing circular PWR vessel.

The filler units were composed of a ring of stainless steel slabs whose purpose was to fill up the area between the outside of the reflector blanket and the core barrel to prevent water flow from bypassing the core through this area.

2.2.3 Core Loading and Fuel Distribution

The Shippingport LWBR core utilized the unique concept of placing a movable, central seed module inside a stationary, annular blanket module. This concept provided maximum flexibility

for the seed to provide neutrons as efficiently as possible and for the blanket to utilize the neutrons efficiently in producing new fissile fuel by neutron absorption in the fertile fuel. One of the main results arising out of minimizing neutron losses is the control of core reactivity by varying the spatial relationship between moveable seed fuel assemblies and stationary blanket assemblies rather than by conventional neutron-absorbing poison control rods. The fuel rods were close-packed with a

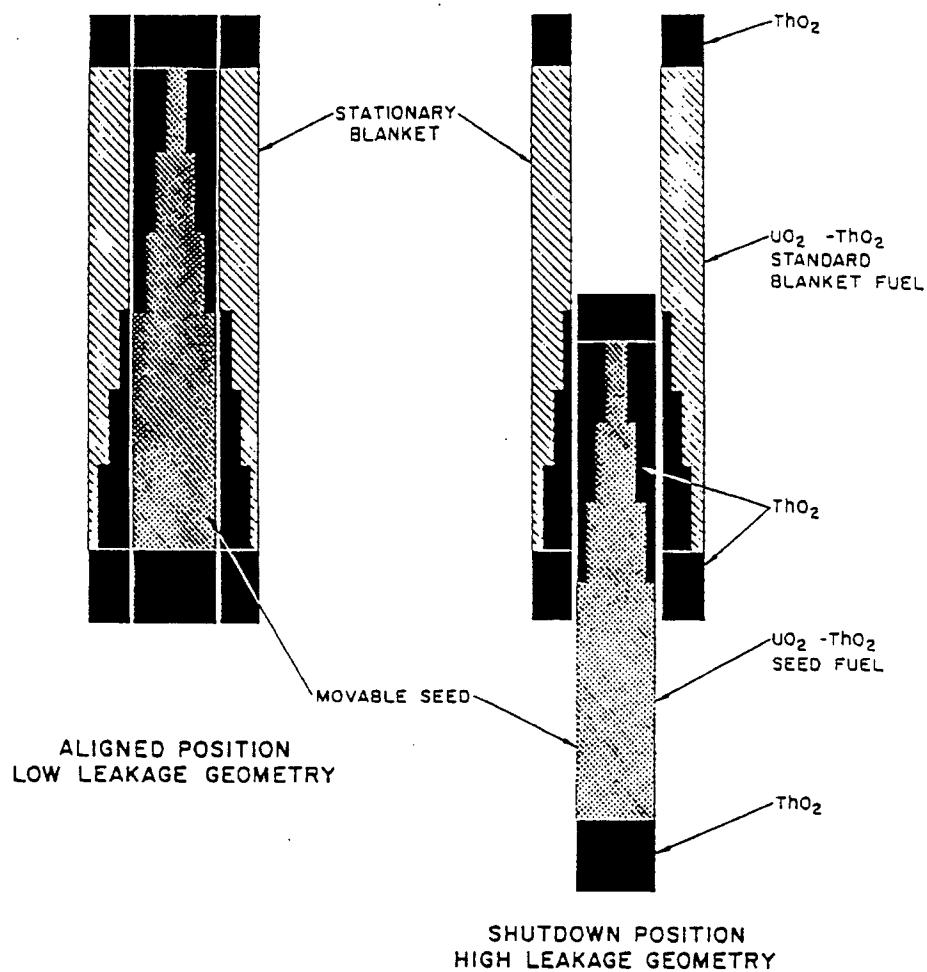


Figure 2-3. Variable Geometry Nuclear Control Concept

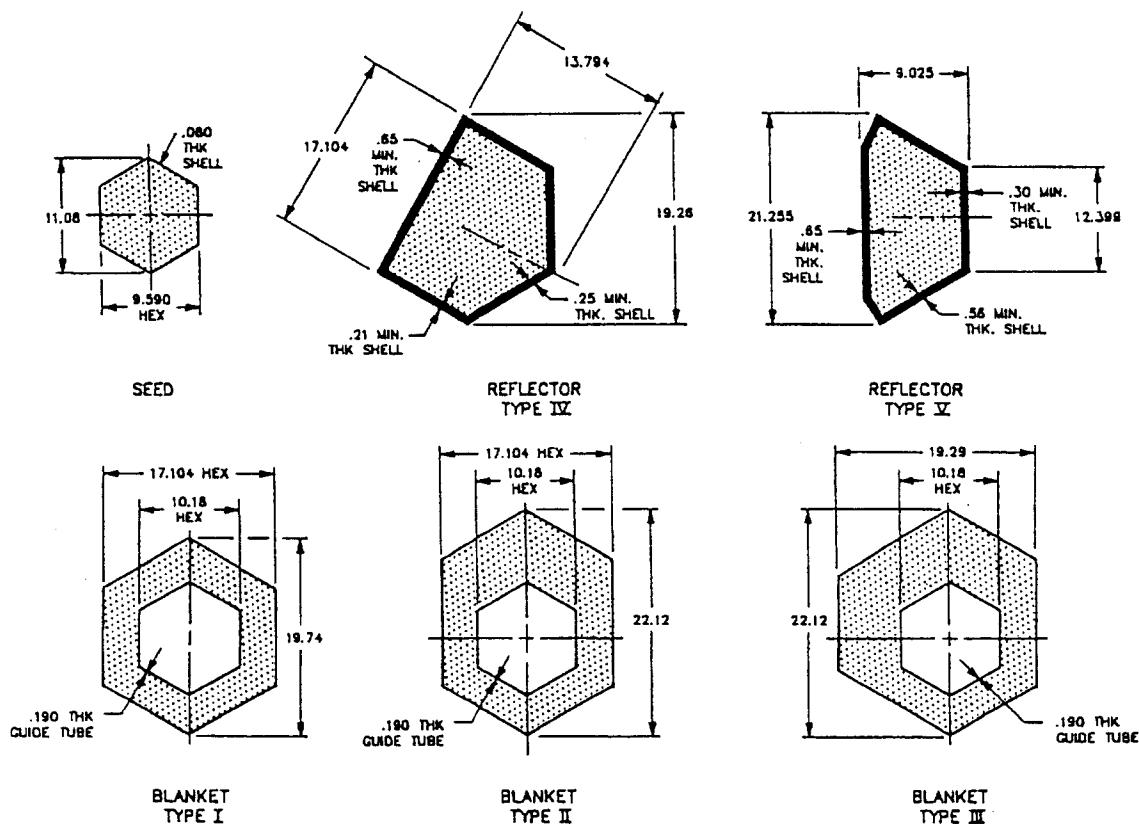


Figure 2-4. LWBR Module Cross Sectional Dimensions

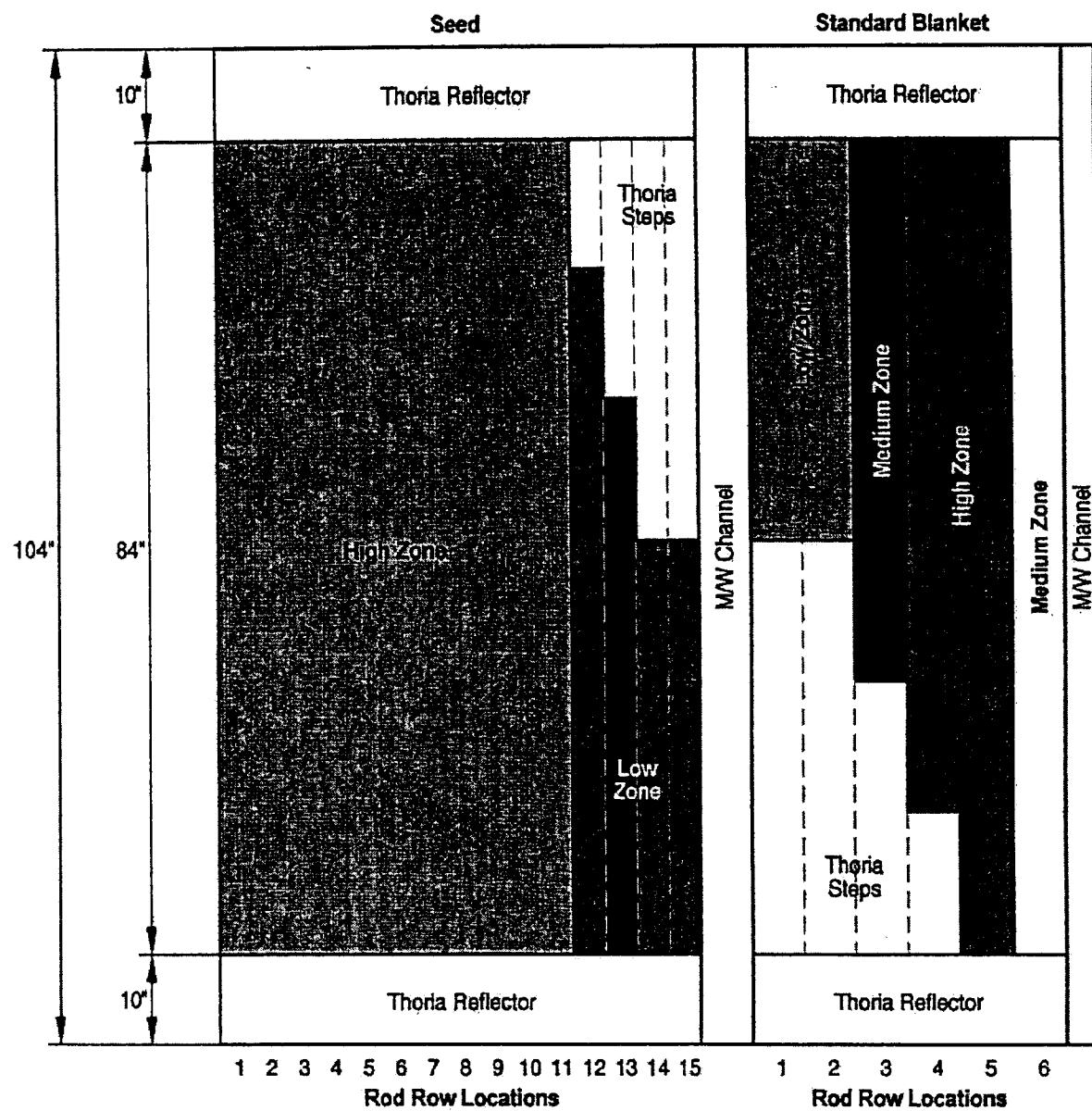
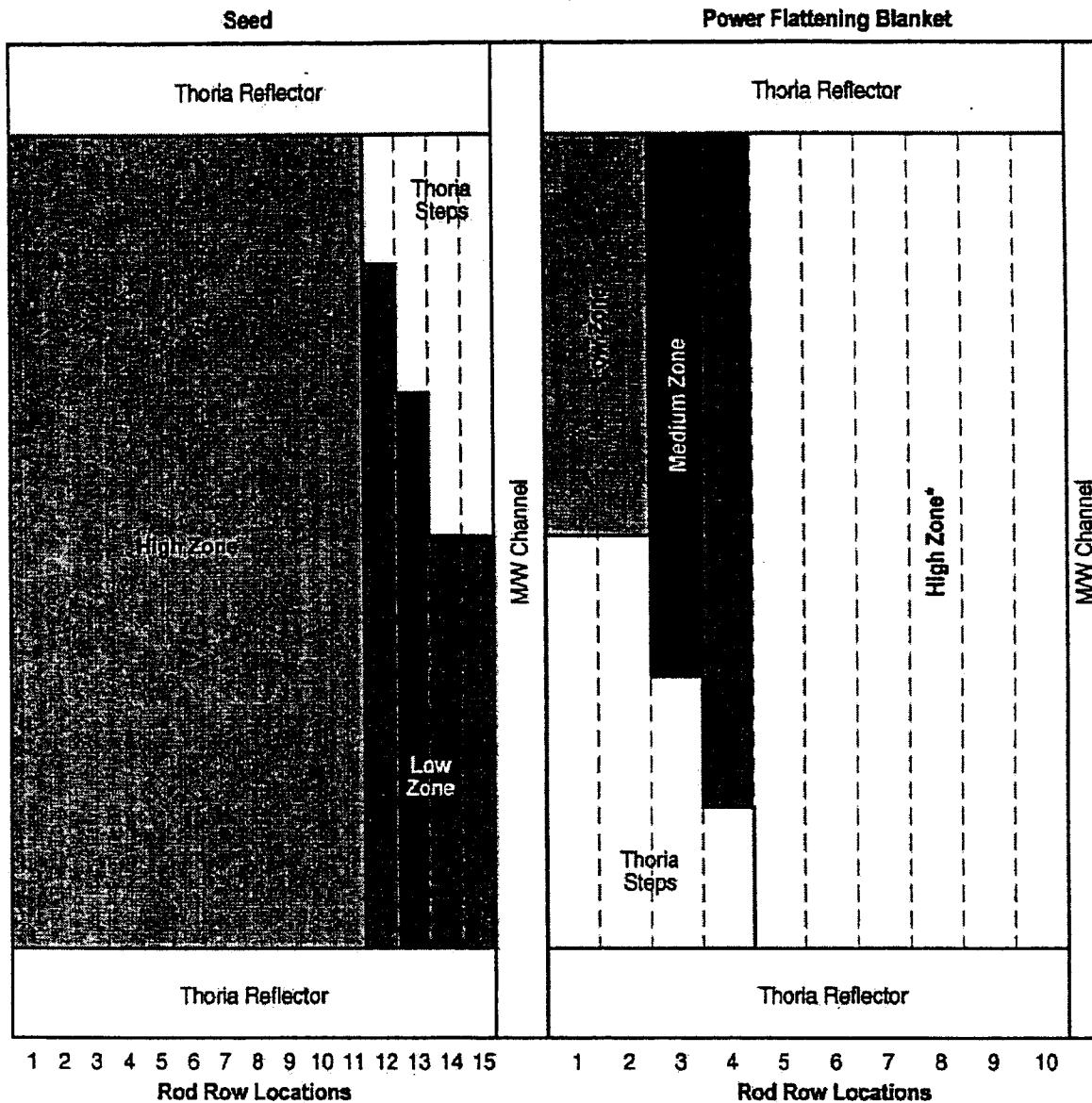


Figure 2-5A. Schematic of LWBR Type I Module Fuel Composition



**Except for eight Medium zone rods per module in row six
(4 on each side, along interface between modules).*

Figure 2-5B. Schematic of Power Flattening Sides of Type II and Type III Modules

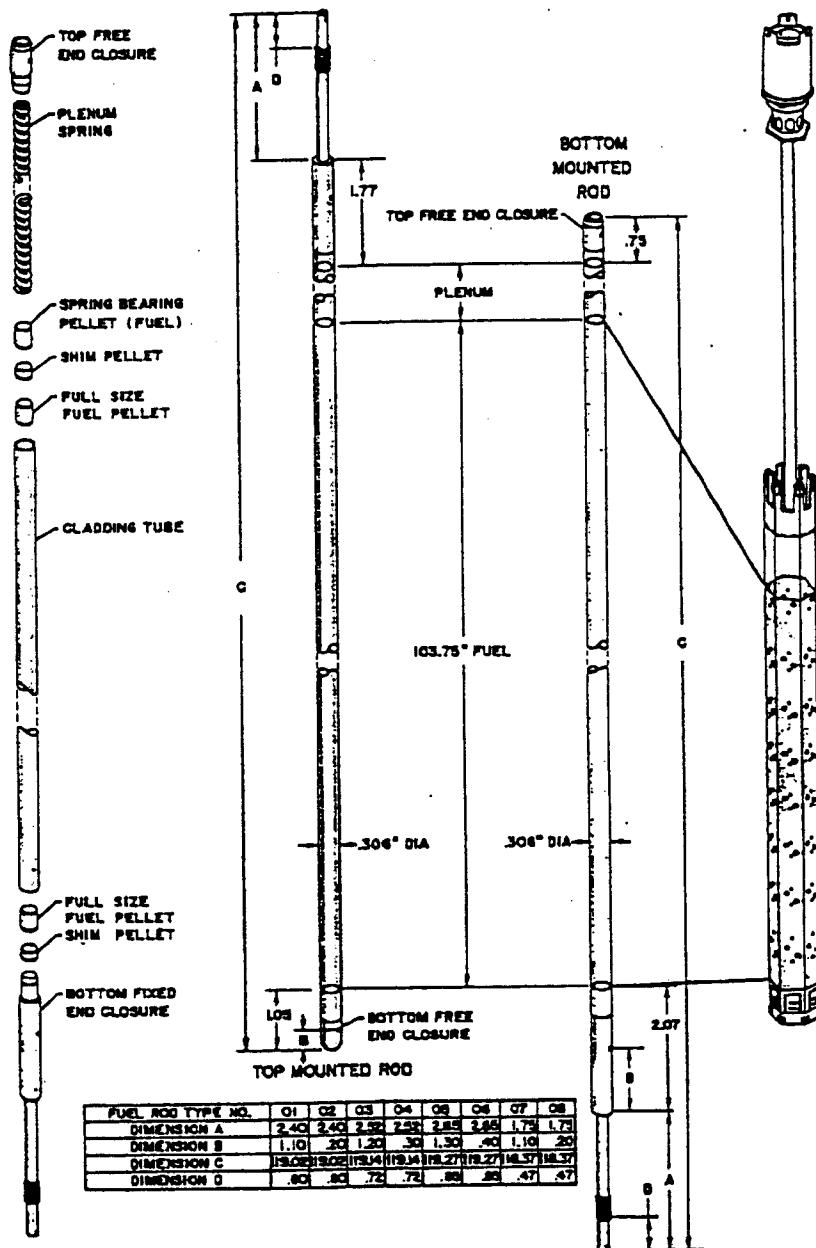
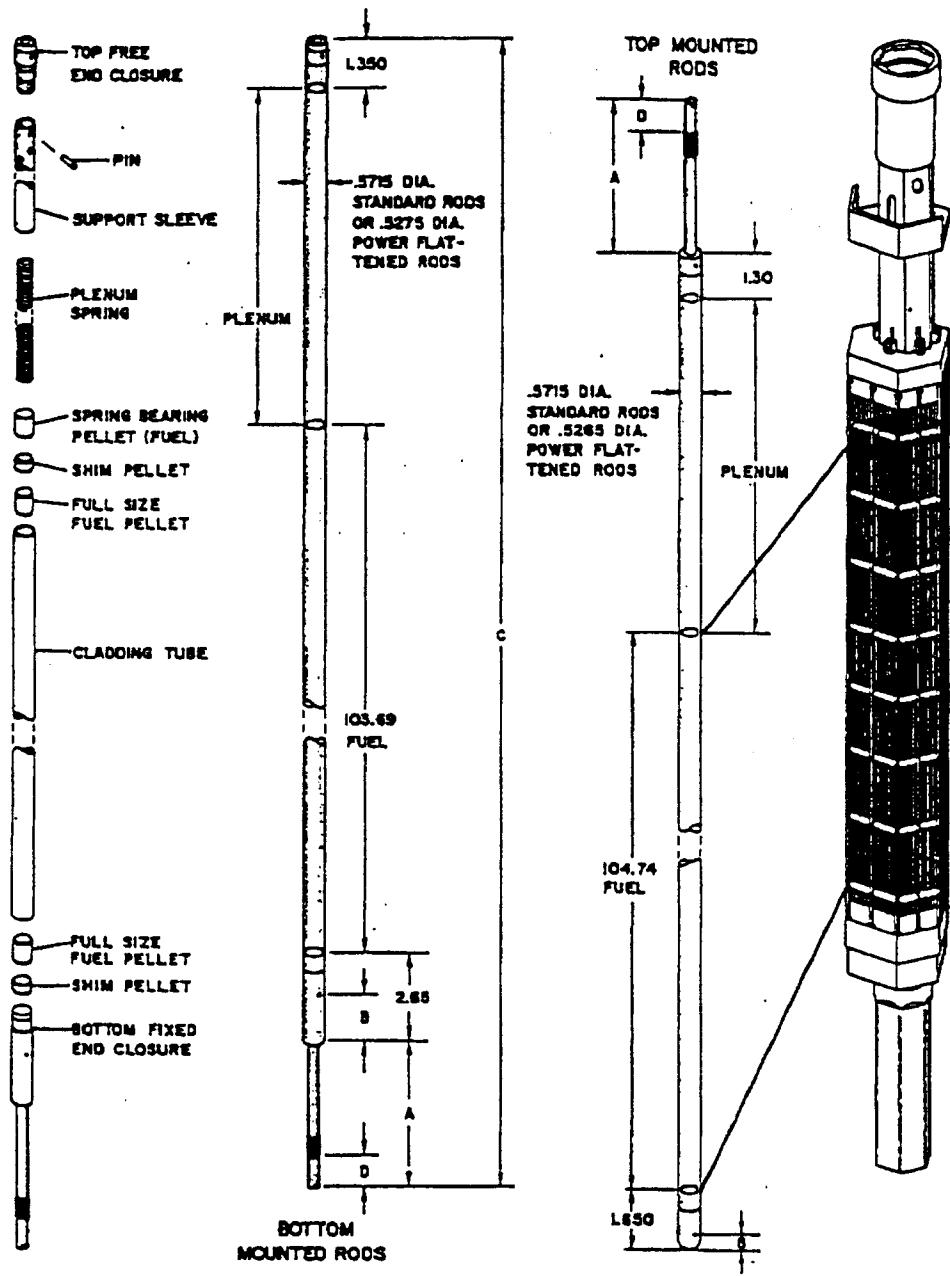


Figure 2-6. Movable Seed Fuel Rods



FUEL ROD TYPE NO.	11	12	13	14	15	16	21	22	23	24	25	26	27
DIMENSION - A	4.23	4.23	4.38	4.38	4.47	4.47	4.23	4.23	4.38	4.38	4.47	4.47	4.60
DIMENSION - B	1.40	.50	1.50	.60	1.60	.70	1.70	.80	1.80	.90	1.90	1.00	2.00
DIMENSION - C ± .07	121.9	121.9	122.0	122.0	122.1	122.1	121.9	121.9	122.0	122.0	122.1	122.1	122.3
DIMENSION - D	.78	.78	.90	.90	L03	L03	.78	.78	.90	.90	L03	L03	L16

Figure 2-7. Standard Blanket Fuel Rods

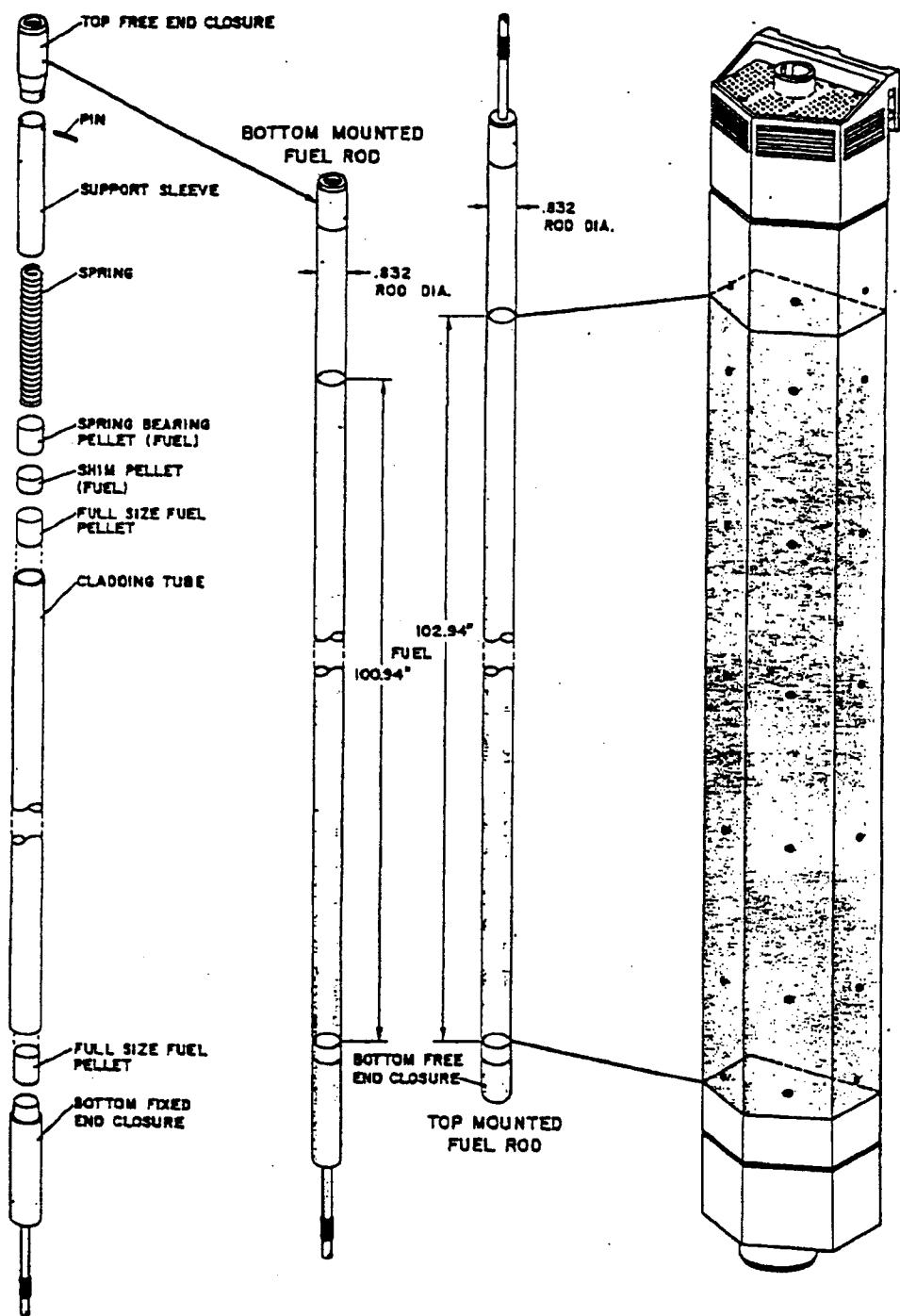


Figure 2-8. Reflector Fuel Rods

triangular pitch with a rod-to-rod spacing of about 0.060 inches to minimize the water in the core, and give the desired neutron energy spectrum. This is significantly tighter than the packing of rods in commercial fuel.

To achieve maximum efficiency, the Shippingport LWBR core contained both radial and axial variation of fuel composition (see Figure 2-5). The fuel is approximately 104 inches long, including an axial reflector of 10 inches of ThO₂ on the top and bottom. In the Central Seed Modules, starting at the core center, there are 11 rows of rods that contain high-zone ²³³UO₂-ThO₂ binary pellets in the middle 84 inches of the total length. In the next four rows the fuel rods contained low-zone binary pellets and, coupled with a larger region, ThO₂ pellets at the top end of the rods to produce the stepped arrangement shown in Figure 2-3.

The blanket assembly contains low-, medium-, and high-zone binary pellets and ThO₂ pellets in the rods arranged as shown in Figure 2-3. This combination of radial and axial fuel zones served the purpose of reducing power peaking in the vicinity of the metal and water channels. The stepped arrangement also improved the reactivity worth of the movable fuel seed assembly as it changed elevation.

The rods in the standard (or regular) blanket region of the core have a 0.571" O.D. The Power-Flattening (PF) blanket region contains smaller rods than the standard blanket; 0.527" O.D., but the rods are on the same pitch as in the standard blanket. This gave the PF blanket region a rod spacing of ~100 mils and a lower metal-to-water ratio. This region also had a higher fissile loading than the standard region. This combination of lower metal-to-water ratio and higher fissile loading gave the power flattening blankets a higher reactivity than the standard blanket, which tended to flatten the radial power distribution across the core.

2.2.4 Variable Geometry Control

The LWBR used a variable geometry control concept based on changing the position of the movable seed fuel assembly, relative to the stationary blanket assembly, to achieve the proper neutron balance in the core. Changing the position of the seed assembly relative to the blanket assembly changed the relative amounts of neutron absorptions in the fissile (uranium-233) and fertile (thorium) fuel materials.

The LWBR nuclear design is such that the more highly loaded seed has a k_{∞} greater than one ($k_{\infty} > 1.0$) and the lower loaded blanket has a k_{∞} less than one. Reactivity is controlled by varying the leakage of neutrons from the high k_{∞} seed regions into the low k_{∞} blanket regions. This is achieved by axially positioning the seed section of the core so as to change core geometry rather than by using conventional parasitic neutron-absorbing poisons. With this method of control, which is made practical by the seed-blanket concept, no neutrons are wasted in control rods or soluble poisons. Rather, any excess neutrons are absorbed in fertile thorium material, and good neutron economy is achieved. The reactivity worth of the movable seed is increased by using lengths of natural thoria in some of the seed and blanket rods (see Figure 2-3).

When the reactor was shut down, the seed assemblies were aligned below the rest of the fuel in the core (see Figure 2-3). To start up the reactor, the operator raised the seed assemblies in a uniform bank by remote control. By moving the seed fuel up, more nearly into alignment with the rest of the core, the operator brought the uranium-233 bearing parts of the fuel closer together increasing the likelihood that some of the excess neutrons would cause fissions in uranium-233 atoms. The movable-fuel control system was designed so that, under any operating condition, when the movable seed fuel assembly was lowered relative to the stationary blanket the reactivity of the core always decreased. This up and down movement of the seed assembly enabled the operator to control the reactor's criticality.

During normal power operation all seeds were aligned as a uniform bank. At the beginning of core life, critical operation occurred with the seeds down about 2 feet lower than the stationary blanket. As the core operated, the seed assemblies were moved gradually upward toward a position about 2 feet higher than the blanket at the end of core life. The operation of the movable fuel control system was similar in many respects to that of the movable poison rod control used in many light water reactors.

2.3 Packaging

After reactor irradiation the fuel was shipped to the Naval Reactors Facility at the INEEL where a Proof of Breeding destructive examination was conducted in the Expended Core Facility. This program involved the removal of fuel rods from selected assemblies (seed, blanket, and reflector) and a destructive examination of some of the rods. The rods were removed underwater by gripping the ends of the rods and pulling them vertically out of the assembly one at a time. The rod pulling equipment utilized a computer controlled, remote, underwater system with underwater television camera monitoring. After the examination the fuel and pieces were placed into a stainless steel storage canister. Table 2-4 describes the contents of the different types of canisters.

Table 2-4. LWBR Storage Configuration and Condition in Canisters

No.	Canister Type	Description
27	Type A	Canisters containing one intact module (seed, blanket, or reflector) with all fuel rods in place. Also, has permanently attached shipping plates and lift adapter plates.
12	Type B	Contain partially de-rodded fuel modules (modules that have had some rods removed). There are special clamps installed inside the canister to hold these partial modules inside the canister w/o movement. <ul style="list-style-type: none"> • 30 to 100 rods were removed from each module • 2 modules (1 seed and 1 reflector) have the outer shells removed. • 1 module (Blanket III-2) is completely disassembled
4	Type C	Contain the rods removed from the modules stored in Type B canisters. These are: <ul style="list-style-type: none"> • 3 blanket canisters, 381 irradiated rods • 1 reflector canister, 127 irradiated rods A special grid was constructed for each canister that allowed the rods to be individually packed into the canister w/o movement inside the canister.
43	Canisters	Total number of irradiated LWBR fuel canisters to be handled by this project

The storage canisters are constructed of 304 stainless steel. The dimensions are 25.5 inch O.D. by 24.75 inch ID by 158.5 inch outside length. The canister shell is welded to a girth ring, which is 2.5 inches thick and contains the machined cut-out shape for the module that fits inside. The girth ring also contains six 1-inch diameter threaded holes for lifting the canister during operations before the closure head is bolted to the canister prior to shipment. Guides, which are bolted to the girth ring and extend downward align the module as it is placed in the canister and laterally support the module once it is inside. Sitting on the bottom plate of the canister is a crushable pad with a load spreading plate upon which the module rests. All components are constructed of 304 stainless steel.

The irradiated fuel modules were loaded into the storage canisters underwater and then the closure head of the storage canister was secured by twelve 1-inch diameter bolts and sealed by a resilient all-metallic gasket. The gasket is silver-plated inconel with an O-ring configuration. Each bolt hole is also sealed by a metallic O-ring. All LWBR fuel was dried using approved procedures by the ECF at Idaho using a vacuum drying processes similar to the commercial nuclear fuel utilities before being shipped to the INTEC. The process used a vacuum inside each storage canister/cask to de-water the interior. No external heating or other conditioning methods were applied along with the vacuum process. After the canister was determined to be de-watered it was isolated and the internal pressure was monitored for increased values. The canisters were backfilled with neon gas and leak tested. The fuel was then shipped to the INTEC where it was stored in dry wells at the INTEC (see Figure 2-9).

2.4 As Stored Condition

No external or internal inspections of the LWBR fuel storage canisters have been performed while in storage at the INTEC. Therefore, the actual condition of the canisters and the fuel material stored inside the canisters is unknown. The general assumption for these particular fuel types is that little to no corrosion can or will take place inside and outside of the canister while in storage due to the dry storage environment and the drying process that was applied to the fuels before storage. The dry well temperature and pressure were measured for sometime after receipt and loading of the fuel at INTEC and no abnormal indications were observed.

2.5 Radionuclide Inventory

Table 2-5 presents the calculated radionuclide inventory for the various LWBR assembly types. The estimated heat generation is 120 watts/assembly.

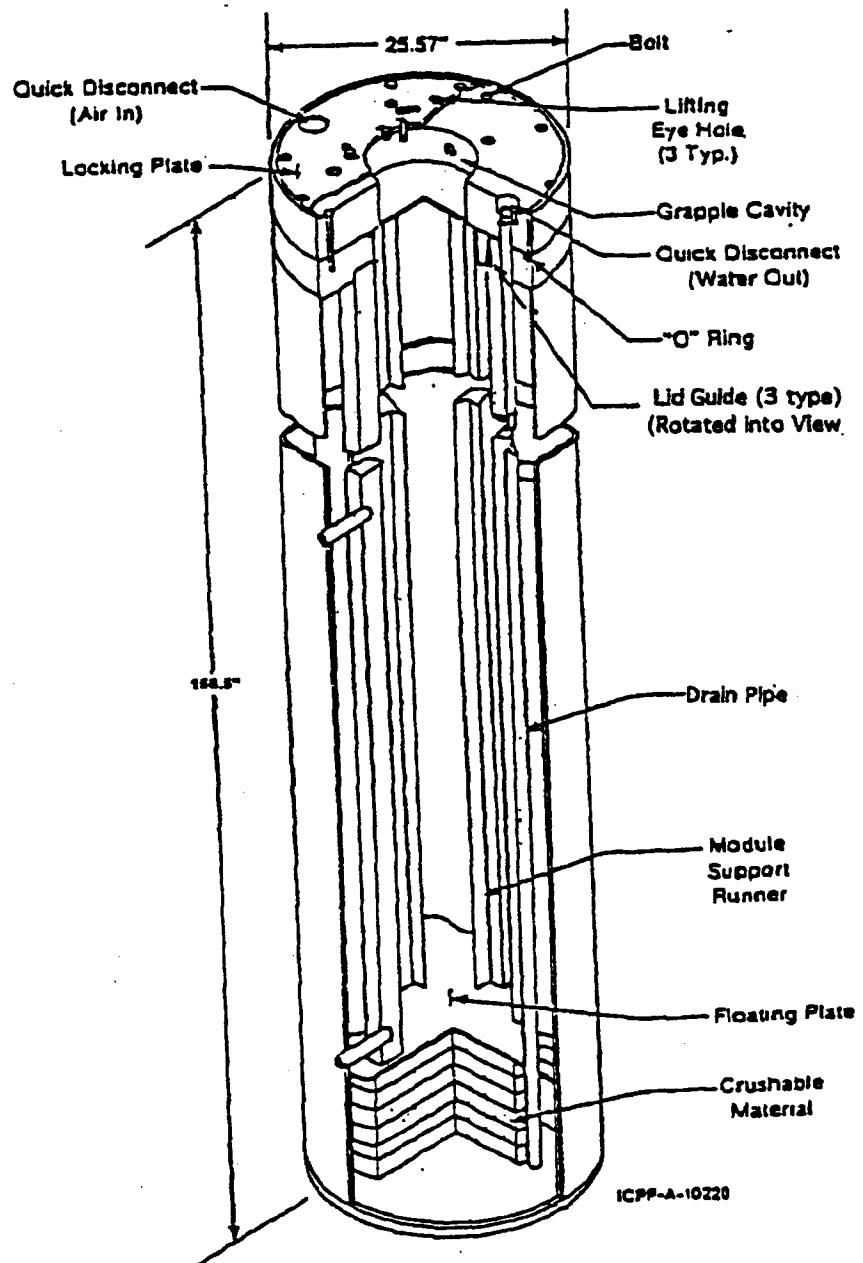


Figure 2-9. Shippingport LWBR Seed Module Storage Canister

Table 2-5A. Isotopic Activity Concentrations in Curies for a single LWBR SEED Module (TYPE I).

Information:	Units:	CURIES
Burnup:	10269.14	MWd (max)
Burnup:	27749.70	MWd/MTHM
BOL U-233:	16877.36	grams U-233 per module
BOL U-234:	221.64	grams U-234 per module
BOL U-235:	15.46	grams U-235 per module
BOL U-236:	3.44	grams U-236 per module
BOL U-238:	63.57	grams U-238 per module
BOL Th-232:	442731.04	grams Th-232 per module
Fuel Metal:	UO ₂ -ThO ₂ (Urania-Thoria)	
Fuel Enrichment:	98.23 wt%	U-233
Clad:	Zircaloy-4	

DECAY DATES							
ISOTOPES	1-Jul-96	1-Jul-98	1-Jul-00	1-Jul-02	1-Jul-05	1-Jul-10	1-Jul-15
H 3	7.277E+01	6.504E+01	5.813E+01	5.196E+01	4.391E+01	3.317E+01	2.505E+01
BE 10	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06
C 14	8.896E-01	8.894E-01	8.892E-01	8.889E-01	8.886E-01	8.881E-01	8.875E-01
CL 36	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02
CR 51	2.833E-52	3.322E-60	3.799E-68	4.454E-76	5.515E-88	8.007E-108	1.162E-127
MN 54	4.511E-04	8.947E-05	1.768E-05	3.502E-06	3.080E-07	5.365E-09	9.345E-11
FE 55	6.220E+00	3.651E+00	2.141E+00	1.257E+00	5.648E-01	1.490E-01	3.928E-02
FE 59	2.8117E-33	3.685E-38	4.746E-43	6.209E-48	2.892E-55	1.762E-67	1.074E-79
CO 60	1.385E+02	1.065E+02	8.183E+01	6.291E+01	4.240E+01	2.197E+01	1.138E+01
NI 59	6.359E-02	6.359E-02	6.359E-02	6.359E-02	6.359E-02	6.358E-02	6.358E-02
NI 63	7.988E+00	7.751E+00	7.635E+00	7.465E+00	7.189E+00	6.923E+00	6.667E+00
ZN 65	2.210E-05	2.775E-06	3.474E-07	4.363E-08	1.936E-09	1.078E-11	6.008E-14
SE 79	3.638E-01	3.637E-01	3.637E-01	3.637E-01	3.637E-01	3.637E-01	3.636E-01
KR 85	2.571E+03	2.260E+03	1.985E+03	1.745E+03	1.437E+03	1.040E+03	7.528E+02
RB 87	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05

SR 89	3.538E-25	1.574E-29	6.909E-34	3.073E-38	8.998E-45	1.172E-55	1.526E-66	1.960E-77	2.553E-88	3.325E-99
SR 90	2.553E+04	2.435E+04	2.321E+04	2.214E+04	2.061E+04	1.830E+04	1.624E+04	1.442E+04	1.280E+04	1.137E+04
Y 90	2.554E+04	2.435E+04	2.322E+04	2.214E+04	2.061E+04	1.830E+04	1.625E+04	1.442E+04	1.281E+04	1.137E+04
Y 91	4.610E-21	8.085E-25	1.401E-28	2.458E-32	5.642E-38	2.271E-47	9.145E-57	3.639E-66	1.464E-75	5.897E-85
ZR 93	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.495E-01
ZR 95	7.539E-19	2.771E-22	1.008E-25	3.704E-29	2.583E-34	6.620E-43	1.697E-51	4.302E-60	1.103E-68	2.826E-77
NB 93M	4.569E-01	4.908E-01	5.215E-01	5.491E-01	5.857E-01	6.355E-01	6.741E-01	7.040E-01	7.272E-01	7.452E-01
NB 94	2.305E-02	2.304E-02	2.304E-02	2.304E-02	2.304E-02	2.303E-02	2.303E-02	2.303E-02	2.303E-02	2.302E-02
NB 95	1.674E-18	6.153E-22	2.238E-25	8.225E-29	5.734E-34	1.470E-42	3.767E-51	9.551E-60	2.448E-68	6.274E-77
NB 95M	5.593E-21	2.056E-24	7.477E-28	2.748E-31	1.916E-36	4.911E-45	1.259E-53	3.191E-62	8.179E-71	2.097E-79
MO 93	4.197E-03	4.195E-03	4.194E-03	4.192E-03	4.190E-03	4.186E-03	4.181E-03	4.177E-03	4.173E-03	4.169E-03
TC 99	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.340E+00	3.340E+00	3.340E+00
RU103	2.868E-34	7.303E-40	1.827E-45	4.651E-51	1.856E-59	1.886E-73	1.916E-87	1.913E-101	1.944E-115	1.976E-129
RU106	1.040E+00	2.630E-01	6.643E-02	1.681E-02	2.135E-03	6.860E-05	2.205E-06	7.072E-08	2.273E-09	7.303E-11
RH103M	2.586E-34	6.583E-40	1.647E-45	4.192E-51	1.673E-59	1.700E-73	1.728E-87	1.725E-101	1.753E-115	1.781E-129
RH106	1.040E+00	2.630E-01	6.643E-02	1.681E-02	2.135E-03	6.860E-05	2.205E-06	7.072E-08	2.273E-09	7.303E-11
PD107	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03
AG110	1.330E-06	1.755E-07	2.311E-08	3.050E-09	1.459E-10	9.210E-13	5.814E-15	3.660E-17	2.311E-19	1.459E-21
AG110M	9.998E-05	1.320E-05	1.737E-06	2.293E-07	1.097E-08	6.924E-11	4.371E-13	2.752E-15	1.738E-17	1.097E-19
AG111	0.000E+00	0.0000E+00								
CD113M	2.379E+00	2.163E+00	1.967E+00	1.789E+00	1.551E+00	1.223E+00	9.646E-01	7.606E-01	5.998E-01	4.730E-01
CD113	0.000E+00	0.0000E+00								
CD115M	1.230E-32	1.452E-37	1.688E-42	1.994E-47	7.968E-55	3.760E-67	1.775E-79	8.248E-92	3.892E-104	1.837E-116
IN114	5.523E-30	2.014E-34	7.240E-39	2.640E-43	5.730E-50	4.536E-61	3.589E-72	2.802E-83	2.218E-94	1.756E-105
IN114M	5.771E-30	2.104E-34	7.565E-39	2.758E-43	5.987E-50	4.739E-61	3.751E-72	2.928E-83	2.318E-94	1.834E-105
IN115M	8.635E-37	1.020E-41	1.186E-46	1.401E-51	5.597E-59	2.641E-71	1.247E-83	5.793E-96	2.734E-108	1.290E-120
SN119M	1.831E-03	2.322E-04	2.936E-05	3.723E-06	1.676E-07	9.572E-10	5.465E-12	3.111E-14	1.777E-16	1.014E-18
SN121M	4.988E-01	4.852E-01	4.719E-01	4.590E-01	4.403E-01	4.109E-01	3.833E-01	3.576E-01	3.336E-01	3.113E-01
SN123	1.178E-09	2.344E-11	4.639E-13	9.226E-15	2.575E-17	1.429E-21	7.936E-26	4.381E-30	2.433E-34	1.351E-38
SN125	0.000E+00	0.0000E+00								
SN126	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.091E-01
SB124	1.678E-23	3.751E-27	8.290E-31	1.854E-34	6.126E-40	4.527E-49	3.344E-58	2.443E-67	1.805E-76	1.334E-85
SB125	1.713E+02	1.039E+02	6.293E+01	3.816E+01	1.801E+01	5.155E+00	1.475E+00	4.220E+01	1.208E+01	3.457E+02
SB126	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.728E-02	5.728E-02	5.728E-02
SB126M	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.091E-01
TE123M	8.484E-13	1.237E-14	1.793E-16	2.615E-18	4.577E-21	1.168E-25	2.982E-30	7.565E-35	1.931E-39	4.928E-44
TE125M	4.179E+01	2.535E+01	1.536E+01	9.315E+00	4.395E+00	1.258E+00	3.600E-01	1.030E-01	2.947E-02	8.434E-03

Table 2-5A Page 2

TE127	6.358E-11	6.128E-13	5.869E-15	5.657E-17	5.319E-20	4.821E-25	4.369E-30	3.935E-35	3.566E-40	3.232E-45
TE127M	6.491E-11	6.256E-13	5.992E-15	5.776E-17	5.431E-20	4.922E-25	4.461E-30	4.017E-35	3.641E-40	3.299E-45
TE129	1.012E-41	2.916E-48	8.233E-55	2.373E-61	3.596E-71	1.570E-87	6.858E-104	2.934E-120	1.282E-136	5.597E-153
TE129M	1.555E-41	4.480E-48	1.265E-54	3.645E-61	5.524E-71	2.412E-87	1.054E-103	4.508E-120	1.969E-136	8.598E-153
I129	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	3.540E+02	1.808E+02	9.226E+01	4.712E+01	1.719E+01	3.201E+00	5.962E-01	1.110E-01	2.067E-02	3.850E-03
CS135	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	2.489E+04	2.377E+04	2.270E+04	2.167E+04	2.022E+04	1.802E+04	1.605E+04	1.430E+04	1.274E+04	1.135E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	2.355E+04	2.249E+04	2.147E+04	2.050E+04	1.913E+04	1.704E+04	1.518E+04	1.353E+04	1.205E+04	1.074E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.078E-41	1.877E-48	3.199E-55	5.570E-62	3.961E-72	4.904E-89	6.072E-106	7.360E-123	9.112E-140	1.128E-156
CE142	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05
CE144	1.024E+00	1.727E-01	2.905E-02	4.898E-03	3.384E-04	3.941E-06	4.591E-08	5.335E-10	6.214E-12	7.239E-14
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	1.024E+00	1.727E-01	2.905E-02	4.899E-03	3.384E-04	3.942E-06	4.591E-08	5.335E-10	6.215E-12	7.239E-14
PR144M	1.229E-02	2.072E-03	3.486E-04	5.878E-05	4.060E-06	4.730E-08	5.510E-10	6.402E-12	7.458E-14	8.687E-16
ND144	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM144	6.376E-03	5.896E-03	5.451E-03	5.041E-03	4.482E-03	3.685E-03	3.030E-03	2.491E-03	2.048E-03	1.684E-03
PM145	7.756E+02	4.574E+02	2.696E+02	1.590E+02	7.195E+01	1.920E+01	5.125E+00	1.367E+00	3.648E-01	9.738E-02
PM147	3.430E-33	1.637E-38	7.680E-44	3.664E-49	3.756E-57	1.837E-70	8.982E-84	4.319E-97	2.112E-110	1.033E-123
PM148M	1.932E-34	9.219E-40	4.326E-45	2.064E-50	2.115E-58	1.035E-71	5.059E-85	2.433E-98	1.190E-111	5.819E-125
PM148	2.050E-06	4.630E-07	1.043E-07	2.356E-08	2.523E-09	6.102E-11	1.476E-12	3.561E-14	8.613E-16	2.083E-17
SM147	1.284E-06	1.292E-06	1.297E-06	1.299E-06	1.301E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06
SM151	1.313E+02	1.293E+02	1.273E+02	1.253E+02	1.225E+02	1.179E+02	1.134E+02	1.091E+02	1.050E+02	1.011E+02
EU152	1.334E+00	1.205E+00	1.088E+00	9.824E-01	8.431E-01	6.535E-01	5.065E-01	3.925E-01	3.043E-01	2.358E-01
EU154	4.955E+02	4.219E+02	3.590E+02	3.056E+02	2.399E+02	1.604E+02	1.072E+02	7.162E+01	4.787E+01	3.199E+01
EU155	1.353E+02	1.023E+02	7.735E+01	5.850E+01	3.846E+01	1.912E+01	9.507E+00	4.725E+00	2.349E+00	1.168E+00
EU156	1.880E-96	6.350E-111	2.049E-125	6.919E-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.632E-05	3.254E-06	4.010E-07	4.956E-08	2.147E-09	1.150E-11	6.156E-14	3.286E-16	1.760E-18	9.422E-21
TB160	3.184E-20	2.909E-23	2.632E-26	2.404E-29	6.574E-34	1.642E-41	4.102E-49	1.015E-56	2.534E-64	6.331E-72

TL206	1.459E-12										
TL207	4.868E-01	5.329E-01	5.762E-01	6.167E-01	6.728E-01	7.551E-01	8.254E-01	8.854E-01	9.365E-01	9.801E-01	9.801E-01
TL208	1.757E+02	1.698E+02	1.667E+02	1.619E+02	1.541E+02	1.469E+02	1.400E+02	1.334E+02	1.271E+02	1.271E+02	1.271E+02
PB210	1.371E-04	1.326E-04	1.288E-04	1.258E-04	1.224E-04	1.200E-04	1.210E-04	1.250E-04	1.318E-04	1.410E-04	1.410E-04
PB211	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01	9.828E-01
PB212	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02	3.539E+02
BI211	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01	9.828E-01
BI212	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02	3.539E+02
PO212	3.134E+02	3.083E+02	3.028E+02	2.972E+02	2.886E+02	2.749E+02	2.620E+02	2.496E+02	2.379E+02	2.267E+02	2.267E+02
PO215	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01	9.828E-01
PO216	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02	3.539E+02
RN219	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01	9.828E-01
RN220	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02	3.539E+02
FR223	6.725E-03	7.360E-03	7.957E-03	8.517E-03	9.293E-03	1.043E-02	1.140E-02	1.223E-02	1.294E-02	1.354E-02	1.354E-02
RA223	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01	9.828E-01
RA224	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02	3.539E+02
RA226	5.858E-05	6.637E-05	7.430E-05	8.234E-05	9.464E-05	1.158E-04	1.376E-04	1.603E-04	1.837E-04	2.079E-04	2.079E-04
RA228	4.067E-02	4.198E-02	4.303E-02	4.389E-02	4.489E-02	4.600E-02	4.666E-02	4.706E-02	4.729E-02	4.743E-02	4.743E-02
AC227	4.873E-01	5.334E-01	5.766E-01	6.172E-01	6.734E-01	7.559E-01	8.262E-01	8.862E-01	9.374E-01	9.810E-01	9.810E-01
TH227	4.815E-01	5.271E-01	5.698E-01	6.099E-01	6.654E-01	7.468E-01	8.163E-01	8.757E-01	9.262E-01	9.693E-01	9.693E-01
TH228	4.881E+02	4.799E+02	4.714E+02	4.627E+02	4.497E+02	4.286E+02	4.085E+02	3.893E+02	3.710E+02	3.536E+02	3.536E+02
TH229	2.202E-01	2.445E-01	2.689E-01	2.933E-01	3.298E-01	3.906E-01	4.514E-01	5.122E-01	5.730E-01	6.337E-01	6.337E-01
TH230	8.986E-03	9.137E-03	9.288E-03	9.439E-03	9.665E-03	1.004E-02	1.042E-02	1.080E-02	1.118E-02	1.155E-02	1.155E-02
TH231	6.271E-04										
TH232	4.764E-02										
TH234	1.814E-05										
PA231	1.234E+00										
PA233	1.271E-03	1.272E-03	1.273E-03	1.274E-03	1.276E-03	1.279E-03	1.283E-03	1.286E-03	1.290E-03	1.294E-03	1.294E-03
PA234M	1.814E-05										
PA234	2.358E-08										
U232	4.774E+02	4.683E+02	4.593E+02	4.506E+02	4.378E+02	4.172E+02	3.976E+02	3.789E+02	3.611E+02	3.441E+02	3.441E+02
U233	1.292E+02										
U234	8.397E+00										
U235	6.271E-04										
U236	1.363E-03										
U237	1.037E-05	9.418E-06	8.553E-06	7.768E-06	6.723E-06	5.285E-06	4.155E-06	3.266E-06	2.567E-06	2.018E-06	2.018E-06
U238	1.814E-05										

NP237	1.271E-03	1.272E-03	1.273E-03	1.274E-03	1.276E-03	1.279E-03	1.283E-03	1.286E-03	1.290E-03	1.294E-03
PU236	2.084E-05	1.282E-05	7.883E-06	4.850E-06	2.340E-06	6.959E-07	2.083E-07	6.364E-08	2.078E-08	8.072E-09
PU237	3.810E-36	5.779E-41	8.632E-46	1.309E-50	7.615E-58	6.719E-70	5.928E-82	5.151E-94	4.544E-106	4.009E-118
PU238	5.164E+00	5.083E+00	5.004E+00	4.925E+00	4.810E+00	4.625E+00	4.446E+00	4.274E+00	4.109E+00	3.951E+00
PU239	2.823E-01	2.823E-01	2.823E-01	2.823E-01	2.822E-01	2.822E-01	2.822E-01	2.821E-01	2.821E-01	2.820E-01
PU240	1.658E-01	1.658E-01	1.658E-01	1.658E-01	1.659E-01	1.659E-01	1.659E-01	1.659E-01	1.659E-01	1.658E-01
PU241	4.227E+01	3.839E+01	3.486E+01	3.167E+01	2.741E+01	2.154E+01	1.694E+01	1.331E+01	1.046E+01	8.227E+00
PU242	4.184E-04	4.184E-04	4.184E-04	4.184E-04	4.184E-04	4.184E-04	4.185E-04	4.185E-04	4.185E-04	4.185E-04
PU244	5.389E-11	5.389E-11								
AM241	1.456E+00	1.580E+00	1.692E+00	1.793E+00	1.926E+00	2.105E+00	2.241E+00	2.344E+00	2.420E+00	2.474E+00
AM242M	1.676E-02	1.660E-02	1.645E-02	1.630E-02	1.608E-02	1.572E-02	1.537E-02	1.502E-02	1.468E-02	1.435E-02
AM242	1.667E-02	1.652E-02	1.637E-02	1.622E-02	1.600E-02	1.564E-02	1.529E-02	1.494E-02	1.461E-02	1.428E-02
AM243	3.199E-03	3.199E-03	3.198E-03	3.198E-03	3.197E-03	3.195E-03	3.194E-03	3.192E-03	3.191E-03	3.189E-03
CM242	1.382E-02	1.369E-02	1.356E-02	1.344E-02	1.326E-02	1.294E-02	1.265E-02	1.236E-02	1.209E-02	1.181E-02
CM243	5.283E-03	5.032E-03	4.793E-03	4.565E-03	4.244E-03	3.758E-03	3.328E-03	2.947E-03	2.609E-03	2.311E-03
CM244	3.293E-01	3.051E-01	2.826E-01	2.618E-01	2.334E-01	1.927E-01	1.592E-01	1.314E-01	1.085E-01	8.964E-02
CM245	7.145E-05	7.143E-05	7.142E-05	7.141E-05	7.139E-05	7.136E-05	7.134E-05	7.131E-05	7.128E-05	7.125E-05
CM246	4.737E-06	4.735E-06	4.734E-06	4.732E-06	4.730E-06	4.727E-06	4.723E-06	4.720E-06	4.716E-06	4.713E-06
CM247	1.674E-11	1.674E-11								
AP+ACT+FP	1.085E+05	1.029E+05	9.771E+04	9.295E+04	8.640E+04	7.669E+04	6.820E+04	6.072E+04	5.411E+04	4.826E+04

Table 2-5A Page 5

Table 2-5B. Isotopic Activity Concentrations in Curies for a single LWBR Standard Blanket Module (TYPE I).

Information:	Units:	CURIES
Burnup:		13,555.10 MWD (max)
Burnup:		12551.74 MWD/MTHM
BOL U-233:		16,471.46 grams U-233 per module
BOL U-234:		216.31 grams U-234 per module
BOL U-235:		15.09 grams U-235 per module
BOL U-236:		3.35 grams U-236 per module
BOL U-238:		62.04 grams U-238 per module
BOL Th-232:		1319931.77 grams Th-232 per module
Fuel Metal:		UO ₂ -ThO ₂ (Urania-Thoria)
Fuel Enrichment:		98.23 wt% U-233
Clad:		Zircaloy-4

DECAY DATES							
ISOTOPES	1-Jul-96	1-Jul-98	1-Jul-00	1-Jul-02	1-Jul-05	1-Jul-10	1-Jul-15
H 3	9.651E+01	8.627E+01	7.711E+01	6.892E+01	5.824E+01	4.399E+01	3.323E+01
BE 10	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06
C 14	1.712E+00	1.711E+00	1.711E+00	1.710E+00	1.709E+00	1.708E+00	1.707E+00
CL 36	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.181E-02
CR 51	3.524E-52	4.132E-60	4.725E-68	5.539E-76	6.859E-88	9.958E-108	1.446E-127
MN 54	6.309E-04	1.249E-04	2.469E-05	4.890E-06	4.301E-07	7.492E-09	1.305E-10
FE 55	9.369E+00	5.499E+00	3.225E+00	1.893E+00	8.506E-01	2.243E-01	5.917E-02
FE 59	3.634E-33	4.753E-38	6.122E-43	8.008E-48	3.731E-55	2.273E-67	1.385E-79
CO 60	2.552E+02	1.962E+02	1.508E+02	1.159E+02	7.812E+01	4.047E+01	2.097E+01
NI 59	1.405E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01
NI 63	1.700E+01	1.675E+01	1.650E+01	1.625E+01	1.589E+01	1.530E+01	1.474E+01
ZN 65	2.528E-05	3.175E-06	3.975E-07	4.991E-08	2.215E-09	1.234E-11	6.874E-14
SE 79	4.782E-01	4.782E-01	4.782E-01	4.782E-01	4.781E-01	4.781E-01	4.781E-01
KR 85	3.415E+03	3.001E+03	2.636E+03	2.317E+03	1.908E+03	1.381E+03	9.997E+02
RB 87	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05

SR 89	4.691E-25	2.087E-29	9.161E-34	4.075E-38	1.193E-44	1.554E-55	2.023E-66	2.599E-77	3.385E-88	4.409E-99
SR 90	3.379E+04	3.222E+04	3.072E+04	2.929E+04	2.727E+04	2.421E+04	2.150E+04	1.908E+04	1.694E+04	1.504E+04
Y 90	3.380E+04	3.223E+04	3.073E+04	2.930E+04	2.728E+04	2.422E+04	2.150E+04	1.909E+04	1.695E+04	1.505E+04
Y 91	6.098E-21	1.069E-24	1.854E-28	3.251E-32	7.463E-38	3.004E-47	1.209E-56	4.813E-66	1.937E-75	7.800E-85
ZR 93	1.126E+00									
ZR 95	9.859E-19	3.624E-22	1.318E-25	4.845E-29	3.378E-34	8.658E-43	2.219E-51	5.627E-60	1.442E-68	3.696E-77
NB 93M	6.061E-01	6.917E-01	7.284E-01	7.768E-01	8.428E-01	8.939E-01	9.335E-01	9.642E-01	9.880E-01	
NB 94	3.098E-02	3.097E-02	3.097E-02	3.097E-02	3.097E-02	3.096E-02	3.096E-02	3.095E-02	3.095E-02	3.094E-02
NB 95	2.189E-18	8.046E-22	2.926E-25	1.075E-28	7.499E-34	1.922E-42	4.927E-51	1.249E-59	3.202E-68	8.205E-77
NB 95M	7.314E-21	2.689E-24	9.777E-28	3.594E-31	2.506E-36	6.423E-45	1.646E-53	4.174E-62	1.070E-70	2.742E-79
MO 93	8.749E-03	8.745E-03	8.742E-03	8.739E-03	8.733E-03	8.725E-03	8.716E-03	8.707E-03	8.699E-03	8.690E-03
TC 99	4.471E+00									
RU103	3.759E-34	9.569E-40	2.394E-45	6.094E-51	2.432E-59	2.471E-73	2.511E-87	2.507-101	2.548-115	2.589-129
RU106	1.360E+00	3.440E-01	8.686E-02	2.198E-02	2.792E-03	8.971E-05	2.883E-06	9.247E-08	2.972E-09	9.550E-11
RH103M	3.388E-34	8.627E-40	2.158E-45	5.494E-51	2.193E-59	2.228E-73	2.264E-87	2.260-101	2.297-115	2.334-129
RH106	1.360E+00	3.440E-01	8.686E-02	2.198E-02	2.792E-03	8.971E-05	2.883E-06	9.247E-08	2.972E-09	9.550E-11
PD107	4.673E-03									
AG110	1.189E-06	1.570E-07	2.067E-08	2.728E-09	1.305E-10	8.238E-13	5.201E-15	3.274E-17	2.067E-19	1.305E-21
AG110M	8.943E-05	1.181E-05	1.554E-06	2.061E-07	9.811E-09	6.194E-11	3.910E-13	2.462E-15	1.554E-17	9.812E-20
AG111	0.000E+00									
CD113M	2.942E+00	2.675E+00	2.432E+00	2.212E+00	1.918E+00	1.513E+00	1.193E+00	9.405E-01	7.417E-01	5.849E-01
CD113	0.000E+00									
CD115M	1.639E-32	1.935E-37	2.250E-42	2.657E-47	1.062E-54	5.012E-67	2.366E-79	1.100E-91	5.188-104	2.449-116
IN114	4.824E-30	1.759E-34	6.323E-39	2.305E-43	5.004E-50	3.961E-61	3.135E-72	2.447E-83	1.937E-94	1.533-105
IN114M	5.041E-30	1.838E-34	6.607E-39	2.409E-43	5.230E-50	4.139E-61	3.276E-72	2.557E-83	2.024E-94	1.602-105
IN115M	1.151E-36	1.359E-41	1.581E-46	1.867E-51	7.461E-59	3.521E-71	1.662E-83	7.723E-96	3.645-108	1.720-120
SN119M	2.108E-03	2.673E-04	3.379E-05	4.285E-06	1.930E-07	1.102E-09	6.290E-12	3.582E-14	2.044E-16	1.168E-18
SN121M	6.561E-01	6.381E-01	6.206E-01	6.037E-01	5.790E-01	5.403E-01	5.040E-01	4.703E-01	4.388E-01	4.093E-01
SN123	1.501E-09	2.986E-11	5.908E-13	1.175E-14	3.279E-17	1.821E-21	1.011E-25	5.581E-30	3.098E-34	1.720E-38
SN125	0.000E+00									
SN126	5.351E-01	5.350E-01	5.350E-01	5.350E-01						
SB124	1.440E-23	3.219E-27	7.114E-31	1.590E-34	5.257E-40	3.885E-49	2.870E-58	2.096E-67	1.549E-76	1.145E-85
SB125	2.233E+02	1.354E+02	8.207E+01	4.977E+01	2.348E+01	6.722E+00	1.924E+00	5.502E-01	1.575E-01	4.507E-02
SB126	7.492E-02	7.492E-02	7.492E-02	7.491E-02	7.491E-02	7.491E-02	7.491E-02	7.490E-02	7.490E-02	7.490E-02
SB126M	5.351E-01	5.350E-01	5.350E-01	5.350E-01						
TE123M	5.544E-13	8.081E-15	1.171E-16	1.708E-18	2.990E-21	7.631E-26	1.947E-30	4.942E-35	1.261E-39	3.219E-44
TE125M	5.448E+01	3.305E+01	2.003E+01	1.215E+01	5.731E+00	1.640E+00	4.694E-01	1.342E-01	3.842E-02	1.100E-02

Table 2-5B Page 2

TE127	8.394E-11	8.091E-13	7.749E-15	7.469E-17	7.023E-20	6.365E-25	5.768E-30	5.195E-35	4.708E-40	4.267E-45
TE127M	8.570E-11	8.260E-13	7.911E-15	7.625E-17	7.170E-20	6.498E-25	5.889E-30	5.303E-35	4.806E-40	4.356E-45
TE129	1.336E-41	3.851E-48	1.087E-54	3.133E-61	4.748E-71	2.074E-87	9.057E-104	3.875E-120	1.692E-136	7.391E-153
TE129M	2.053E-41	5.916E-48	1.670E-54	4.813E-61	7.294E-71	3.186E-87	1.391E-103	5.963E-120	2.600E-136	1.135E-152
I129	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	3.812E+02	1.947E+02	9.936E+01	5.075E+01	1.851E+01	3.447E+00	6.421E-01	1.195E-01	2.226E-02	4.146E-03
CS135	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	3.286E+04	3.138E+04	2.996E+04	2.861E+04	2.669E+04	2.378E+04	2.119E+04	1.887E+04	1.682E+04	1.498E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	3.109E+04	2.969E+04	2.834E+04	2.706E+04	2.525E+04	2.250E+04	2.004E+04	1.786E+04	1.591E+04	1.417E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.427E-41	2.485E-48	4.236E-55	7.374E-62	5.244E-72	6.493E-89	8.039E-106	9.744E-123	1.206E-139	1.494E-156
CE142	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05
CE144	1.359E+00	2.292E-01	3.856E-02	6.502E-03	4.491E-04	5.232E-06	6.094E-08	7.081E-10	8.249E-12	9.609E-14
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	1.359E+00	2.292E-01	3.856E-02	6.502E-03	4.491E-04	5.232E-06	6.094E-08	7.082E-10	8.249E-12	9.609E-14
PR144M	1.631E-02	2.751E-03	4.627E-04	7.802E-05	5.390E-06	6.278E-08	7.313E-10	8.498E-12	9.899E-14	1.153E-15
ND144	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM145	8.478E-03	7.840E-03	7.249E-03	6.704E-03	5.960E-03	4.901E-03	4.029E-03	3.313E-03	2.724E-03	2.239E-03
PM147	1.191E+03	7.022E+02	4.138E+02	2.441E+02	1.105E+02	2.948E+01	7.868E+00	2.099E+00	5.601E-01	1.495E-01
PM148M	3.409E-33	1.627E-38	7.632E-44	3.642E-49	3.732E-57	1.825E-70	8.926E-84	4.293E-97	2.099E-110	1.027E-123
PM148	1.920E-34	9.162E-40	4.299E-45	2.051E-50	2.102E-58	1.028E-71	5.028E-85	2.418E-98	1.182E-111	5.782E-125
SM145	2.457E-06	5.548E-07	1.250E-07	2.823E-08	3.024E-09	7.312E-11	1.768E-12	4.267E-14	1.032E-15	2.496E-17
SM147	1.954E-06	1.966E-06	1.973E-06	1.977E-06	1.980E-06	1.982E-06	1.983E-06	1.983E-06	1.983E-06	1.983E-06
SM151	1.589E+02	1.564E+02	1.540E+02	1.517E+02	1.482E+02	1.426E+02	1.373E+02	1.321E+02	1.271E+02	1.223E+02
EU152	2.550E+00	2.302E+00	2.080E+00	1.878E+00	1.611E+00	1.249E+00	9.681E-01	7.502E-01	5.815E-01	4.507E-01
EU154	5.409E+02	4.604E+02	3.918E+02	3.335E+02	2.619E+02	1.750E+02	1.170E+02	7.817E+01	5.225E+01	3.492E+01
EU155	1.475E+02	1.115E+02	8.430E+01	6.374E+01	4.191E+01	2.084E+01	1.036E+01	5.150E+00	2.561E+00	1.273E+00
EU156	1.921E-96	6.489E-111	2.094E-125	7.071E-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.130E-05	2.632E-06	3.243E-07	4.009E-08	1.736E-09	9.299E-12	4.979E-14	2.659E-16	1.423E-18	7.621E-21
TB160	2.784E-20	2.543E-23	2.301E-26	2.102E-29	5.747E-34	1.435E-41	3.585E-49	8.871E-57	2.216E-64	5.535E-72

Table 2-5B Page 3

TL206	1.261E-12										
TL207	1.058E+00	1.156E+00	1.247E+00	1.333E+00	1.452E+00	1.626E+00	1.775E+00	1.902E+00	2.010E+00	2.103E+00	2.103E+00
TL208	2.884E+02	2.837E+02	2.786E+02	2.734E+02	2.656E+02	2.529E+02	2.410E+02	2.297E+02	2.189E+02	2.086E+02	2.086E+02
PB210	1.697E-04	1.662E-04	1.639E-04	1.625E-04	1.621E-04	1.658E-04	1.742E-04	1.869E-04	2.034E-04	2.233E-04	2.233E-04
PB211	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00	2.109E+00
PB212	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02	5.806E+02
BI211	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00	2.109E+00
BI212	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02	5.806E+02
PO212	5.143E+02	5.059E+02	4.968E+02	4.876E+02	4.735E+02	4.509E+02	4.298E+02	4.096E+02	3.903E+02	3.720E+02	3.720E+02
PO215	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00	2.109E+00
PO216	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02	5.806E+02
RN219	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00	2.109E+00
RN220	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02	5.806E+02
FR223	1.461E-02	1.596E-02	1.723E-02	1.841E-02	2.005E-02	2.246E-02	2.452E-02	2.627E-02	2.777E-02	2.904E-02	2.904E-02
RA223	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00	2.109E+00
RA224	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02	5.806E+02
RA226	1.062E-04	1.199E-04	1.337E-04	1.478E-04	1.691E-04	2.055E-04	2.430E-04	2.815E-04	3.211E-04	3.616E-04	3.616E-04
RA228	1.219E-01	1.257E-01	1.289E-01	1.314E-01	1.344E-01	1.377E-01	1.397E-01	1.408E-01	1.415E-01	1.419E-01	1.419E-01
AC227	1.059E+00	1.157E+00	1.248E+00	1.334E+00	1.453E+00	1.628E+00	1.777E+00	1.904E+00	2.012E+00	2.105E+00	2.105E+00
TH227	1.046E+00	1.143E+00	1.234E+00	1.318E+00	1.436E+00	1.608E+00	1.756E+00	1.881E+00	1.988E+00	2.080E+00	2.080E+00
TH228	8.010E+02	7.875E+02	7.734E+02	7.591E+02	7.377E+02	7.032E+02	6.702E+02	6.387E+02	6.087E+02	5.801E+02	5.801E+02
TH229	3.428E-01	3.811E-01	4.195E-01	4.578E-01	5.153E-01	6.111E-01	7.068E-01	8.025E-01	8.981E-01	9.937E-01	9.937E-01
TH230	1.581E-02	1.602E-02	1.623E-02	1.643E-02	1.674E-02	1.726E-02	1.778E-02	1.830E-02	1.882E-02	1.933E-02	1.933E-02
TH231	7.749E-04										
TH232	1.426E-01										
TH234	1.814E-05										
PA231	2.641E+00	2.641E+00	2.641E+00	2.641E+00	2.641E+00	2.641E+00	2.640E+00	2.640E+00	2.640E+00	2.640E+00	2.640E+00
PA233	1.182E-03	1.183E-03	1.184E-03	1.185E-03	1.186E-03	1.189E-03	1.193E-03	1.196E-03	1.199E-03	1.203E-03	1.203E-03
PA234M	1.814E-05										
PA234	2.358E-08										
U232	7.831E+02	7.682E+02	7.536E+02	7.392E+02	7.181E+02	6.844E+02	6.522E+02	6.216E+02	5.924E+02	5.645E+02	5.645E+02
U233	2.034E+02										
U234	1.153E+01	1.153E+01	1.153E+01	1.153E+01	1.153E+01	1.152E+01	1.152E+01	1.152E+01	1.152E+01	1.152E+01	1.152E+01
U235	7.749E-04										
U236	1.523E-03										
U237	9.216E-06	8.371E-06	7.602E-06	6.904E-06	5.976E-06	4.698E-06	3.693E-06	2.903E-06	2.282E-06	1.794E-06	1.794E-06
U238	1.814E-05										

NP237	1.182E-03	1.183E-03	1.184E-03	1.185E-03	1.186E-03	1.189E-03	1.193E-03	1.196E-03	1.199E-03	1.203E-03
PU236	1.155E-05	7.106E-06	4.369E-06	2.688E-06	1.297E-06	3.855E-07	1.154E-07	3.520E-08	1.145E-08	4.405E-09
PU237	1.680E-36	2.547E-41	3.805E-46	5.771E-51	3.357E-58	2.962E-70	2.613E-82	2.271E-94	2.003E-106	1.767E-118
PU238	4.516E+00	4.446E+00	4.376E+00	4.308E+00	4.207E+00	4.045E+00	3.888E+00	3.738E+00	3.594E+00	3.455E+00
PU239	2.430E-01	2.430E-01	2.429E-01	2.429E-01	2.429E-01	2.429E-01	2.429E-01	2.428E-01	2.428E-01	2.428E-01
PU240	1.481E-01	1.481E-01	1.481E-01	1.481E-01	1.482E-01	1.482E-01	1.482E-01	1.482E-01	1.481E-01	1.481E-01
PU241	3.757E+01	3.412E+01	3.099E+01	2.815E+01	2.436E+01	1.915E+01	1.505E+01	1.183E+01	9.301E+00	7.312E+00
PU242	4.069E-04	4.070E-04	4.070E-04							
PU244	4.173E-11	4.173E-11								
AM241	1.317E+00	1.427E+00	1.527E+00	1.617E+00	1.735E+00	1.894E+00	2.014E+00	2.105E+00	2.172E+00	2.221E+00
AM242M	1.194E-02	1.183E-02	1.172E-02	1.162E-02	1.146E-02	1.120E-02	1.095E-02	1.070E-02	1.046E-02	1.022E-02
AM242	1.188E-02	1.177E-02	1.167E-02	1.156E-02	1.140E-02	1.115E-02	1.089E-02	1.065E-02	1.041E-02	1.017E-02
AM243	3.053E-03	3.052E-03	3.051E-03	3.051E-03	3.050E-03	3.049E-03	3.047E-03	3.046E-03	3.044E-03	3.043E-03
CM242	9.844E-03	9.753E-03	9.665E-03	9.577E-03	9.450E-03	9.221E-03	9.013E-03	8.810E-03	8.612E-03	8.418E-03
CM243	4.174E-03	3.976E-03	3.787E-03	3.607E-03	3.354E-03	2.970E-03	2.630E-03	2.328E-03	2.062E-03	1.826E-03
CM244	2.685E-01	2.487E-01	2.304E-01	2.134E-01	1.903E-01	1.571E-01	1.298E-01	1.072E-01	8.849E-02	7.308E-02
CM245	4.965E-05	4.964E-05	4.963E-05	4.962E-05	4.961E-05	4.959E-05	4.957E-05	4.955E-05	4.953E-05	4.951E-05
CM246	3.660E-06	3.659E-06	3.658E-06	3.657E-06	3.655E-06	3.653E-06	3.650E-06	3.647E-06	3.645E-06	3.642E-06
CM247	1.150E-11	1.150E-11								
SUBTOTAL	1.447E+05	1.372E+05	1.303E+05	1.240E+05	1.153E+05	1.025E+05	9.119E+04	8.126E+04	7.248E+04	6.470E+04
AP+ACT+FP	1.447E+05	1.372E+05	1.303E+05	1.240E+05	1.153E+05	1.025E+05	9.119E+04	8.126E+04	7.248E+04	6.471E+04

Table 2-5B Page 5

Table 2-5C. Isotopic Activity Concentrations in Curies for a single LWBR Standard/Power Flattening (PF) Blanket Module (TYPE II).

Information:	Units:	CURIES
Burnup:		15098.75 MWd (max)
Burnup:		9682.70 MWd/MTHM
BOL U-233:	25020.61	grams U-233 per module
BOL U-234:	328.58	grams U-234 per module
BOL U-235:	22.92	grams U-235 per module
BOL U-236:	5.10	grams U-236 per module
BOL U-238:	94.24	grams U-238 per module
BOL Th-232:	1533876.10	grams Th-232 per module
Fuel Meat:		UO ₂ -ThO ₂ (Urania-Thoria)
Fuel Enrichment:		98.23 wt% U-233
Clad:		Zircaloy-4

DECAY DATES						
ISOTOPES	1-Jul-96	1-Jul-98	1-Jul-00	1-Jul-02	1-Jul-05	1-Jul-10
H 3	1.073E+02	9.568E+01	8.569E+01	7.660E+01	6.472E+01	4.889E+01
BE 10	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06
C 14	1.650E+00	1.649E+00	1.648E+00	1.647E+00	1.646E+00	1.645E+00
CL 36	4.026E-02	4.026E-02	4.026E-02	4.026E-02	4.026E-02	4.025E-02
CR 51	3.732E-52	4.376E-60	5.004E-68	5.867E-76	7.264E-88	1.055-107
MN 54	6.473E-04	1.282E-04	2.534E-05	5.018E-06	4.413E-07	7.688E-09
FE 55	9.354E+00	5.491E+00	3.220E+00	1.890E+00	8.493E-01	2.240E-01
FE 59	3.763E-33	4.922E-38	6.339E-43	8.292E-48	3.863E-55	2.354E-67
CO 60	2.516E+02	1.935E+02	1.487E+02	1.143E+02	7.704E+01	3.991E+01
NI 59	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01
NI 63	1.638E+01	1.614E+01	1.589E+01	1.566E+01	1.531E+01	1.474E+01
ZN 65	2.650E-05	3.328E-06	4.167E-07	5.232E-08	2.322E-09	1.293E-11
SE 79	5.349E-01	5.349E-01	5.349E-01	5.349E-01	5.348E-01	5.348E-01
KR 85	3.789E+03	3.329E+03	2.925E+03	2.571E+03	2.117E+03	1.109E+03
RB 87	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05

SR 89	5.220E-25	2.322E-29	1.019E-33	4.534E-38	1.327E-44	1.729E-55	2.251E-66	2.892E-77	3.766E-88	4.905E-99
SR 90	3.587E+04	3.420E+04	3.261E+04	3.037E+04	2.696E+04	2.394E+04	2.125E+04	1.886E+04	1.675E+04	1.675E+04
Y 90	3.763E+04	3.588E+04	3.421E+04	3.262E+04	3.037E+04	2.697E+04	2.394E+04	2.125E+04	1.887E+04	1.675E+04
Y 91	6.786E-21	1.190E-24	2.063E-28	3.618E-32	8.305E-38	3.343E-47	1.346E-56	5.355E-66	2.156E-75	8.679E-85
ZR 93	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00
ZR 95	1.096E-18	4.028E-22	1.464E-25	5.384E-29	3.754E-34	9.622E-43	2.466E-51	6.252E-60	1.603E-68	4.108E-77
NB 93M	6.675E-01	7.170E-01	7.618E-01	8.022E-01	8.556E-01	9.283E-01	9.846E-01	1.028E+00	1.062E+00	1.088E+00
NB 94	3.123E-02	3.122E-02	3.122E-02	3.122E-02	3.122E-02	3.121E-02	3.121E-02	3.120E-02	3.120E-02	3.119E-02
NB 95	2.432E-18	8.943E-22	3.252E-25	1.196E-28	8.335E-34	2.136E-42	5.476E-51	1.388E-59	3.558E-68	9.119E-77
NB 95M	8.128E-21	2.988E-24	1.087E-27	3.994E-31	2.785E-36	7.138E-45	1.830E-53	4.639E-62	1.189E-70	3.047E-79
MO 93	8.376E-03	8.373E-03	8.370E-03	8.367E-03	8.362E-03	8.353E-03	8.345E-03	8.337E-03	8.328E-03	8.320E-03
TC 99	5.066E+00	5.065E+00								
RU103	4.186E-34	1.066E-39	2.666E-45	6.788E-51	2.709E-59	2.753E-73	2.797E-87	2.793-101	2.838-115	2.883-129
RU106	1.519E+00	3.844E-01	9.707E-02	2.456E-02	3.119E-03	1.002E-04	3.222E-06	1.033E-07	3.321E-09	1.067E-10
RH103M	3.774E-34	9.608E-40	2.403E-45	6.119E-51	2.442E-59	2.482E-73	2.522E-87	2.517-101	2.558-115	2.599-129
RH106	1.519E+00	3.844E-01	9.707E-02	2.456E-02	3.119E-03	1.002E-04	3.222E-06	1.033E-07	3.321E-09	1.067E-10
PD107	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03
AG110	1.197E-06	1.580E-07	2.080E-08	2.746E-09	1.313E-10	8.291E-13	5.234E-15	3.295E-17	2.080E-19	1.313E-21
AG110M	9.000E-05	1.188E-05	1.564E-06	2.064E-07	9.874E-09	6.233E-11	3.935E-13	2.478E-15	1.564E-17	9.875E-20
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	3.133E+00	2.849E+00	2.591E+00	2.356E+00	2.043E+00	1.611E+00	1.271E+00	1.002E+00	7.900E-01	6.230E-01
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.802E-32	2.128E-37	2.474E-42	1.922E-47	1.168E-54	5.511E-67	2.601E-79	1.209E-91	5.705-104	2.692-116
IN114	4.298E-30	1.567E-34	5.635E-39	2.054E-43	4.460E-50	3.530E-61	2.794E-72	2.181E-83	1.726E-94	1.366-105
IN114M	4.492E-30	1.637E-34	5.888E-39	2.147E-43	4.660E-50	3.688E-61	2.919E-72	2.279E-83	1.804E-94	1.428-105
IN115M	1.266E-36	1.496E-41	1.738E-46	2.053E-51	8.203E-59	3.872E-71	1.827E-83	8.491E-96	4.007-108	1.891-120
SN119M	2.213E-03	2.806E-04	3.548E-05	4.498E-06	2.026E-07	1.157E-09	6.603E-12	3.759E-14	2.146E-16	1.225E-18
SN121M	6.731E-01	6.547E-01	6.368E-01	6.194E-01	5.941E-01	5.543E-01	5.172E-01	4.825E-01	4.502E-01	4.201E-01
SN123	1.6558E-09	3.299E-11	6.527E-13	1.299E-14	3.623E-17	2.011E-21	1.117E-25	6.166E-30	3.423E-34	1.900E-38
SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	5.999E-01	5.999E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.997E-01	5.997E-01
SB124	1.410E-23	3.153E-27	6.970E-31	1.559E-34	5.151E-40	3.805E-49	2.812E-58	2.054E-67	1.518E-76	1.121E-85
SB125	2.459E+02	1.492E+02	9.039E+01	5.481E+01	2.587E+01	7.404E+00	2.119E+00	6.061E-01	1.735E-01	4.964E-02
SB126	8.398E-02	8.398E-02	8.398E-02	8.398E-02	8.398E-02	8.397E-02	8.397E-02	8.396E-02	8.396E-02	8.396E-02
SB126M	5.999E-01	5.998E-01	5.997E-01	5.997E-01						
TE123M	4.183E-13	6.099E-15	8.841E-17	1.289E-18	2.257E-21	5.759E-26	1.470E-30	3.730E-35	9.520E-40	2.429E-44
TE125M	6.001E+01	3.640E+01	2.206E+01	1.338E+01	6.311E+00	1.806E+00	5.170E-01	1.479E-01	4.232E-02	1.211E-02

Table 2-5C Page 2

TE127	9.303E-11	9.053E-13	8.671E-15	8.357E-17	7.858E-20	7.122E-25	6.455E-30	5.813E-35	5.268E-40	4.774E-45
TE127M	9.589E-11	9.243E-13	8.852E-15	8.532E-17	8.023E-20	7.271E-25	6.590E-30	5.934E-35	5.378E-40	4.874E-45
TE129	1.494E-41	4.304E-48	1.215E-54	3.502E-61	5.307E-71	2.318E-87	1.012E-103	4.331E-120	1.892E-136	8.261E-153
TE129M	2.295E-41	6.613E-48	1.867E-54	5.380E-61	8.153E-71	3.561E-87	1.555E-103	6.653E-120	2.906E-136	1.269E-152
I129	2.430E-02	2.430E-02	2.430E-02	2.430E-02						
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
CS134	3.722E+02	1.901E+01	4.954E+01	1.807E+01	3.365E+00	6.269E-01	1.167E-01	2.173E-02	4.047E-03	
CS135	4.358E-01	4.358E-01	4.358E-01	4.358E-01						
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
CS137	3.662E+04	3.497E+04	3.339E+04	3.188E+04	2.974E+04	2.650E+04	2.361E+04	2.103E+04	1.874E+04	1.669E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
BA137M	3.464E+04	3.308E+04	3.158E+04	3.016E+04	2.814E+04	2.507E+04	2.233E+04	1.990E+04	1.773E+04	1.579E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
CE141	1.589E-41	2.766E-48	4.714E-55	8.207E-62	5.836E-72	7.226E-89	8.946E-106	1.084E-122	1.343E-139	1.662E-156
CE142	1.499E-05	1.499E-05	1.499E-05	1.499E-05						
CE144	1.510E+00	2.545E-01	4.282E-02	7.221E-03	4.988E-04	5.810E-06	6.768E-08	7.864E-10	9.161E-12	1.067E-13
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
PR144	1.510E+00	2.546E-01	4.282E-02	7.221E-03	4.988E-04	5.810E-06	6.768E-08	7.865E-10	9.161E-12	1.067E-13
PR144M	1.811E-02	3.055E-03	5.138E-04	8.665E-05	5.985E-06	6.972E-08	8.121E-10	9.437E-12	1.099E-13	1.281E-15
ND144	6.110E-10	6.110E-10	6.110E-10	6.110E-10						
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00						
PM145	8.551E-03	7.907E-03	7.311E-03	6.761E-03	6.011E-03	4.943E-03	4.064E-03	3.341E-03	2.747E-03	2.259E-03
PM147	1.423E+03	8.393E+02	4.946E+02	2.917E+02	1.320E+02	3.524E+01	9.404E+00	2.508E+00	6.695E-01	1.787E-01
PM148M	3.749E-33	1.789E-38	8.394E-44	4.005E-49	4.105E-57	2.007E-70	9.817E-84	4.721E-97	2.309E-110	1.129E-123
PM148	2.112E-34	1.008E-39	4.728E-45	2.256E-50	2.312E-58	1.131E-71	5.529E-85	2.659E-98	1.300E-111	6.359E-125
SM145	2.579E-06	5.824E-07	1.313E-07	2.964E-08	3.174E-09	7.676E-11	1.856E-12	4.480E-14	1.083E-15	2.620E-17
SM147	2.363E-06	2.377E-06	2.386E-06	2.391E-06	2.394E-06	2.397E-06	2.397E-06	2.398E-06	2.398E-06	2.398E-06
SM151	1.919E+02	1.889E+02	1.860E+02	1.832E+02	1.790E+02	1.722E+02	1.657E+02	1.594E+02	1.534E+02	1.476E+02
EU152	3.499E+00	3.160E+00	2.854E+00	2.577E+00	2.212E+00	1.714E+00	1.329E+00	1.029E+00	7.981E-01	6.186E-01
EU154	5.113E+02	4.352E+02	3.704E+02	3.152E+02	2.475E+02	1.655E+02	1.106E+02	7.388E+01	4.938E+01	3.300E+01
EU155	1.400E+02	1.059E+02	8.004E+01	6.053E+01	3.980E+01	1.979E+01	9.839E+00	4.890E+00	2.431E+00	1.208E+00
EU156	1.684E-96	5.688-111	1.835-125	6.197-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.534E-05	3.132E-06	3.860E-07	4.771E-08	2.067E-09	1.107E-11	5.926E-14	3.164E-16	9.071E-21	
TB160	2.701E-20	2.467E-23	2.232E-26	2.039E-29	5.575E-34	1.393E-41	3.479E-49	8.606E-57	2.150E-64	5.370E-72

Table 2-5C Page 3

TL206	1.321E-12												
TL207	1.120E+00	1.224E+00	1.321E+00	1.412E+00	1.537E+00	1.722E+00	1.880E+00	2.014E+00	2.129E+00	2.227E+00	2.227E+00	2.227E+00	2.227E+00
TL208	2.528E+02	2.487E+02	2.442E+02	2.397E+02	2.328E+02	2.217E+02	2.113E+02	2.014E+02	1.919E+02	1.829E+02	1.829E+02	1.829E+02	1.829E+02
PB210	1.261E-04	1.255E-04	1.257E-04	1.268E-04	1.300E-04	1.390E-04	1.522E-04	1.693E-04	1.897E-04	2.133E-04	2.133E-04	2.133E-04	2.133E-04
PB211	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00	2.233E+00	2.233E+00	2.233E+00
PB212	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02	5.090E+02	5.090E+02	5.090E+02
BI211	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00	2.233E+00	2.233E+00	2.233E+00
BI212	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02	5.090E+02	5.090E+02	5.090E+02
PO212	4.508E+02	4.435E+02	4.355E+02	4.275E+02	4.151E+02	3.953E+02	3.768E+02	3.591E+02	3.422E+02	3.261E+02	3.261E+02	3.261E+02	3.261E+02
PO215	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00	2.233E+00	2.233E+00	2.233E+00
PO216	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02	5.090E+02	5.090E+02	5.090E+02
RN219	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00	2.233E+00	2.233E+00	2.233E+00
RN220	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02	5.090E+02	5.090E+02	5.090E+02
FR223	1.548E-02	1.690E-02	1.824E-02	1.949E-02	2.123E-02	2.379E-02	2.597E-02	2.782E-02	2.941E-02	3.075E-02	3.075E-02	3.075E-02	3.075E-02
RA223	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00	2.233E+00	2.233E+00	2.233E+00
RA224	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02	5.090E+02	5.090E+02	5.090E+02
RA226	1.082E-04	1.224E-04	1.367E-04	1.512E-04	1.733E-04	2.112E-04	2.503E-04	2.906E-04	3.320E-04	3.747E-04	3.747E-04	3.747E-04	3.747E-04
RA228	1.421E-01	1.466E-01	1.503E-01	1.532E-01	1.567E-01	1.605E-01	1.628E-01	1.641E-01	1.654E-01	1.654E-01	1.654E-01	1.654E-01	1.654E-01
AC227	1.121E+00	1.225E+00	1.322E+00	1.413E+00	1.539E+00	1.724E+00	1.882E+00	2.016E+00	2.131E+00	2.229E+00	2.229E+00	2.229E+00	2.229E+00
TH227	1.108E+00	1.210E+00	1.306E+00	1.396E+00	1.520E+00	1.703E+00	1.859E+00	1.992E+00	2.105E+00	2.202E+00	2.202E+00	2.202E+00	2.202E+00
TH228	7.021E+02	6.904E+02	6.780E+02	6.655E+02	6.468E+02	6.165E+02	5.875E+02	5.599E+02	5.336E+02	5.086E+02	5.086E+02	5.086E+02	5.086E+02
TH229	4.352E-01	4.841E-01	5.330E-01	5.818E-01	6.551E-01	7.772E-01	8.993E-01	1.021E+00	1.143E+00	1.265E+00	1.265E+00	1.265E+00	1.265E+00
TH230	1.631E-02	1.654E-02	1.678E-02	1.702E-02	1.737E-02	1.797E-02	1.856E-02	1.916E-02	1.975E-02	2.035E-02	2.035E-02	2.035E-02	2.035E-02
TH231	7.946E-04	7.946E-04	7.946E-04	7.947E-04									
TH232	1.661E-01												
TH234	2.826E-05												
PA231	2.797E+00	2.797E+00	2.797E+00	2.797E+00	2.797E+00	2.797E+00	2.796E+00	2.796E+00	2.796E+00	2.795E+00	2.795E+00	2.795E+00	2.795E+00
PA233	1.101E-03	1.102E-03	1.103E-03	1.104E-03	1.106E-03	1.110E-03	1.113E-03	1.117E-03	1.121E-03	1.125E-03	1.125E-03	1.125E-03	1.125E-03
PA234M	2.826E-05												
PA234	3.674E-08												
U232	6.865E+02	6.734E+02	6.606E+02	6.480E+02	6.295E+02	6.000E+02	5.718E+02	5.449E+02	5.193E+02	4.949E+02	4.949E+02	4.949E+02	4.949E+02
U233	2.593E+02												
U234	1.322E+01												
U235	7.946E-04	7.946E-04	7.946E-04	7.947E-04									
U236	1.470E-03												
U237	1.024E-05	9.305E-06	8.450E-06	7.675E-06	6.643E-06	5.222E-06	4.105E-06	3.227E-06	2.537E-06	1.994E-06	1.994E-06	1.994E-06	1.994E-06
U238	2.826E-05												

NP237	1.101E-03	1.102E-03	1.103E-03	1.104E-03	1.106E-03	1.110E-03	1.113E-03	1.117E-03	1.121E-03	1.125E-03
PU236	9.911E-06	6.097E-06	3.748E-06	2.306E-06	1.113E-06	3.309E-07	9.903E-08	3.026E-08	9.883E-09	3.839E-09
PU237	1.294E-36	1.962E-41	2.931E-46	4.446E-51	2.586E-58	2.282E-70	2.013E-82	1.749E-94	1.543E-106	1.362E-118
PU238	3.889E+00	3.828E+00	3.768E+00	3.709E+00	3.623E+00	3.483E+00	3.348E+00	3.219E+00	3.094E+00	2.975E+00
PU239	3.480E-01	3.480E-01	3.480E-01	3.480E-01	3.480E-01	3.479E-01	3.479E-01	3.478E-01	3.478E-01	3.477E-01
PU240	1.954E-01	1.954E-01	1.954E-01	1.953E-01	1.953E-01	1.953E-01	1.952E-01	1.951E-01	1.951E-01	1.950E-01
PU241	4.176E+01	3.793E+01	3.445E+01	3.129E+01	2.708E+01	2.129E+01	1.673E+01	1.315E+01	1.034E+01	8.128E+00
PU242	3.590E-04	3.591E-04	3.591E-04	3.591E-04						
PU244	2.417E-11	2.417E-11								
AM241	1.458E+00	1.581E+00	1.691E+00	1.791E+00	1.922E+00	2.099E+00	2.233E+00	2.334E+00	2.409E+00	2.463E+00
AM242M	1.178E-02	1.168E-02	1.157E-02	1.146E-02	1.131E-02	1.105E-02	1.081E-02	1.056E-02	1.032E-02	1.009E-02
AM242	1.172E-02	1.162E-02	1.151E-02	1.141E-02	1.125E-02	1.100E-02	1.075E-02	1.051E-02	1.027E-02	1.004E-02
AM243	2.243E-03	2.243E-03	2.242E-03	2.242E-03	2.241E-03	2.240E-03	2.239E-03	2.238E-03	2.237E-03	2.236E-03
CM242	9.715E-03	9.625E-03	9.538E-03	9.451E-03	9.325E-03	9.100E-03	8.895E-03	8.694E-03	8.499E-03	8.307E-03
CM243	3.072E-03	2.926E-03	2.787E-03	2.655E-03	2.468E-03	2.185E-03	1.935E-03	1.714E-03	1.517E-03	1.344E-03
CM244	1.567E-01	1.451E-01	1.344E-01	1.245E-01	1.110E-01	9.169E-02	7.572E-02	6.253E-02	5.164E-02	4.265E-02
CM245	2.390E-05	2.390E-05	2.389E-05	2.389E-05	2.388E-05	2.387E-05	2.386E-05	2.385E-05	2.384E-05	2.383E-05
CM246	1.398E-06	1.397E-06	1.397E-06	1.396E-06	1.395E-06	1.394E-06	1.393E-06	1.392E-06	1.391E-06	1.391E-06
CM247	3.556E-12	3.556E-12								
AP+ACT+FP	1.596E+05	1.513E+05	1.437E+05	1.367E+05	1.271E+05	1.128E+05	1.003E+05	8.933E+04	7.961E+04	7.101E+04

Table 2-5D. Isotopic Activity Concentrations in Curies for a single LWBR Standard/Power Flattening (PF) Blanket Module (TYPE III).

Information:	Units:	CURIES
Burnup:		14558.84 MWd (max)
Burnup:		8555.73 MWd/MTHM
BOL U-233:		29415.81 grams U-233 per module
BOL U-234:		386.30 grams U-234 per module
BOL U-235:		26.95 grams U-235 per module
BOL U-236:		5.99 grams U-236 per module
BOL U-238:		110.80 grams U-238 per module
BOL Th-232:		1671701.60 grams Th-232 per module
Fuel Meat:		UO ₂ -ThO ₂ (Urania-Thoria)
Fuel Enrichment:		98.23 wt% U-233
Clad:		Zircaloy-4

DECAY DATES						
ISOTOPE	1-Jul-96	1-Jul-98	1-Jul-00	1-Jul-02	1-Jul-05	1-Jul-10
H 3	1.034E+02	9.239E+01	8.257E+01	7.381E+01	6.237E+01	4.711E+01
BE 10	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06
C 14	1.503E+00	1.502E+00	1.502E+00	1.501E+00	1.500E+00	1.499E+00
CL 36	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02
CR 51	3.425E-52	4.016E-60	4.593E-68	5.385E-76	6.667E-88	9.679E-108
MN 54	5.905E-04	1.169E-04	2.311E-05	4.577E-06	4.026E-07	7.012E-09
FE 55	8.472E+00	4.973E+00	2.916E+00	1.712E+00	7.692E-01	2.029E-01
FE 59	3.425E-33	4.480E-38	5.771E-43	7.549E-48	3.517E-55	2.143E-67
CO 60	2.311E+02	1.777E+02	1.366E+02	1.050E+02	7.076E+01	3.666E+01
Ni 59	1.282E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01
Ni 63	1.506E+01	1.484E+01	1.461E+01	1.440E+01	1.407E+01	1.355E+01
Zn 65	2.390E-05	3.001E-06	3.758E-07	4.719E-08	2.094E-09	1.166E-11
SE 79	5.168E-01	5.168E-01	5.167E-01	5.167E-01	5.167E-01	5.166E-01
KR 85	3.648E+03	3.206E+03	2.817E+03	2.476E+03	2.039E+03	1.476E+03
RB 87	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05

SR 89	5.032E-25	2.239E-29	9.827E-34	4.372E-38	1.280E-44	1.667E-55	2.171E-66	2.788E-77	3.631E-88	4.729E-99
SR 90	3.628E+04	3.459E+04	3.298E+04	3.145E+04	2.928E+04	2.600E+04	2.308E+04	2.049E+04	1.819E+04	1.615E+04
Y 90	3.629E+04	3.460E+04	3.299E+04	3.146E+04	2.929E+04	2.601E+04	2.309E+04	2.050E+04	1.820E+04	1.616E+04
Y 91	6.541E-21	1.147E-24	1.988E-28	3.487E-32	8.005E-38	3.222E-47	1.297E-56	5.162E-66	2.078E-75	8.366E-85
ZR 93	1.188E+00	1.188E+00	1.188E+00							
ZR 95	1.053E-18	3.873E-22	1.408E-25	5.177E-29	3.609E-34	9.251E-43	2.371E-51	6.012E-60	1.541E-68	3.949E-77
NB 93M	6.391E-01	6.865E-01	7.294E-01	7.680E-01	8.192E-01	8.887E-01	9.427E-01	9.845E-01	1.017E+00	1.042E+00
NB 94	2.802E-02	2.802E-02	2.801E-02	2.801E-02	2.801E-02	2.800E-02	2.800E-02	2.799E-02	2.799E-02	2.799E-02
NB 95	2.339E-18	8.598E-22	3.127E-25	1.149E-28	8.013E-34	2.054E-42	5.264E-51	1.335E-59	3.421E-68	8.768E-77
NB 95M	7.815E-21	2.873E-24	1.045E-27	3.840E-31	2.678E-36	6.863E-45	1.759E-53	4.459E-62	1.143E-70	2.930E-79
MO 93	7.658E-03	7.655E-03	7.652E-03	7.649E-03	7.645E-03	7.637E-03	7.629E-03	7.622E-03	7.614E-03	7.607E-03
TC 99	4.947E+00	4.946E+00	4.946E+00	4.946E+00						
RU103	4.031E-34	1.026E-39	2.567E-45	6.536E-51	2.609E-59	2.651E-73	2.693E-87	2.689E-101	2.732E-115	2.776E-129
RU106	1.466E+00	3.708E-01	9.363E-02	2.369E-02	3.009E-03	9.670E-05	3.108E-06	9.968E-08	3.203E-09	1.029E-10
RH103M	3.634E-34	9.252E-40	2.314E-45	5.892E-51	2.352E-59	2.390E-73	2.428E-87	2.424E-101	2.463E-115	2.503E-129
RH106	1.466E+00	3.708E-01	9.363E-02	2.369E-02	3.009E-03	9.670E-05	3.108E-06	9.968E-08	3.203E-09	1.029E-10
PD107	5.077E-03	5.077E-03	5.077E-03							
AG110	1.021E-06	1.347E-07	1.773E-08	2.341E-09	1.120E-10	7.068E-13	4.462E-15	2.809E-17	1.774E-19	1.120E-21
AG110M	7.673E-05	1.013E-05	1.333E-06	1.760E-07	8.418E-09	5.314E-11	3.355E-13	2.112E-15	1.334E-17	8.419E-20
AG111	0.000E+00	0.000E+00	0.000E+00							
CD113M	2.927E+00	2.662E+00	2.421E+00	2.201E+00	1.909E+00	1.505E+00	1.187E+00	9.360E-01	7.381E-01	5.821E-01
CD113	0.000E+00	0.000E+00	0.000E+00							
CD115M	1.728E-32	2.040E-37	2.372E-42	2.801E-47	1.119E-54	5.284E-67	2.494E-79	1.158E-91	5.469E-104	2.581E-116
IN114	3.332E-30	1.215E-34	4.367E-39	1.592E-43	3.456E-50	2.736E-61	2.166E-72	1.690E-83	1.337E-94	1.058E-105
IN114M	3.482E-30	1.269E-34	4.564E-39	1.664E-43	3.612E-50	2.859E-61	2.262E-72	1.766E-83	1.397E-94	1.106E-105
IN115M	1.213E-36	1.433E-41	1.667E-46	1.968E-51	7.865E-59	3.712E-71	1.752E-83	8.141E-96	3.842E-108	1.814E-120
SN119M	1.997E-03	2.533E-04	3.202E-05	4.062E-06	1.829E-07	1.044E-09	5.962E-12	3.394E-14	1.938E-16	1.107E-18
SN121M	6.120E-01	5.953E-01	5.789E-01	5.631E-01	5.401E-01	5.039E-01	4.702E-01	4.386E-01	4.093E-01	3.818E-01
SN123	1.582E-09	3.147E-11	6.227E-13	1.239E-14	3.456E-17	1.919E-21	1.065E-25	5.882E-30	3.265E-34	1.813E-38
SN125	0.000E+00	0.000E+00	0.000E+00							
SN126	5.798E-01	5.798E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.796E-01	5.796E-01	5.796E-01
SB124	1.175E-23	2.627E-27	5.806E-31	1.298E-34	4.291E-40	3.170E-49	2.343E-58	1.711E-67	1.265E-76	9.343E-86
SB125	2.348E+02	1.424E+02	8.629E+01	5.233E+01	2.470E+01	7.068E+00	2.023E+00	5.785E-01	1.656E-01	4.739E-02
SB126	8.117E-02	8.117E-02	8.116E-02	8.116E-02	8.116E-02	8.116E-02	8.116E-02	8.115E-02	8.115E-02	8.115E-02
SB126M	5.798E-01	5.798E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.796E-01	5.796E-01	5.796E-01
TE123M	2.801E-13	4.084E-15	5.920E-17	8.632E-19	1.511E-21	3.856E-26	9.843E-31	2.497E-35	6.375E-40	1.627E-44
TE125M	5.729E+01	3.476E+01	2.106E+01	1.277E+01	6.026E+00	1.724E+00	4.936E-01	1.411E-01	4.040E-02	1.156E-02

Table 2-5D Page 2

TE127	9.080E-11	8.752E-13	8.382E-15	8.079E-17	7.597E-20	6.885E-25	6.240E-30	5.619E-35	5.093E-40	4.616E-45
TE127M	9.270E-11	8.935E-13	8.558E-15	8.248E-17	7.756E-20	7.029E-25	6.370E-30	5.737E-35	5.199E-40	4.712E-45
TE129	1.443E-41	4.159E-48	1.174E-54	3.383E-61	5.127E-71	2.239E-87	9.780E-104	4.184E-120	1.827E-136	7.981E-153
TE129M	2.217E-41	6.389E-48	1.804E-54	5.198E-61	7.877E-71	3.440E-87	1.503E-103	6.428E-120	2.807E-136	1.226E-152
I129	2.360E-02									
I131	0.0000E+00									
XE131M	0.0000E+00									
XE133	0.0000E+00									
CS134	3.112E+02	1.590E+02	8.112E+01	4.143E+01	1.511E+01	2.814E+00	5.242E-01	9.756E-02	1.817E-02	3.385E-03
CS135	4.430E-01									
CS136	0.0000E+00									
CS137	3.532E+04	3.372E+04	3.220E+04	3.075E+04	2.869E+04	2.556E+04	2.277E+04	2.028E+04	1.807E+04	1.610E+04
BA136M	0.0000E+00									
BA137M	3.341E+04	3.190E+04	3.046E+04	2.909E+04	2.714E+04	2.418E+04	2.154E+04	1.919E+04	1.710E+04	1.523E+04
BA140	0.0000E+00									
LA140	0.0000E+00									
CE141	1.531E-41	2.666E-48	4.544E-55	7.911E-62	5.626E-72	6.966E-89	8.624E-106	1.045E-122	1.294E-139	1.602E-156
CE142	1.446E-05									
CE144	1.454E+00	2.452E-01	4.125E-02	6.955E-03	4.805E-04	5.597E-06	6.519E-08	7.575E-10	8.824E-12	1.028E-13
PR143	0.0000E+00									
PR144	1.454E+00	2.452E-01	4.125E-02	6.955E-03	4.805E-04	5.597E-06	6.519E-08	7.576E-10	8.825E-12	1.028E-13
PR144M	1.745E-02	2.942E-03	4.950E-04	8.347E-05	5.766E-06	6.716E-08	7.823E-10	9.091E-12	1.059E-13	1.233E-15
ND144	5.792E-10									
ND147	0.0000E+00									
PM145	7.664E-03	7.087E-03	6.553E-03	6.060E-03	5.388E-03	4.430E-03	3.642E-03	2.994E-03	2.462E-03	2.024E-03
PM147	1.469E+03	8.663E+02	5.106E+02	3.011E+02	1.363E+02	3.637E+01	9.707E+00	2.589E+00	6.910E-01	1.844E-01
PM148M	3.492E-33	1.666E-38	7.817E-44	3.730E-49	3.823E-57	1.869E-70	9.142E-84	4.397E-97	2.150E-110	1.051E-123
PM148	1.967E-34	9.383E-40	4.403E-45	2.101E-50	2.153E-58	1.053E-71	5.149E-85	2.476E-98	1.211E-111	5.922E-125
SM145	2.337E-06	5.278E-07	1.190E-07	2.686E-08	2.877E-09	6.957E-11	1.682E-12	4.060E-14	9.818E-16	2.374E-17
SM147	2.452E-06	2.475E-06	2.484E-06	2.480E-06	2.487E-06	2.488E-06	2.488E-06	2.488E-06	2.488E-06	2.488E-06
SM151	2.036E+02	2.005E+02	1.975E+02	1.944E+02	1.900E+02	1.828E+02	1.760E+02	1.692E+02	1.628E+02	1.567E+02
EU152	4.119E+00	3.720E+00	3.359E+00	3.034E+00	2.603E+00	2.018E+00	1.564E+00	1.212E+00	9.396E-01	7.283E-01
EU154	4.131E+02	3.516E+02	2.992E+02	2.547E+02	2.000E+02	1.336E+02	8.933E+01	5.969E+01	3.989E+01	2.666E+01
EU155	1.176E+02	8.899E+01	6.727E+01	5.088E+01	3.245E+01	1.663E+01	8.269E+00	4.110E+00	2.043E+00	1.016E+00
EU156	1.295E-96	4.374E-111	1.411E-125	4.765E-140	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
GD153	2.496E-05	3.085E-06	3.801E-07	4.698E-08	2.036E-09	1.090E-11	5.835E-14	3.115E-16	1.668E-18	8.932E-21
TB160	2.229E-20	2.036E-23	1.843E-26	1.683E-29	4.602E-34	1.150E-41	2.871E-49	7.103E-57	1.774E-64	4.432E-72

Table 2-5D Page 3

TL206	1.228E-12											
TL207	1.114E+00	1.217E+00	1.313E+00	1.403E+00	1.528E+00	1.711E+00	1.868E+00	2.001E+00	2.115E+00	2.212E+00	2.212E+00	2.212E+00
TL208	2.127E+02	2.092E+02	2.054E+02	2.016E+02	1.958E+02	1.865E+02	1.777E+02	1.694E+02	1.614E+02	1.538E+02	1.538E+02	1.538E+02
PB210	9.378E-05	9.478E-05	9.654E-05	9.903E-05	1.041E-04	1.157E-04	1.309E-04	1.495E-04	1.711E-04	1.955E-04	1.955E-04	1.955E-04
PB211	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00	2.218E+00	2.218E+00
PB212	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02	4.282E+02	4.282E+02
BI211	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00	2.218E+00	2.218E+00
BI212	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02	4.282E+02	4.282E+02
PO212	3.792E+02	3.730E+02	3.663E+02	3.596E+02	3.492E+02	3.325E+02	3.169E+02	3.020E+02	2.878E+02	2.743E+02	2.743E+02	2.743E+02
PO215	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00	2.218E+00	2.218E+00
PO216	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02	4.282E+02	4.282E+02
RN219	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00	2.218E+00	2.218E+00
RN220	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02	4.282E+02	4.282E+02
FR223	1.539E-02	1.680E-02	1.813E-02	1.938E-02	2.110E-02	2.364E-02	2.580E-02	2.764E-02	2.921E-02	3.055E-02	3.055E-02	3.055E-02
RA223	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00	2.218E+00	2.218E+00
RA224	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02	4.282E+02	4.282E+02
RA226	1.036E-04	1.171E-04	1.309E-04	1.449E-04	1.662E-04	2.027E-04	2.404E-04	2.794E-04	3.195E-04	3.608E-04	3.608E-04	3.608E-04
RA228	1.553E-01	1.602E-01	1.641E-01	1.674E-01	1.711E-01	1.753E-01	1.778E-01	1.793E-01	1.801E-01	1.807E-01	1.807E-01	1.807E-01
AC227	1.115E+00	1.218E+00	1.314E+00	1.404E+00	1.529E+00	1.713E+00	1.869E+00	2.003E+00	2.117E+00	2.214E+00	2.214E+00	2.214E+00
TH227	1.102E+00	1.203E+00	1.299E+00	1.388E+00	1.511E+00	1.692E+00	1.847E+00	1.979E+00	2.091E+00	2.187E+00	2.187E+00	2.187E+00
TH228	5.906E+02	5.807E+02	5.703E+02	5.597E+02	5.440E+02	5.185E+02	4.942E+02	4.710E+02	4.489E+02	4.278E+02	4.278E+02	4.278E+02
TH229	4.915E-01	5.466E-01	6.018E-01	6.569E-01	7.395E-01	8.772E-01	1.015E+00	1.152E+00	1.290E+00	1.427E+00	1.427E+00	1.427E+00
TH230	1.567E-02	1.591E-02	1.615E-02	1.638E-02	1.674E-02	1.734E-02	1.793E-02	1.853E-02	1.912E-02	1.971E-02	1.971E-02	1.971E-02
TH231	7.118E-04											
TH232	1.814E-01											
TH234	3.387E-05											
PA231	2.778E+00	2.778E+00	2.777E+00	2.777E+00	2.777E+00	2.777E+00	2.777E+00	2.777E+00	2.776E+00	2.776E+00	2.776E+00	2.776E+00
PA233	9.167E-04	9.176E-04	9.185E-04	9.195E-04	9.210E-04	9.239E-04	9.269E-04	9.301E-04	9.334E-04	9.368E-04	9.368E-04	9.368E-04
PA234M	3.387E-05											
PA234	4.403E-08											
U232	5.774E+02	5.664E+02	5.556E+02	5.450E+02	5.295E+02	5.046E+02	4.809E+02	4.583E+02	4.368E+02	4.162E+02	4.162E+02	4.162E+02
U233	2.924E+02											
U234	1.323E+01											
U235	7.118E-04											
U236	1.269E-03											
U237	8.861E-06	8.048E-06	7.309E-06	6.638E-06	5.745E-06	4.517E-06	3.551E-06	2.791E-06	2.194E-06	1.725E-06	1.725E-06	1.725E-06
U238	3.387E-05											

NP237	9.167E-04	9.176E-04	9.185E-04	9.195E-04	9.210E-04	9.239E-04	9.269E-04	9.301E-04	9.334E-04	9.368E-04
PU236	7.504E-06	4.616E-06	2.838E-06	1.746E-06	8.425E-07	2.506E-07	7.504E-08	2.296E-08	7.532E-09	2.956E-09
PU237	8.631E-37	1.309E-41	1.955E-46	2.965E-51	1.725E-58	1.522E-70	1.343E-82	1.167E-94	1.029E-106	9.082E-119
PU238	2.949E+00	2.903E+00	2.858E+00	2.813E+00	2.747E+00	2.641E+00	2.539E+00	2.441E+00	2.347E+00	2.256E+00
PU239	3.832E-01	3.832E-01	3.832E-01	3.831E-01	3.831E-01	3.831E-01	3.830E-01	3.830E-01	3.829E-01	3.828E-01
PU240	1.979E-01	1.979E-01	1.978E-01	1.978E-01	1.978E-01	1.977E-01	1.976E-01	1.975E-01	1.974E-01	1.973E-01
PU241	3.612E+01	3.281E+01	2.979E+01	2.706E+01	2.342E+01	1.841E+01	1.447E+01	1.138E+01	8.943E+00	7.030E+00
PU242	2.552E-04	2.552E-04								
PU244	1.188E-11	1.188E-11								
AM241	1.260E+00	1.366E+00	1.462E+00	1.548E+00	1.662E+00	1.815E+00	1.931E+00	2.018E+00	2.083E+00	2.130E+00
AM242M	9.293E-03	9.208E-03	9.125E-03	9.042E-03	8.919E-03	8.718E-03	8.522E-03	8.329E-03	8.142E-03	7.958E-03
AM242	9.246E-03	9.163E-03	9.079E-03	8.997E-03	8.875E-03	8.675E-03	8.479E-03	8.288E-03	8.101E-03	7.918E-03
AM243	1.357E-03	1.357E-03	1.357E-03	1.356E-03	1.356E-03	1.356E-03	1.355E-03	1.354E-03	1.353E-03	1.353E-03
CM242	7.662E-03	7.591E-03	7.522E-03	7.454E-03	7.355E-03	7.177E-03	7.015E-03	6.857E-03	6.703E-03	6.551E-03
CM243	1.849E-03	1.761E-03	1.678E-03	1.598E-03	1.485E-03	1.315E-03	1.165E-03	1.031E-03	9.133E-04	8.087E-04
CM244	7.792E-02	7.218E-02	6.686E-02	6.193E-02	5.521E-02	4.560E-02	3.766E-02	3.109E-02	2.568E-02	2.121E-02
CM245	1.005E-05	1.005E-05	1.004E-05	1.004E-05	1.004E-05	1.004E-05	1.003E-05	1.003E-05	1.002E-05	1.002E-05
CM246	4.834E-07	4.832E-07	4.831E-07	4.830E-07	4.827E-07	4.824E-07	4.820E-07	4.817E-07	4.813E-07	4.810E-07
CM247	1.026E-12	1.026E-12								
AP+ACT+FP	1.532E+05	1.452E+05	1.379E+05	1.312E+05	1.219E+05	1.082E+05	9.621E+04	8.564E+04	7.630E+04	6.803E+04

Table 2-5D Page 5

Table 2-5E. Isotopic Activity Concentrations in Curies for a single LWBR Reflector Module (TYPE IV).

Information:	Units:	CURIES	MWd (max)	MWd/MTHM
Burnup:				
BOL U-233:		0	grams U-233 per module	
BOL U-234:		0	grams U-234 per module	
BOL U-235:		0	grams U-235 per module	
BOL U-236:		0	grams U-236 per module	
BOL U-238:		0	grams U-238 per module	
BOL Th-232:		1438800.00	grams Th-232 per module	
Fuel Metal:		ThO ₂ (Thorium)		
Fuel Enrichment:		0.00 wt% U-233 at BOL		
Clad:		Zircaloy-4		

REFLECTOR IV (or REFLECTOR 4)

DECAY DATES						
ISOTOPE	1-Jul-96	1-Jul-98	1-Jul-00	1-Jul-02	1-Jul-05	1-Jul-10
H 3	2.207E+00	1.973E+00	1.763E+00	1.576E+00	1.332E+00	1.006E+00
BE 10	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08
C 14	3.603E-02	3.602E-02	3.601E-02	3.599E-02	3.597E-02	3.595E-02
CL 36	5.438E-07	5.438E-07	5.438E-07	5.438E-07	5.437E-07	5.437E-07
CR 51	1.240E-52	1.454E-60	1.663E-68	1.950E-76	2.414E-88	0.000E+00
MN 54	4.389E-05	8.692E-06	1.718E-06	3.402E-07	2.992E-08	5.212E-10
FE 55	5.602E-01	3.288E-01	1.929E-01	1.132E-01	5.086E-02	1.342E-02
FE 59	5.428E-34	7.099E-39	9.145E-44	1.196E-48	5.572E-56	3.395E-68
CO 60	7.530E+00	5.789E+00	4.449E+00	3.421E+00	2.305E+00	1.194E+00
Ni 59	9.806E-04	9.805E-04	9.805E-04	9.805E-04	9.804E-04	9.804E-04
NI 63	1.096E-01	1.079E-01	1.063E-01	1.047E-01	1.024E-01	9.861E-02
ZN 65	3.028E-06	3.802E-07	4.760E-08	5.978E-09	2.652E-10	1.478E-12
SE 79	9.790E-03	9.790E-03	9.790E-03	9.789E-03	9.788E-03	9.788E-03
KR 85	7.958E+01	6.994E+01	6.145E+01	5.400E+01	4.447E+01	3.219E+01

RB 87	4.213E-07													
SR 89	4.117E-26	1.831E-30	8.038E-35	3.577E-39	1.047E-45	1.363E-56	1.775E-67	2.281E-78	2.970E-89	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 90	7.382E+02	7.039E+02	6.712E+02	6.400E+02	5.959E+02	5.290E+02	4.697E+02	4.170E+02	3.702E+02	3.286E+02	3.286E+02	3.287E+02	3.287E+02	3.287E+02
Y 90	7.384E+02	7.041E+02	6.713E+02	6.401E+02	5.960E+02	5.292E+02	4.698E+02	4.171E+02	3.703E+02	3.287E+02	3.287E+02	3.287E+02	3.287E+02	3.287E+02
Y 91	4.699E-22	8.242E-26	1.429E-29	2.505E-33	5.751E-39	2.315E-48	9.322E-58	3.708E-67	1.493E-76	6.010E-86	6.010E-86	6.010E-86	6.010E-86	6.010E-86
ZR 93	3.421E-02													
ZR 95	7.665E-20	2.818E-23	1.025E-26	3.766E-30	2.626E-35	6.731E-44	1.725E-52	4.374E-61	1.121E-69	2.873E-78	2.873E-78	2.873E-78	2.873E-78	2.873E-78
NB 93M	1.791E-02	1.933E-02	2.061E-02	2.176E-02	2.328E-02	2.535E-02	2.696E-02	2.821E-02	2.917E-02	2.992E-02	2.992E-02	2.992E-02	2.992E-02	2.992E-02
NB 94	3.037E-03	3.037E-03	3.037E-03	3.037E-03	3.036E-03	3.036E-03	3.035E-03	3.035E-03	3.034E-03	3.034E-03	3.034E-03	3.034E-03	3.034E-03	3.034E-03
NB 95	1.702E-19	6.255E-23	2.275E-26	8.362E-30	5.831E-35	1.494E-43	3.830E-52	9.710E-61	2.489E-69	6.379E-78	6.379E-78	6.379E-78	6.379E-78	6.379E-78
NB 95M	5.686E-22	2.091E-25	7.601E-29	2.795E-32	1.948E-37	4.993E-46	1.279E-54	3.244E-63	8.316E-72	2.132E-80	2.132E-80	2.132E-80	2.132E-80	2.132E-80
MO 93	7.496E-05	7.493E-05	7.490E-05	7.487E-05	7.483E-05	7.475E-05	7.468E-05	7.461E-05	7.453E-05	7.446E-05	7.446E-05	7.446E-05	7.446E-05	7.446E-05
TC 99	9.932E-02	9.932E-02	9.932E-02	9.932E-02	9.932E-02	9.932E-02	9.931E-02							
RU103	4.028E-35	1.026E-40	2.565E-46	6.531E-52	2.607E-60	2.649E-74	2.691E-88	0.000E+00						
RU106	4.432E-02	1.121E-02	2.832E-03	7.164E-04	9.100E-05	2.924E-06	9.398E-08	3.015E-09	9.688E-11	3.113E-12	3.113E-12	3.113E-12	3.113E-12	3.113E-12
RH103M	3.631E-35	9.245E-41	2.313E-46	5.888E-52	2.350E-60	2.388E-74	2.426E-88	0.000E+00						
RH106	4.432E-02	1.121E-02	2.832E-03	7.164E-04	9.100E-05	2.924E-06	9.398E-08	3.015E-09	9.688E-11	3.113E-12	3.113E-12	3.113E-12	3.113E-12	3.113E-12
PD107	9.466E-05													
AG110	3.000E-09	3.959E-10	5.212E-11	6.880E-12	3.291E-13	2.077E-15	1.312E-17	8.257E-20	5.213E-22	3.291E-24	3.291E-24	3.291E-24	3.291E-24	3.291E-24
AG110M	2.255E-07	2.977E-08	3.919E-09	5.173E-10	2.474E-11	1.562E-13	9.861E-16	6.208E-18	3.919E-20	2.474E-22	2.474E-22	2.474E-22	2.474E-22	2.474E-22
AG111	0.000E+00													
CD113M	5.749E-02	5.228E-02	4.754E-02	4.323E-02	3.749E-02	2.956E-02	2.331E-02	1.838E-02	1.449E-02	1.143E-02	1.143E-02	1.143E-02	1.143E-02	1.143E-02
CD113	0.000E+00													
CD115M	1.713E-33	2.023E-38	2.353E-43	2.779E-48	1.110E-55	5.242E-68	2.474E-80	1.149E-92	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IN114	1.078E-31	3.927E-36	1.411E-40	5.147E-45	1.118E-51	8.845E-63	7.001E-74	5.464E-85	4.325E-96	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IN114M	1.126E-31	4.104E-36	1.476E-40	5.379E-45	1.168E-51	9.242E-63	7.316E-74	5.710E-85	4.519E-96	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IN115M	1.203E-37	1.421E-42	1.652E-47	1.951E-52	7.797E-60	3.680E-72	1.737E-84	8.070E-97	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN119M	2.527E-04	3.203E-05	4.051E-06	5.137E-07	2.312E-08	1.321E-10	7.540E-13	4.293E-15	2.451E-17	1.400E-19	1.400E-19	1.400E-19	1.400E-19	1.400E-19
SN121M	5.102E-02	4.962E-02	4.826E-02	4.694E-02	4.503E-02	4.201E-02	3.920E-02	3.657E-02	3.412E-02	3.183E-02	3.183E-02	3.183E-02	3.183E-02	3.183E-02
SN123	9.993E-11	1.988E-12	3.933E-14	7.825E-16	2.183E-18	1.212E-22	6.729E-27	3.716E-31	2.063E-35	1.145E-39	1.145E-39	1.145E-39	1.145E-39	1.145E-39
SN125	0.000E+00													
SN126	1.062E-02													
SB124	1.097E-25	2.453E-29	5.421E-33	1.212E-36	4.006E-42	2.959E-51	2.187E-60	1.597E-69	1.181E-78	8.723E-88	8.723E-88	8.723E-88	8.723E-88	8.723E-88
SB125	8.772E+00	5.320E+00	3.224E+00	1.955E+00	9.227E-01	2.641E-01	7.558E-02	2.162E-02	6.187E-03	1.771E-03	1.771E-03	1.771E-03	1.771E-03	1.771E-03
SB126	1.487E-03	1.487E-03	1.487E-03	1.487E-03	1.487E-03	1.487E-03	1.486E-03							
SB126M	1.062E-02													

TE123M	3.674E-16	5.357E-18	7.765E-20	1.132E-21	1.982E-24	5.058E-29	1.291E-33	3.276E-38	8.361E-43	2.134E-47
TE125M	2.141E+00	1.298E+00	7.868E-01	4.772E-01	2.251E-01	6.444E-02	1.844E-02	5.275E-03	1.510E-03	4.321E-04
TE127	4.383E-12	4.224E-14	4.046E-16	3.900E-18	3.667E-21	3.323E-26	3.012E-31	2.712E-36	2.458E-41	2.228E-46
TE127M	4.475E-12	4.313E-14	4.131E-16	3.981E-18	3.744E-21	3.393E-26	3.075E-31	2.769E-36	2.510E-41	2.274E-46
TE129	1.772E-42	5.107E-49	1.442E-55	4.155E-62	6.296E-72	2.750E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE129M	2.722E-42	7.845E-49	2.215E-55	6.383E-62	9.673E-72	4.225E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I129	4.443E-04									
I131	0.000E+00									
XE131M	0.000E+00									
XE133	0.000E+00									
CS134	1.033E+00	5.277E-01	2.693E-01	1.375E-01	5.015E-02	9.342E-03	1.740E-03	3.238E-04	6.032E-05	1.124E-05
CS135	1.016E-02									
CS136	0.000E+00									
CS137	7.080E+02	6.760E+02	6.455E+02	6.163E+02	5.750E+02	5.123E+02	4.564E+02	4.066E+02	3.623E+02	3.227E+02
BA136M	0.000E+00									
BA137M	6.697E+02	6.395E+02	6.106E+02	5.830E+02	5.440E+02	4.846E+02	4.318E+02	3.847E+02	3.427E+02	3.053E+02
BA140	0.000E+00									
LA140	0.000E+00									
CE141	2.012E-42	3.503E-49	5.971E-56	1.040E-62	7.393E-73	9.153E-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE142	2.815E-07									
CE144	5.167E-02	8.713E-03	1.466E-03	2.471E-04	1.707E-05	1.989E-07	2.316E-09	2.692E-11	3.136E-13	3.652E-15
PR143	0.000E+00									
PR144	5.167E-02	8.713E-03	1.466E-03	2.472E-04	1.707E-05	1.989E-07	2.317E-09	2.692E-11	3.136E-13	3.653E-15
PR144M	6.200E-04	1.046E-04	1.759E-05	2.966E-06	2.049E-07	2.386E-09	2.780E-11	3.230E-13	3.763E-15	4.383E-17
ND144	1.114E-11									
ND147	0.000E+00									
PM145	8.394E-04	7.762E-04	7.177E-04	6.637E-04	5.901E-04	4.852E-04	3.989E-04	3.280E-04	2.696E-04	2.217E-04
PM147	5.632E+01	3.322E+01	1.958E+01	1.154E+01	5.225E+00	1.394E+00	3.722E-01	9.927E-02	2.649E-02	7.071E-03
PM148M	5.258E-35	2.509E-40	1.177E-45	5.617E-51	5.757E-59	2.815E-72	1.377E-85	6.621E-99	0.000E+00	0.000E+00
PM148	2.961E-36	1.413E-41	6.630E-47	3.164E-52	3.242E-60	1.586E-73	7.754E-87	0.000E+00	0.000E+00	0.000E+00
SM145	2.919E-07	6.593E-08	1.486E-08	3.355E-09	3.593E-10	8.689E-12	2.101E-13	5.071E-15	1.226E-16	2.966E-18
SM147	8.572E-08	8.569E-08	8.602E-08	8.622E-08	8.638E-08	8.647E-08	8.649E-08	8.650E-08	8.650E-08	8.650E-08
SM151	7.374E+00	7.262E+00	7.150E+00	7.041E+00	6.880E+00	6.620E+00	6.370E+00	6.129E+00	5.898E+00	5.675E+00
EU152	1.406E-01	1.270E-01	1.147E-01	1.036E-01	8.889E-02	6.890E-02	5.340E-02	4.139E-02	3.208E-02	2.486E-02
EU154	1.366E+00	1.163E+00	9.893E-01	8.422E-01	6.612E-01	4.419E-01	2.954E-01	1.974E-01	1.319E-01	8.817E-02
EU155	1.903E+00	1.439E+00	1.089E+00	8.229E-01	5.410E-01	2.690E-01	1.337E-01	6.647E-02	3.305E-02	1.643E-02

EU156	2.707E-97	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	3.324E-07	4.108E-08	5.063E-09	6.257E-10	2.712E-11	1.452E-13	7.773E-16	4.150E-18	2.222E-20	1.190E-22	
TB160	1.608E-22	1.469E-25	1.329E-28	1.214E-31	3.320E-36	8.293E-44	2.071E-51	5.124E-59	1.280E-66	3.197E-74	
TL206	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	
TL207	1.234E-01	1.348E-01	1.454E-01	1.554E-01	1.692E-01	1.894E-01	2.067E-01	2.215E-01	2.341E-01	2.448E-01	
TL208	2.838E+00	2.795E+00	2.748E+00	2.700E+00	2.625E+00	2.504E+00	2.390E+00	2.281E+00	2.176E+00	2.077E+00	
PB210	1.876E-06	2.292E-06	2.745E-06	3.234E-06	4.028E-06	5.501E-06	7.140E-06	8.924E-06	1.083E-05	1.285E-05	
PB211	1.2338E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01	
PB212	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00	
BI211	1.2338E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01	
BI212	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00	
PO212	5.061E+00	4.985E+00	4.900E+00	4.814E+00	4.680E+00	4.465E+00	4.261E+00	4.067E+00	3.881E+00	3.704E+00	
PO215	1.2338E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01	
PO216	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00	
RN219	1.2338E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01	
RN220	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00	
FR223	1.705E-03	1.861E-03	2.008E-03	2.146E-03	2.337E-03	2.617E-03	2.856E-03	3.060E-03	3.233E-03	3.381E-03	
RA223	1.2338E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01	
RA224	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00	
RA226	8.267E-06	9.299E-06	1.034E-05	1.137E-05	1.294E-05	1.555E-05	1.818E-05	2.084E-05	2.350E-05	2.618E-05	
RA228	1.350E-01	1.392E-01	1.426E-01	1.454E-01	1.486E-01	1.522E-01	1.543E-01	1.556E-01	1.563E-01	1.568E-01	
AC227	1.2335E-01	1.349E-01	1.455E-01	1.555E-01	1.693E-01	1.896E-01	2.069E-01	2.217E-01	2.343E-01	2.450E-01	
TH227	1.221E-01	1.3333E-01	1.4338E-01	1.5337E-01	1.673E-01	1.874E-01	2.046E-01	2.191E-01	2.315E-01	2.421E-01	
TH228	7.883E+00	7.760E+00	7.628E+00	7.494E+00	7.292E+00	6.962E+00	6.645E+00	6.342E+00	6.052E+00	5.776E+00	
TH229	4.837E-02	5.437E-02	6.037E-02	6.637E-02	7.537E-02	9.035E-02	1.053E-01	1.203E-01	1.353E-01	1.502E-01	
TH230	1.199E-03	1.203E-03	1.207E-03	1.211E-03	1.217E-03	1.227E-03	1.238E-03	1.248E-03	1.258E-03	1.268E-03	
TH231	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	
TH232	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	
TH234	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	
PA231	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.074E-01	
PA233	2.545E-08	2.566E-08	2.588E-08	2.612E-08	2.650E-08	2.719E-08	2.794E-08	2.872E-08	2.954E-08	3.038E-08	
PA234M	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	
PA234	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	
U232	7.588E+00	7.443E+00	7.301E+00	7.162E+00	6.958E+00	6.631E+00	6.320E+00	6.022E+00	5.739E+00	5.470E+00	
U233	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	
U234	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	

U235	1.653E-06									
U236	4.015E-07	4.017E-07								
U237	2.194E-09	1.993E-09	1.810E-09	1.644E-09	1.423E-09	1.118E-09	8.791E-10	6.910E-10	5.432E-10	4.270E-10
U238	3.489E-07									
NP237	2.545E-08	2.566E-08	2.588E-08	2.612E-08	2.650E-08	2.719E-08	2.794E-08	2.872E-08	2.954E-08	3.038E-08
PU236	1.226E-11	7.539E-12	4.635E-12	2.852E-12	1.376E-12	4.094E-13	1.227E-13	3.765E-14	1.245E-14	4.977E-15
PU237	1.819E-41	2.759E-46	4.121E-51	6.251E-56	3.636E-63	3.208E-75	2.830E-87	2.459E-99	0.000E+00	0.000E+00
PU238	2.000E-05	1.969E-05	1.938E-05	1.908E-05	1.864E-05	1.793E-05	1.725E-05	1.659E-05	1.596E-05	1.535E-05
PU239	9.138E-04	9.137E-04	9.137E-04	9.136E-04	9.135E-04	9.134E-04	9.133E-04	9.131E-04	9.130E-04	9.129E-04
PU240	2.166E-04	2.166E-04	2.165E-04	2.165E-04	2.164E-04	2.163E-04	2.162E-04	2.161E-04	2.160E-04	2.158E-04
PU241	8.943E-03	7.377E-03	6.700E-03	5.799E-03	4.558E-03	3.589E-03	2.817E-03	2.214E-03	1.741E-03	
PU242	1.994E-08	1.994E-08	1.994E-08	1.994E-08	1.995E-08	1.995E-08	1.995E-08	1.995E-08	1.995E-08	1.995E-08
PU244	3.242E-17									
AM241	3.073E-04	3.336E-04	3.574E-04	3.787E-04	4.069E-04	4.448E-04	4.736E-04	4.952E-04	5.112E-04	5.229E-04
AM242M	3.592E-07	3.559E-07	3.527E-07	3.495E-07	3.447E-07	3.370E-07	3.294E-07	3.220E-07	3.147E-07	3.076E-07
AM242	3.574E-07	3.542E-07	3.509E-07	3.478E-07	3.430E-07	3.353E-07	3.277E-07	3.203E-07	3.131E-07	3.061E-07
AM243	2.017E-08	2.016E-08	2.016E-08	2.015E-08	2.014E-08	2.013E-08	2.012E-08	2.011E-08	2.010E-08	
CM242	2.962E-07	2.934E-07	2.908E-07	2.881E-07	2.843E-07	2.774E-07	2.712E-07	2.650E-07	2.591E-07	2.532E-07
CM243	2.034E-08	1.937E-08	1.845E-08	1.758E-08	1.634E-08	1.447E-08	1.281E-08	1.135E-08	1.005E-08	8.897E-09
CM244	1.821E-07	1.687E-07	1.562E-07	1.447E-07	1.290E-07	1.065E-07	8.799E-08	7.266E-08	6.001E-08	4.956E-08
CM245	3.204E-12	3.203E-12	3.202E-12	3.201E-12	3.200E-12	3.199E-12	3.197E-12	3.196E-12	3.195E-12	
CM246	6.253E-14	6.251E-14	6.249E-14	6.248E-14	6.245E-14	6.240E-14	6.236E-14	6.231E-14	6.227E-14	6.222E-14
CM247	2.116E-20									
SUBTOTAL	3.120E+03	2.948E+03	2.795E+03	2.656E+03	2.466E+03	2.189E+03	1.947E+03	1.735E+03	1.548E+03	1.381E+03
AP+ACT+FP	3.121E+03	2.949E+03	2.795E+03	2.656E+03	2.467E+03	2.190E+03	1.948E+03	1.736E+03	1.549E+03	1.383E+03

Table 2-5F. Isotopic Activity Concentrations in Curies for a single LWBR Reflector Module (TYPE V).

Information:	Units:	CURIES	MWd (max)
	Burnup:	MWd/MTHM	
BOL U-233:	Burnup:	0 grams U-233 per module	
BOL U-234:		0 grams U-234 per module	
BOL U-235:		0 grams U-235 per module	
BOL U-236:		0 grams U-236 per module	
BOL U-238:		0 grams U-238 per module	
BOL Th-232:		1047547.00 grams Th-232 per module	
Fuel/Melt:		ThO ₂ (Thorium)	
Fuel Enrichment:		0.00 wt% U-233 at BOL	
Clad:		Zircaloy-4	

DECAY DATES

ISOTOPES	1-Jul-96	1-Jul-98	1-Jul-00	1-Jul-02	1-Jul-05	1-Jul-10	1-Jul-15	1-Jul-20	1-Jul-25	1-Jul-30
H 3	1.607E+00	1.436E+00	1.283E+00	1.147E+00	9.697E-01	7.324E-01	5.531E-01	4.177E-01	3.155E-01	2.383E-01
BE 10	3.807E-08									
C 14	2.623E-02	2.622E-02	2.622E-02	2.620E-02	2.619E-02	2.617E-02	2.616E-02	2.614E-02	2.613E-02	2.613E-02
CL 36	3.959E-07	3.959E-07	3.959E-07	3.959E-07	3.959E-07	3.958E-07	3.958E-07	3.958E-07	3.958E-07	3.958E-07
CR 51	9.027E-53	1.059E-60	1.211E-68	1.420E-76	1.757E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
MN 54	3.195E-05	6.328E-06	1.251E-06	2.477E-07	2.178E-08	3.794E-10	6.609E-12	1.149E-13	2.001E-15	3.486E-17
FE 55	4.078E-01	2.394E-01	1.404E-01	8.241E-02	3.703E-02	9.770E-03	2.576E-03	6.789E-04	1.790E-04	4.722E-05
FE 59	3.952E-34	5.168E-39	6.658E-44	8.707E-49	4.056E-56	2.472E-68	1.506E-80	9.042E-93	0.000E+00	0.000E+00
CO 60	5.482E+00	4.214E+00	3.239E+00	2.490E+00	1.678E+00	8.692E-01	4.505E-01	2.333E-01	1.208E-01	6.263E-02
NI 59	7.139E-04	7.138E-04	7.138E-04	7.138E-04	7.137E-04	7.137E-04	7.137E-04	7.137E-04	7.137E-04	7.137E-04
NI 63	7.979E-02	7.855E-02	7.739E-02	7.622E-02	7.455E-02	7.179E-02	6.913E-02	6.658E-02	6.411E-02	6.174E-02

ZN 65	2.204E-06	2.768E-07	3.465E-08	4.352E-09	1.931E-10	1.076E-12	5.993E-15	3.329E-17	1.855E-19	1.034E-21
SE 79	7.127E-03	7.127E-03	7.127E-03	7.126E-03	7.126E-03	7.126E-03	7.126E-03	7.126E-03	7.125E-03	7.125E-03
KR 85	5.793E+01	5.092E+01	4.474E+01	3.931E+01	3.237E+01	2.343E+01	1.696E+01	1.227E+01	8.882E+00	6.430E+00
RB 87	3.067E-07									
SR 89	2.997E-26	1.333E-30	5.852E-35	2.604E-39	7.622E-46	9.923E-57	1.292E-67	1.661E-78	2.162E-89	0.000E+00
SR 90	5.374E+02	5.124E+02	4.886E+02	4.659E+02	4.338E+02	3.851E+02	3.419E+02	3.036E+02	2.695E+02	2.392E+02
Y 90	5.376E+02	5.126E+02	4.887E+02	4.660E+02	4.339E+02	3.853E+02	3.420E+02	3.036E+02	2.696E+02	2.393E+02
Y 91	3.421E-22	6.000E-26	1.040E-29	1.824E-33	4.187E-39	1.685E-48	6.786E-58	2.699E-67	1.087E-76	4.375E-86
ZR 93	2.490E-02									
ZR 95	5.580E-20	2.052E-23	7.462E-27	2.742E-30	1.912E-35	4.900E-44	1.256E-52	3.184E-61	8.161E-70	2.092E-78
NB 93M	1.304E-02	1.407E-02	1.500E-02	1.584E-02	1.695E-02	1.845E-02	1.963E-02	2.054E-02	2.124E-02	2.178E-02
NB 94	2.211E-03	2.211E-03	2.211E-03	2.211E-03	2.210E-03	2.210E-03	2.209E-03	2.209E-03	2.209E-03	2.209E-03
NB 95	1.239E-19	4.554E-23	1.656E-26	6.088E-30	4.245E-35	1.088E-43	2.788E-52	7.069E-61	1.812E-69	4.644E-78
NB 95M	4.139E-22	1.522E-25	5.534E-29	2.035E-32	1.418E-37	3.635E-46	9.311E-55	2.362E-63	6.054E-72	1.552E-80
MO 93	5.457E-05	5.455E-05	5.453E-05	5.451E-05	5.448E-05	5.442E-05	5.437E-05	5.432E-05	5.426E-05	5.421E-05
TC 99	7.230E-02									
RU103	2.932E-35	7.469E-41	1.867E-46	4.755E-52	1.898E-60	1.928E-74	1.959E-88	0.000E+00	0.000E+00	0.000E+00
RU106	3.226E-02	8.161E-03	2.062E-03	5.215E-04	6.625E-05	2.129E-06	6.842E-08	2.195E-09	7.053E-11	2.266E-12
RH103M	2.643E-35	6.730E-41	1.684E-46	4.286E-52	1.711E-60	1.738E-74	1.766E-88	0.000E+00	0.000E+00	0.000E+00
RH106	3.226E-02	8.161E-03	2.062E-03	5.215E-04	6.625E-05	2.129E-06	6.842E-08	2.195E-09	7.053E-11	2.266E-12
PD107	6.891E-05									
AG110	2.184E-09	2.882E-10	3.794E-11	5.009E-12	2.396E-13	1.512E-15	9.551E-18	6.011E-20	3.795E-22	2.396E-24
AG110M	1.642E-07	2.167E-08	2.853E-09	3.766E-10	1.801E-11	1.137E-13	7.179E-16	4.519E-18	2.853E-20	1.801E-22
AG111	0.000E+00									
CD113M	4.185E-02	3.806E-02	3.461E-02	3.147E-02	2.729E-02	2.152E-02	1.697E-02	1.338E-02	1.055E-02	8.321E-03
CD113	0.000E+00									
CD115M	1.247E-33	1.473E-38	1.713E-43	2.023E-48	8.081E-56	3.816E-68	1.801E-80	8.365E-93	0.000E+00	0.000E+00
IN114	7.848E-32	2.859E-36	1.027E-40	3.747E-45	8.139E-52	6.439E-63	5.097E-74	3.978E-85	3.149E-96	0.000E+00
IN114M	8.197E-32	2.988E-36	1.075E-40	3.916E-45	8.503E-52	6.728E-63	5.326E-74	4.157E-85	3.290E-96	0.000E+00
IN115M	8.758E-38	1.034E-42	1.203E-47	1.420E-52	5.676E-60	2.679E-72	1.265E-84	5.875E-97	0.000E+00	0.000E+00
SN119M	1.840E-04	2.332E-05	2.949E-06	3.740E-07	1.683E-08	9.617E-11	5.489E-13	3.125E-15	1.784E-17	1.019E-19
SN121M	3.714E-02	3.612E-02	3.513E-02	3.417E-02	3.278E-02	3.058E-02	2.854E-02	2.662E-02	2.484E-02	2.317E-02
SN123	7.275E-11	1.447E-12	2.863E-14	5.697E-16	1.589E-18	8.823E-23	4.899E-27	2.705E-31	1.502E-35	8.336E-40
SN125	0.000E+00									
SN126	7.731E-03									
SB124	7.986E-26	1.786E-29	3.946E-33	8.823E-37	2.916E-42	2.154E-51	1.592E-60	1.163E-69	8.598E-79	6.350E-88

SB125	6.386E+00	3.873E+00	2.347E+00	1.423E+00	6.717E-01	1.923E-01	5.502E-02	1.574E-02	4.504E-03	1.289E-03
SB126	1.083E-03	1.083E-03	1.083E-03	1.083E-03	1.083E-03	1.083E-03	1.082E-03	1.082E-03	1.082E-03	1.082E-03
SB126M	7.731E-03									
TE123M	2.675E-16	3.900E-18	5.653E-20	8.241E-22	1.443E-24	3.682E-29	9.398E-34	2.385E-38	6.087E-43	1.554E-47
TE125M	1.559E+00	9.449E-01	5.728E-01	3.474E-01	1.639E-01	4.691E-02	1.342E-02	3.840E-03	1.099E-03	3.146E-04
TE127	3.191E-12	3.075E-14	2.945E-16	2.839E-18	2.670E-21	2.419E-26	2.193E-31	1.974E-36	1.789E-41	1.622E-46
TE127M	3.258E-12	3.140E-14	3.007E-16	2.898E-18	2.726E-21	2.470E-26	2.239E-31	2.016E-36	1.827E-41	1.655E-46
TE129	1.290E-42	3.718E-49	1.050E-55	3.025E-62	4.583E-72	2.002E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE129M	1.982E-42	5.711E-49	1.613E-55	4.647E-62	7.042E-72	3.076E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I129	3.235E-04									
I131	0.000E+00									
XE131M	0.000E+00									
XE133	0.000E+00									
CS134	7.520E-01	3.842E-01	1.961E-01	1.001E-01	3.651E-02	6.801E-03	1.267E-03	2.357E-04	4.391E-05	8.183E-06
CS135	7.396E-03									
CS136	0.000E+00									
CS137	5.154E+02	4.921E+02	4.699E+02	4.487E+02	4.186E+02	3.730E+02	3.323E+02	2.960E+02	2.638E+02	2.349E+02
BA136M	0.000E+00									
BA137M	4.875E+02	4.656E+02	4.445E+02	4.244E+02	3.960E+02	3.528E+02	3.144E+02	2.801E+02	2.495E+02	2.223E+02
BA140	0.000E+00									
LA140	0.000E+00									
CE141	1.465E-42	2.550E-49	4.347E-56	7.571E-63	5.382E-73	6.663E-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE142	2.049E-07									
CE144	3.762E-02	6.343E-03	1.067E-03	1.799E-04	1.243E-05	1.448E-07	1.686E-09	1.960E-11	2.283E-13	2.659E-15
PR143	0.000E+00									
PR144	3.762E-02	6.343E-03	1.067E-03	1.800E-04	1.243E-05	1.448E-07	1.687E-09	1.960E-11	2.283E-13	2.659E-15
PR144M	4.514E-04	7.615E-05	1.281E-05	2.159E-06	1.492E-07	1.737E-09	2.024E-11	2.351E-13	2.739E-15	3.191E-17
ND144	8.110E-12									
ND147	0.000E+00									
PM145	6.111E-04	5.651E-04	5.225E-04	4.832E-04	4.296E-04	3.532E-04	2.904E-04	2.388E-04	1.963E-04	1.614E-04
PM147	4.100E+01	2.418E+01	1.425E+01	8.401E+00	3.804E+00	1.015E+00	2.710E-01	7.227E-02	1.928E-02	5.148E-03
PM148M	3.828E-35	1.827E-40	8.569E-46	4.089E-51	4.191E-59	2.049E-72	1.002E-85	4.820E-99	0.000E+00	0.000E+00
PM149	2.156E-36	1.029E-41	4.827E-47	2.303E-52	2.360E-60	1.155E-73	5.645E-87	0.000E+00	0.000E+00	0.000E+00
SM145	2.125E-07	4.800E-08	1.082E-08	2.442E-09	2.616E-10	6.326E-12	1.530E-13	3.692E-15	8.925E-17	2.159E-18
SM147	6.197E-08	6.238E-08	6.262E-08	6.277E-08	6.288E-08	6.295E-08	6.296E-08	6.297E-08	6.297E-08	6.297E-08
SM151	5.368E+00	5.287E+00	5.205E+00	5.126E+00	5.009E+00	4.819E+00	4.637E+00	4.462E+00	4.294E+00	4.131E+00

EU152	1.024E-01	9.246E-02	8.350E-02	7.542E-02	6.471E-02	5.016E-02	3.888E-02	3.013E-02	2.335E-02	1.810E-02
EU154	9.944E-01	8.467E-01	7.202E-01	6.131E-01	4.814E-01	3.217E-01	2.151E-01	1.437E-01	9.602E-02	6.419E-02
EU155	1.385E+00	1.048E+00	7.928E-01	5.991E-01	3.938E-01	1.958E-01	9.733E-02	4.839E-02	2.406E-02	1.196E-02
EU156	1.971E-97	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.420E-07	2.991E-08	3.6886E-09	4.555E-10	1.974E-11	1.057E-13	5.659E-16	3.021E-18	1.618E-20	8.663E-23
TB160	1.171E-22	1.069E-25	9.675E-29	8.838E-32	2.417E-36	6.037E-44	1.508E-51	3.730E-59	9.318E-67	2.327E-74
TL206	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15
TL207	8.984E-02	9.813E-02	1.059E-01	1.131E-01	1.232E-01	1.379E-01	1.505E-01	1.613E-01	1.704E-01	1.782E-01
TL208	2.066E+00	2.035E+00	2.001E+00	1.966E+00	1.911E+00	1.823E+00	1.740E+00	1.661E+00	1.584E+00	1.512E+00
PB210	1.366E-06	1.669E-06	1.998E-06	2.354E-06	2.932E-06	4.005E-06	5.198E-06	6.497E-06	7.884E-06	9.355E-06
PB211	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
PB212	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
BI211	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
BI212	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
PO212	3.684E+00	3.629E+00	3.567E+00	3.505E+00	3.407E+00	3.251E+00	3.102E+00	2.961E+00	2.825E+00	2.697E+00
PO215	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
PO216	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
RN219	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
RN220	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
FR223	1.241E-03	1.355E-03	1.462E-03	1.562E-03	1.701E-03	1.905E-03	2.079E-03	2.228E-03	2.354E-03	2.461E-03
RA223	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
RA224	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
RA226	6.018E-06	6.770E-06	7.528E-06	8.277E-06	9.420E-06	1.132E-05	1.324E-05	1.517E-05	1.711E-05	1.906E-05
RA228	9.828E-02	1.013E-01	1.038E-01	1.059E-01	1.082E-01	1.108E-01	1.123E-01	1.133E-01	1.138E-01	1.142E-01
AC227	8.991E-02	9.821E-02	1.059E-01	1.132E-01	1.233E-01	1.380E-01	1.506E-01	1.614E-01	1.706E-01	1.784E-01
TH227	8.889E-02	9.704E-02	1.047E-01	1.119E-01	1.218E-01	1.364E-01	1.489E-01	1.595E-01	1.685E-01	1.762E-01
TH228	5.739E+00	5.649E+00	5.553E+00	5.456E+00	5.309E+00	5.068E+00	4.838E+00	4.617E+00	4.406E+00	4.205E+00
TH229	3.521E-02	3.958E-02	4.395E-02	4.832E-02	5.487E-02	6.577E-02	7.666E-02	8.758E-02	9.850E-02	1.093E-01
TH230	8.729E-04	8.758E-04	8.787E-04	8.816E-04	8.860E-04	8.933E-04	9.013E-04	9.085E-04	9.158E-04	9.231E-04
TH231	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06
TH232	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01
TH234	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07
PA231	2.238E-01	2.238E-01	2.238E-01	2.238E-01	2.237E-01	2.237E-01	2.236E-01	2.236E-01	2.236E-01	2.236E-01
PA233	1.853E-08	1.868E-08	1.884E-08	1.902E-08	1.929E-08	1.979E-08	2.034E-08	2.091E-08	2.151E-08	2.212E-08
PA234	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07
PA234	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10

U232	5.524E+00	5.419E+00	5.315E+00	5.214E+00	5.065E+00	4.827E+00	4.601E+00	4.384E+00	4.178E+00	3.982E+00
U233	2.316E+01									
U234	1.656E-01									
U235	1.203E-06									
U236	2.923E-07	2.923E-07	2.923E-07	2.923E-07	2.923E-07	2.924E-07	2.924E-07	2.924E-07	2.924E-07	2.924E-07
U237	1.597E-09	1.451E-09	1.318E-09	1.197E-09	1.036E-09	8.139E-10	6.400E-10	5.030E-10	3.954E-10	3.109E-10
U238	2.540E-07									
NP237	1.853E-08	1.868E-08	1.884E-08	1.902E-08	1.929E-08	1.979E-08	2.034E-08	2.091E-08	2.151E-08	2.212E-08
PU236	8.925E-12	5.488E-12	3.374E-12	2.076E-12	1.002E-12	2.980E-13	8.933E-14	2.741E-14	9.064E-15	3.623E-15
PU237	1.324E-41	2.009E-46	3.000E-51	4.551E-56	2.647E-63	2.335E-75	2.060E-87	1.790E-99	0.000E+00	0.000E+00
PU238	1.456E-05	1.433E-05	1.411E-05	1.389E-05	1.357E-05	1.305E-05	1.256E-05	1.208E-05	1.162E-05	1.117E-05
PU239	6.652E-04	6.652E-04	6.652E-04	6.651E-04	6.650E-04	6.650E-04	6.649E-04	6.647E-04	6.647E-04	6.646E-04
PU240	1.577E-04	1.577E-04	1.576E-04	1.576E-04	1.575E-04	1.575E-04	1.574E-04	1.573E-04	1.572E-04	1.571E-04
PU241	6.511E-03	5.914E-03	5.370E-03	4.878E-03	4.222E-03	3.318E-03	2.608E-03	2.051E-03	1.612E-03	1.267E-03
PU242	1.452E-08									
PU244	2.360E-17									
AM241	2.237E-04	2.429E-04	2.602E-04	2.757E-04	2.962E-04	3.238E-04	3.448E-04	3.605E-04	3.722E-04	3.807E-04
AM242M	2.615E-07	2.591E-07	2.568E-07	2.544E-07	2.509E-07	2.453E-07	2.398E-07	2.344E-07	2.291E-07	2.239E-07
AM242	2.602E-07	2.579E-07	2.555E-07	2.532E-07	2.497E-07	2.441E-07	2.386E-07	2.332E-07	2.279E-07	2.228E-07
AM243	1.468E-08	1.468E-08	1.468E-08	1.468E-08	1.467E-08	1.466E-08	1.465E-08	1.465E-08	1.464E-08	1.463E-08
CM242	2.156E-07	2.136E-07	2.117E-07	2.097E-07	2.070E-07	2.019E-07	1.974E-07	1.929E-07	1.886E-07	1.843E-07
CM243	1.481E-08	1.410E-08	1.343E-08	1.280E-08	1.190E-08	1.053E-08	9.326E-09	8.263E-09	7.316E-09	6.477E-09
CM244	1.326E-07	1.228E-07	1.137E-07	1.053E-07	9.391E-08	7.753E-08	6.406E-08	5.290E-08	4.369E-08	3.608E-08
CM245	2.333E-12	2.332E-12	2.331E-12	2.330E-12	2.330E-12	2.329E-12	2.327E-12	2.327E-12	2.326E-12	2.326E-12
CM246	4.552E-14	4.551E-14	4.549E-14	4.546E-14	4.543E-14	4.540E-14	4.536E-14	4.533E-14	4.530E-14	4.530E-14
CM247	1.540E-20									
SUBTOTAL	2.272E+03	2.146E+03	2.035E+03	1.933E+03	1.795E+03	1.593E+03	1.418E+03	1.263E+03	1.127E+03	1.006E+03
AP+ACT+FP										

3.0 TRIGA FUEL TYPES

3.1 Introduction

In general, TRIGA fuel elements consist of uranium-zirconium hydride (UZrH_x) fuel rods with metal cladding (most with aluminum or stainless steel tubes, some with Incoloy). The fuel rod is axially centered in the tube with a graphite moderator slug at each end. Burnable poison discs, if present, are placed in between the fuel rod and the graphite. There is no bonding material between the fuel and cladding. Fixtures are heliarc welded to the top and bottom ends of the cladding encapsulating all of the internal pieces. The bottom end fixtures of the fuel element are designed to guide the fuel elements into the bottom support plate of the reactor core. The top end fixtures provide a grooved end surface that the coupling end of the handling tool can grip. Each fuel element has a permanent serial number engraved on the top end fixture in approximately 0.25-inch numerals. The serial number is unique for each element and can be used to trace the fabrication history of the components within an element.

TRIGA fuel has several unique characteristics, including:

1. Prompt negative temperature coefficient of reactivity; provides the inherent safety and ability to pulse.
2. High fission product retention - experiments have proven that unclad TRIGA fuel material releases less than 10^{-4} of gaseous fission products under postulated accident conditions.
3. No metal/water reactions - the uranium-zirconium hydride fuel of TRIGA reactors exhibits no significant metal-water reactions even when quenched in water from 1200°C.
4. High-temperature strength and ductility of the stainless steel clad TRIGA fuel.

Distinctions among TRIGA fuel elements are typically associated with one of two variables: 1) the specifications for fuel fabrication in use at General Atomics (GA) at time of manufacture and 2) specific parameters of the requestor. Changes in the GA manufacturing process were implemented throughout the TRIGA program to improve reactor power capacity and increase in the useful life of the fuel elements. Requestors would specify the end fixtures required to accommodate their particular grid plate and coolant flow designs.

3.2 Physical Description of Fuel

3.2.1 Uranium Zirconium Hydride Fuel Matrix

The TRIGA fuel fabrication process used by GA in the early 1960s produced solid rods of uranium zirconium hydride with a hydrogen to zirconium ratio of about 1 (UZrH_1). In 1965 GA implemented a major manufacturing change by drilling a 0.25-inch hole through the uranium

zirconium hydride rods to facilitate hydriding. These hollow rods yielded a more uniform hydride content throughout the entire fuel meat matrix. The nominal hydrogen to zirconium atom ratio of 1.7 ($\text{UZrH}_{1.7}$) was fairly consistent throughout the entire fuel matrix. The hole in the hollow rod was filled with a 0.225-inch diameter solid zirconium rod after hydriding had taken place. Limited documentation is publicly available concerning the GA fabrication process. Procedures and specifications identifying details such as fuel meat density, impurity levels, porosity, and hydride gradients are not available at this time.

3.2.2 Standard Stainless Steel Clad Elements

3.2.2.1 Standard Stainless Steel Clad Fuel Moderator Elements

Standard stainless steel clad moderator TRIGA elements homogeneously combine a zirconium hydride moderator with enriched uranium fuel (see Figure 3-1). The uniform hydrogen-to-zirconium atom ratio of 1.7 to 1 is achieved through the use of the hollow rod design. The active fuel section is 1.435 inches in diameter and 15 inches long (composed of three 5-inch long UZrH_{1.7} pieces) and contains 8.5wt % uranium enriched to 20% in ²³⁵U. The nominal ²³⁵U content is 39 g. The samarium trioxide burnable poison discs were not used in the standard stainless steel clad elements. Above and below the fuel section, 3.42 inch long graphite slugs act as neutron reflectors.

The standard stainless steel elements were clad with 0.02 inch thick type 304 stainless steel with end fitting closures made by heliarc welding. The ²³⁵U content comprises about 1.7% of the weight of the active section. Each element contains 156 g ²³⁸U and 2088 g zirconium (nominal values). A plenum gap of at least 0.25 inch is left above the upper section of graphite to accommodate thermal expansion between the fuel-moderator material and the graphite. The overall element measures 28.94 inches with the end fitting design (see Table 3-1).

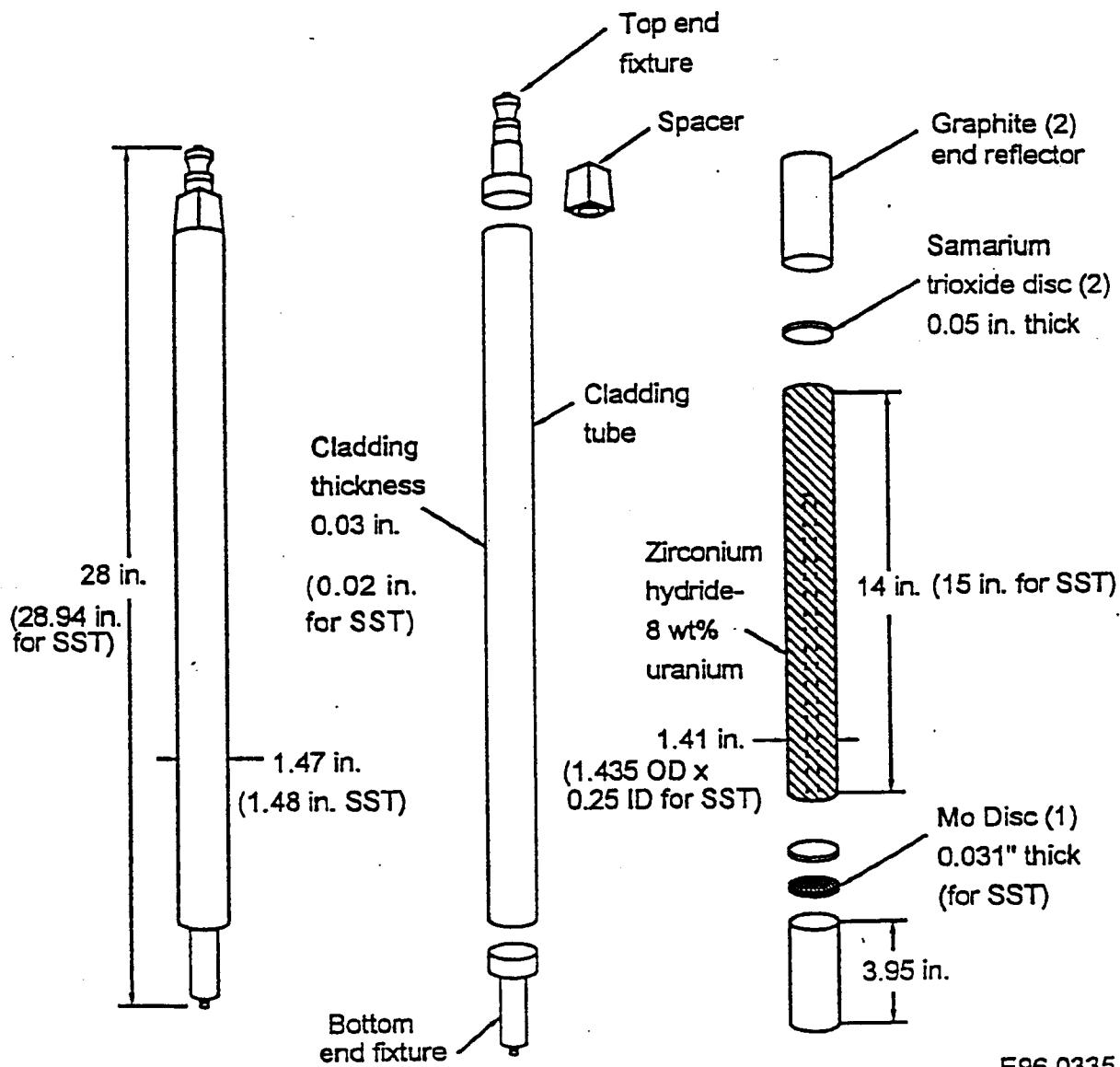
3.2.2.2 Instrumented Standard Stainless Steel Clad Elements

Stainless steel clad instrumented elements were also received from GA. These are similar to the standard stainless steel clad fuel moderator elements describe above, but in addition these elements have three chromel-alumel thermocouples embedded into the fuel meat. The sensing tips are located halfway between the outer radius and the vertical centerline of the fuel section, and at the horizontal center and one inch above and below this position. The thermocouple lead out wires pass through a seal at the upper-end fixture and then through additional tubing to provide a watertight conduit to carry the lead-out wires above the water surface. All other dimensions are identical to the standard stainless steel clad fuel moderator element.

3.2.3 Fuel Follower Control Rod Elements

The Advanced TRIGA reactor also operates with several fuel follower control rod (FFCR) elements to offset the long term effects of fuel burnup. There are three types of FFCRs: a safety rod, a regulating rod, and a shim rod. All three types are basically the same element, but they each serve a different function within the core. These elements are sealed Type 304 stainless steel tubes 45.0 inches long by 1.35 inches in diameter. The uppermost 6.5 inch section is an air void with the next 15 inches being a solid boron carbide neutron absorber rod. Directly below the neutron absorber is a fuel section consisting of 15 inches of UZrH_{1.7} fuel. The bottom section of the rod has a 6.5 inch air void. The fuel sections of the FFCR weigh approximately 2000 g with uranium comprising 8.5 wt % of the total mass (20% initial enrichment). Each element is clad with a 0.02 inch thick stainless steel tube. Stainless steel fixtures are attached by heliarc welding to both ends of the tube.

There are three variations on the initial fuel loading for the FFCRs: The first is a standard 20% U-235 enrichment with 8.5 wt % U. The second is the FLIP-LEU-I loading (20% enrichment, 20 wt %). The first and second variations have the same dimensions. The third is the ACPR loading (20% enrichment, 12 wt %).



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Figure 3-1. Standard TRIGA Rod

Table 3-1. Physical Characteristics of the Standard TRIGA Fuel Elements

Characteristics	Al Clad Elements	Standard SST Clad Elements
Element dim., in.	1.47 dia x 28 long	1.478 dia. x 28.94 long
Geometry of fuel meat	Solid rod	Hollow rod
Effective fuel length, in.	1.41 dia x 14 long	1.435 OD x 0.25 ID x 15 long
Plenum gap length	NA	0.25 in.
Fuel meat material	UZrH ₁	UZrH _{1.7}
Nominal ²³⁵ U	36 g	39 g
Nominal Total U	180 g	195 g
Nominal fuel meat weight	2250 g	2283 g
Total element weight	2.9 kg	3.4 kg
U ppt size	NA	NA
Burnable poisons	Samarium trioxide	None Used
Poison dim., in.	1.42 dia x 0.05 thick	---
Rod-Cladding gap	NA	NA
Cladding	1100F Al	Type 304 SST
Clad thickness	0.03 in.	0.02 in.
Weld filler material	NA	NA
2 End fixtures	140 g	530 g
2 Graphite end reflectors	1.41 dia x 3.95 long each	1.435 dia. x 3.42 long each
Material added to element	None known	0.225 in dia. Zr rod inside hollow fuel rod. Molybdenum disc,* 1.435 in. dia. x 0.031 inches thick

NA = Information is not available at this time.

* located between the fuel meat and the bottom graphite end reflector, ONLY in elements produced after 4/15/71.

** Contradictory information has been identified: some of these parameters may not be correct depending on date of fabrication.

ACPR FFCRs are assembled slightly differently than the standard. The overall length is 66.5 in. and the diameter is 1.5 in. The length of the fuel meat is 14.25 in. (about 5% shorter than the regular ACPR element). This is positioned just below the poison, or neutron absorber, boron carbide that is 15 inches of three segments. The bottom section of the rod is 25 in. of air void. The cladding of these elements is similar to that of the regular element in that the 304-type SST clad, thickness, fabrication methods and insulation gap, and dimple design are all the same.

3.2.4 New Stainless Steel Clad TRIGA

New stainless steel clad TRIGA elements currently being produced by GA (these elements would have been fabricated after April 15, 1971) have a 0.031-inch thick 1.435-inch diameter molybdenum disc between the fuel rod and the bottom graphite plug. All other dimensions are the same as the standard stainless steel clad elements.

3.2.5 Streamline Stainless Steel Clad Elements

The standard streamline element has a 15 inch fuel meat length with a central zirconium rod (the zirconium rod manufacture did not begin until the end of 1964). The graphite reflectors, located at each end of the fuel meat, are different lengths in this assembly. The upper graphite section is 2.56 inches and the lower graphite is 3.72 inches long. The overall length of the assembly is 29.68 inches and the total diameter is 1.478 inches.

3.2.6 Fuel Life Improvement Program Elements

The Fuel Life Improvement Program (FLIP) was designed to extend the life of the standard TRIGA elements. The first of these FLIP elements is HEU or high enriched uranium. It is 70% U-235 enriched with the standard 8.5 wt % total U. The FLIP element has the central zirconium rod for a Zr/H ratio of 1.6 and is clad in stainless steel. The use of erbium in conjunction with the higher U-235 loadings permits longer core lifetimes than obtainable with the original TRIGA fuel. Erbium enrichment is about 1.48 to 1.6 wt %. All the analyses that have been made on the alloy show that the erbium is dispersed uniformly, creating an erbium hydride, meaning that erbium is fairly stable within the fuel matrix.

The combination of high peak fuel temperatures that occur during a pulse and the increased zirconium-hydride ratio can cause excessive hydrogen pressures in the fuel matrix, which can cause excessive swelling and fuel element deformation. Pulse sizes should be reduced in longer burning cores (i.e., FLIP cores) to account for the effects of hydrogen redistribution. However, this effect is independent of uranium content.

The FLIP-LEU-I is a low enriched FLIP fuel element with 20% U-235 enrichment at 20 wt % and 0.5 wt % of Er. The behavior of the LEU-I and II is indistinguishable from that of the standard 8.5 wt %, and should permit a one-for-one fuel element replacement in the reactor core.

The FLIP-LEU-II is also a low enriched FLIP fuel element with 20% U-235 enrichment at 30 wt % and 0.9 wt % Er.

3.2.7 Annular Core Pulsed Reactor TRIGA Elements

The Annular Core Pulsed Reactor fuel is TRIGA fuel made especially for the ACPR reactor. This fuel has 20% U-235 enrichment and 12 wt % total U. Other dimensions and cladding are similar to the standard stainless steel clad elements. Also called pseudo-standard, this fuel can also be used as partial replacement for standard fuel elements

ACPR cladding is provided with internal dimples to act as spacers ensuring a thermal gap between the fuel meat and the cladding. This gap ($375\mu\text{m}$, 0.015 inch), a built-in thermal barrier, introduces a thermal resistance to control heat flow rates from the fuel immediately after pulsed

operation and to prevent film boiling.

ACPR also has its own instrumented elements and its own type of fuel followed control rod (FFCR) that are used in the ACPR reactor.

3.2.8 Aluminum Clad Elements

The aluminum-clad element is the original design from General Atomic. The tubing used for cladding was 0.03 inch thick type 1100F aluminum. Aluminum-clad TRIGA fuel elements have poorer integrity and robustness, and are more prone to failure during handling. Consequently, they were phased out of use and replaced by stainless steel because of its high durability, comparable resistivity to handling damage, and better burnup statistics.

The overall length of the aluminum clad moderator elements is approximately 28 inches with a 14 inch active fuel section composed of a single solid UZrH rod 1.41 inch in diameter. Reflector rods, located between the end fittings and the poison discs or fuel meat at both ends of the assembly, are made of graphite. The 14 inch fuel rod has 8.0-8.5 wt % uranium enriched to 20% in U-235. The burnable poison disks contained samarium trioxide.

Since 1964, newer aluminum clad elements were produced with 15 inch hollow fuel sections with the zirconium-hydride ratio of ~1.6. The uranium loading and enrichment remained about the same, but the poison disks were discontinued.

Aluminum clad instrumented fuel elements have three chromel-alumel thermocouples embedded in the fuel. The thermocouple wires pass through an aluminum lead-out tube at the top of the element and are otherwise similar to the fuel moderator elements.

3.2.9 Incoloy Clad Elements

The Incoloy clad elements use the Incoloy 800 alloy, also referred to as Alloy 800. The cladding is 0.016 in. thick with outside diameters of 0.54 inch or 1.2 inches. Element length is 30.37 inches. The active fuel section is 22 in. long by 0.51 in. diameter. This fuel section is divided into four 5.5-in. segments, sometimes called pellets, rather than the three 5-inch segments used in the standard element configurations. End fittings may be made of either stainless steel or Incoloy.

The Incoloy clad TRIGA is an HEU fuel that consists of 93% enriched U-235 with approximate 10 wt % total U and 2.8 wt % Er. A LEU variation of Incoloy clad fuel elements is also available enriched to 19.7% U-235, 45 wt % total U and 1.1 wt % Er.

Although the Incoloy clad elements have a zirconium-hydride ratio of 1 to 1.6, the elements do not have a zirconium rod in the center. Graphite reflector rods are also absent in the Incoloy clad elements, replaced by a plenum region that accommodates a 3 in. spring made of Incoloy 800. The spring is there to keep the fuel meat in place and to accommodate axial fuel growth.

Incoloy clad instrumented elements are also used. Chromel-alumel thermocouples are attached to the fuel and wired through a lead-out tube at the top of the element. Other dimensions are comparable to the Incoloy clad fuel moderator elements.

3.2.10 Multiple Element Clusters

For several conversion reactors, TRIGA fuel elements are bundled into "clusters" to better replace plate type fuels. This appears to justify some of the size variations in the Incoloy clad and "streamline" stainless steel TRIGA elements.

3.3 Packaging

There are currently 1,159 TRIGA fuel rods in three storage locations at the INTEC. There are 303 rods in 67 cans in wet storage at the CPP-603 basin. DOE will place these fuels in dry storage within the IFSF prior to delivery to the Contractor. There are 576 rods currently stored in 14 canisters at the IFSF. There are another 280 rods within 19 buckets in wet storage at CPP-666. DOE will place these fuels in dry storage within the IFSF prior to delivery to the Contractor. TRIGA fuel continues to be brought to the INEEL from domestic and foreign sources.

The 583 TRIGA elements currently stored under water are in open top aluminum or stainless steel cans with three, four or five elements per can (see Figures 3-2 and 3-3). CPP-666 buckets typically hold four cans each (see Figure 3-4). These cans, or buckets, are in turn stored in aluminum or stainless steel racks at the CPP-603 and CPP-666 fuel storage facilities. To the extent possible, the aluminum clad fuel is stored in aluminum hardware, and the stainless steel clad fuel is likewise stored in stainless steel hardware (i.e., cans, buckets, and racks).

The IFSF storage canisters hold up to 60 TRIGA elements (see Figure 3-5). The canister lids allow gas exchange, and the IFSF is a vented (filtered) dry storage environment. Details on the baskets and cans used inside these canisters will be made available as needed after the award of this contract.

The INEEL is expected to receive a large number of TRIGA elements during the next 10 years from domestic reactors as well as Foreign Research Reactors (FRR) worldwide. TRIGA fuels arriving at the INEEL have likely been stored in water for some time, but they will be placed in dry storage within the IFSF upon arrival.

Worldwide, TRIGA fuel elements are stored in a variety of different configurations and in a wide range of environmental conditions (i.e., dry vs. wet, clean vs. questionable environments, etc.). Since these conditions are not currently known for the reactors throughout the world, the as stored condition is not available for the entire TRIGA inventory. However, in general, the stainless steel clad fuel elements should be relatively free of corrosion or degradation due to the durability of the stainless steel cladding material.

3.4 As Stored Condition

Generally, the TRIGA fuels should be in very good condition. The container may have degraded badly, but the fuel meat itself is highly stable and will not degrade under most normal storage conditions (i.e., 30 C in a water or air environment). Zirconium hydride is one of the most chemically, thermally, and radiolytically stable hydrides, particularly in monolithic form. The monolithic hydride is essentially stable in underwater storage. At ambient temperatures, zirconium hydride reacts very slowly with air or water, and is protected from further reaction by the formation of a tenacious, impermeable oxide film. Furthermore at ambient temperatures the hydride is thermodynamically stable compared to the parent elements, and will not lose hydrogen

by dissociation and loss of hydrogen by diffusion. In fact, at ambient temperatures, pure zirconium metal (if not contaminated with an oxide film), will rapidly absorb hydrogen to form the hydride.

Metal hydrides can be grouped into three rather broad categories: 1) saline hydrides (e.g., alkaline earth hydrides such as LiH, NaH); 2) covalent hydrides (e.g., aluminum hydride, tin hydride); and 3) metallic hydrides. Of these hydrides, the metallic hydrides, which include zirconium hydride, are the most stable. Furthermore, zirconium hydride is one of the most stable metallic hydrides.

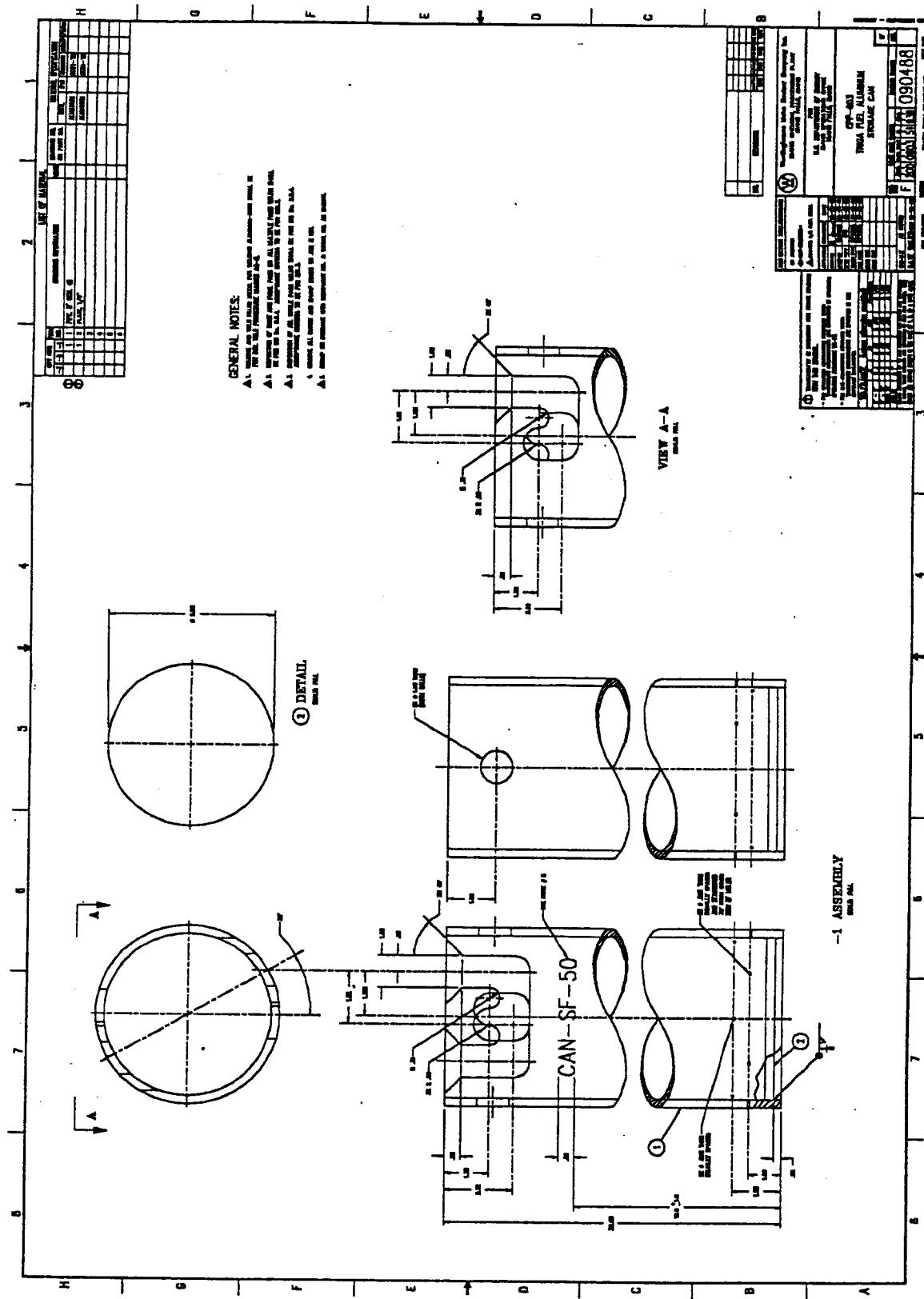


Figure 3-2. CPP-603 TRIGA Fuel Aluminum Storage Canister

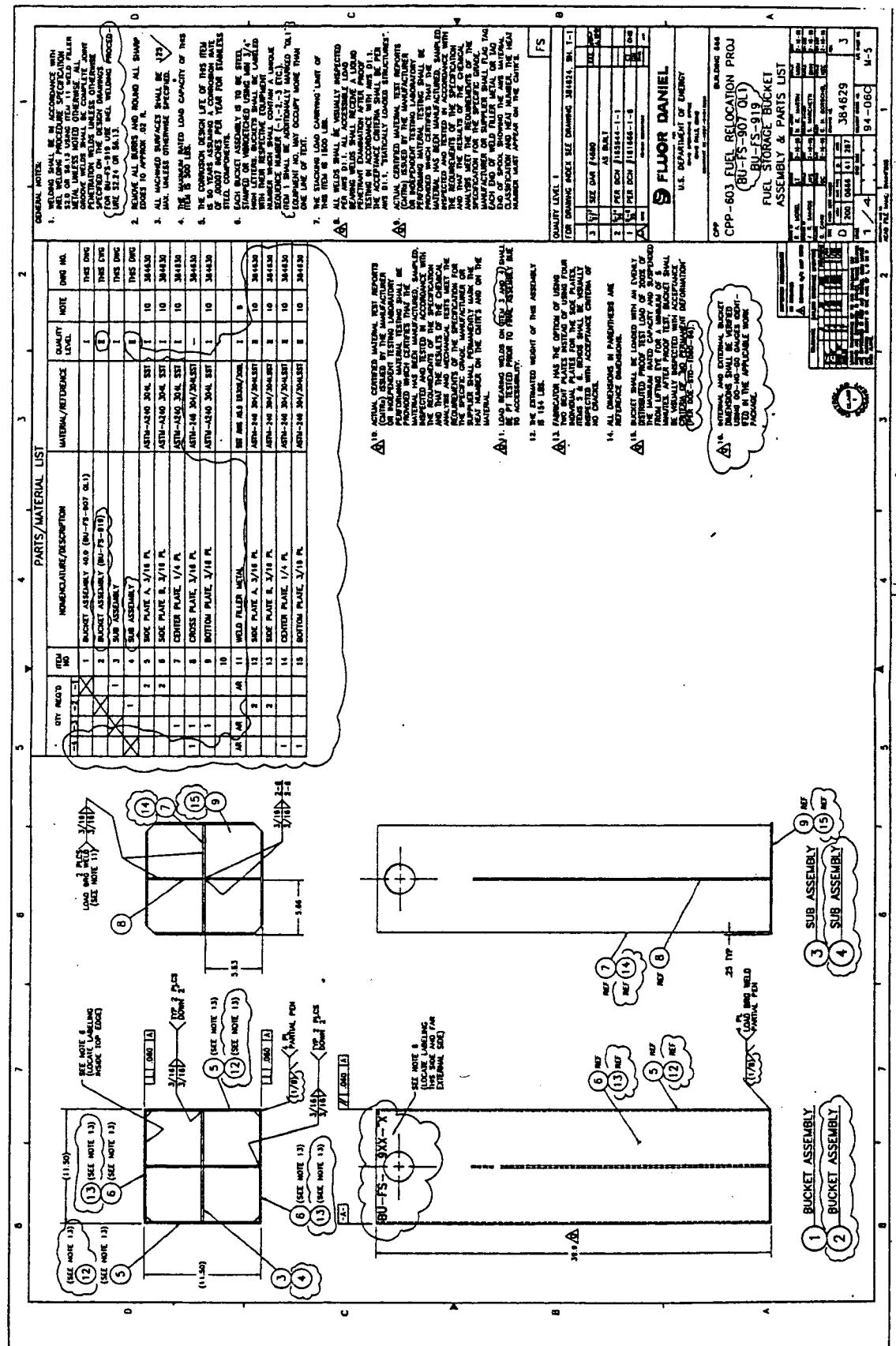


Figure 3-4. CPP-666 TRUGA Storage Buckets

In the present context, the mechanisms that may affect the stability of zirconium hydride include:

- Reaction with water;
- Reaction with dissolved oxygen or air;
- Thermal dissociation, or thermally-driven redistribution of hydrogen and loss by diffusion; and
- Radiolytic dissociation.

The effects of these mechanisms are qualitatively discussed below.

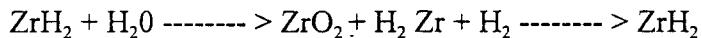
3.4.1 Reaction with Water

Monolithic zirconium hydride is stable in water up to approximately 100°C, and relatively stable up to 300°C. Under these conditions, the hydride reacts so slowly that even the powder is considered to be stable. At these temperatures, the rate of hydride reaction with water is negligible. Further, the extent of reaction with water is limited by the formation of a very thin, tenacious non-hygroscopic film of oxide that completely protects the bulk of the hydride from further hydrolysis.

The zirconium oxide films are characteristically relatively impermeable to hydrogen permeation. However, the thin ZrO₂ films formed at 25°C are denser and more impermeable than thicker ZrO films formed at elevated temperatures. The permeability of ZrO₂ films formed at 250°C is several orders of magnitude greater than the permeability of films formed at 25°C. The trend in permeation characteristics of these non-hygroscopic films is comparable for water permeation, except that the permeation constant for H₂O is many orders of magnitude lower than that of H₂ because of the molecular size difference.

Nevertheless, oxide films formed at a high temperature offer significant protection and stability for the zirconium hydride; the effect is particularly evident in harsher, very corrosive conditions. Zirconium hydride exposed to steam at 300 to 400°C will react very slowly over a period of days with only a slight weight gain due to formation of oxide film. However, at higher temperatures, particularly above 500°C, the resultant oxide film becomes more permeable to water. In addition, if there is a significant metal phase present, the zirconium oxide film can start to dissolve into the metal phase at temperatures higher than 500°C. Therefore, the oxide films on the hydride at high temperatures are not completely protective against further reaction. Nevertheless, at these temperatures the rate of reaction is still slow compared to the reactivity of other materials. Zirconium hydride quenched from beta phase (> 550°C) in water or brine shows minimal effects except for slight surface reaction.

In general, the lower the hydrogen content, the lower is the corrosion resistance of the zirconium hydride. However, when the hydride contains a considerable excess of zirconium metal, the metal may react with the hydrogen that is liberated by the hydrolysis to re-form some of the hydride mass:



In addition, alloys with uranium may have slightly lower corrosion resistance. While powders of Zr-U-H alloys (1:0.03: 1) may be quenched in water with formation of only light films of oxide, prolonged immersion in boiling water produces an oxide film that may flake off, resulting in a slight mass loss (mass loss of 0.8 mg/cm² in one year).

3.4.2 Reaction with Oxygen or Air

Loss of hydrogen by oxidation of the zirconium hydride by the oxygen or air dissolved in basin water is not an issue in underwater storage. The zirconium oxide film on the hydride is an effective barrier to oxygen permeation as it is to hydrogen and water.

Metal hydrides, as a class, are considered strong reducing agents, and most will rapidly oxidize, many of them pyrophorically. Zirconium hydride, however, is one of the most stable of the metal hydrides. Monolithic zirconium hydride is stable in air up to 600°C. An exposure of monolithic zirconium hydride to 760°C in air for 100 hours oxidized the hydride only to a depth of 0.02 inches (500 microns). In addition, only negligible losses of hydrogen occur during exposures at temperatures up to 750°C in an oxidizing environment such as air or CO₂. Evidently, the initial oxide films that form in these reactions are highly effective barriers to oxygen and hydrogen permeation.

3.4.3 Thermal Dissociation

Loss of hydrogen by thermal dissociation of the hydride to its component elements is not an issue in wet fuel storage. The surface temperatures and the average fuel temperature are kept relatively low by water cooling in basin storage. As mentioned above, the protective zirconium oxide film is quite impermeable to hydrogen, and effectively prevents the desorption of free hydrogen and the decomposition of the hydride. A more germane question is - whether any hydrogen loss may have occurred at the higher temperatures of reactor service?

Almost all metal hydrides will dissociate to the metal and hydrogen at temperatures well below the hydride melting points. The decomposition temperature may be as low as ambient temperature for unstable hydrides, or as high as 1000°C for stable hydrides. The degree of dissociation will be a function of temperature, hydrogen pressure and the type of metal hydride. The extent of hydrogen loss by a hydride will depend on the extent of dissociation at a given temperature, the diffusion rate of hydrogen through the fuel matrix, and the diffusion rate through any barrier films or cladding.

Zirconium hydride has a moderately high thermal stability for hydride phases ranging from ZrH_{1.33} to ZrH₂. Zirconium hydride will dissociate slightly at elevated temperatures. However, the equilibrium hydrogen pressures from dissociation are low at 635°C, the equilibrium hydrogen pressure is 1 mm Hg; at 500°C, 0.1 mm Hg; and at 370°C, 0.001 mm Hg. These data suggest that hydrogen losses even at reactor temperatures will be relatively low, for the impervious oxide

film will retain the free hydrogen. Performance measurements have indicated that the equilibrium hydrogen pressure at 760°C results in negligible hydrogen loss, and thus is insufficient to drive measurable diffusion of H₂ through the oxide film.

Partial dissociation of the hydride can result in hydrogen redistribution as a consequence of an internal thermal gradient. Such gradients would be expected in reactor service and in storage. Such temperature gradients can establish a hydride concentration gradient, forming a hydrogen-rich phase at the cooler end of the gradient, and possibly cause a loss of hydrogen. In fact, disastrously large concentration gradients have been developed in metal hydride research for reactor applications. The dissociation-driven redistribution is a well-documented phenomenon in the metal hydrides, including zirconium hydride. However, in view of the documented impermeability of hydrogen in the zirconium oxide films, particularly for the low dissociation pressures characteristic for ZrH₂, this mechanism would not be a realistic loss mechanism for stored fuels.

3.4.4 Radiolytic Dissociation

Dissociation of zirconium hydride can also occur by radiolysis due to the in-reactor neutron flux and the decay radiation. Since dissociation is a reversible process, and the recombination reaction is very fast, no irreversible, adverse effects are expected from radiolytic dissociation unless the hydrogen were to escape rapidly. Because of the permeation characteristics of the zirconium oxide film, hydrogen loss due to radiolytic dissociation is not realistic unless the zirconium hydride is radiolytically unstable and high pressures of hydrogen are produced.

Zirconium hydride is relatively stable in high radiation fields. No changes in characteristic dissociation pressures have been measured for irradiated zirconium hydride. Furthermore, no adverse effects have been detected in experimental irradiation studies on zirconium hydrides.

3.5 Radionuclide Inventory

There is a great variation in the burn-up for TRIGA fuel that is irradiated in different reactors and for differing uranium loading and U-235 enrichment. Table 3-2 presents a calculated radionuclide inventory for a high burn-up standard stainless steel clad TRIGA element as a function of decay time. The estimated dose rate with ten years of cooling at 3 meters in air is 1.2 E+4 mrem/hr. The estimated decay heat for a high burn-up TRIGA element with ten years of cooling is 2 watts.

3.6 References

Ebner, MA; "Stability of Zirconium Hydride Spent Fuels in Wet Storage", MAE-01-94, January 28, 1994.

Tomsio, N., *Characterization of TRIGA Fuel*, GA Technologies, GA-3442, October, 1986.

Table 3-2: Stainless Steel-clad TRIGA Fuel Activity (Curies) as a function of Decay Time.

ACTIVITY (CURIES)							
ISOTOPE	0-days*	14-days	28-days	0.25-years	1-years	3-years	5-years
BU: U-235	7.0 g						
BU: % U-235	17.95%						
BU: MWd	6.65						
BU: MWD/MTU	34103						
U-235 DEPL	8.08 g						
BURNUP (BU)							
BU: U-235	7.0 g						
BU: % U-235	17.95%						
BU: MWd	6.65						
BU: MWD/MTU	34103						
U-235 DEPL	8.08 g						
20-years							
H 3	9.781E-02	9.760E-02	9.738E-02	9.645E-02	9.511E-02	9.248E-02	7.389E-02
BE 10	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07
C 14	8.564E-04	8.564E-04	8.564E-04	8.563E-04	8.561E-04	8.559E-04	8.554E-04
CL 36	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05
CR 51	4.603E+01	3.243E+01	2.285E+01	4.695E-00	4.789E-01	4.984E-03	5.843E-11
MN 54	2.769E-00	2.684E-00	2.602E-00	2.262E-00	1.847E-00	1.232E-00	2.441E-01
FE 55	1.944E+01	1.924E+01	1.905E+01	1.819E+01	1.702E+01	1.489E+01	8.742E-00
FE 59	8.559E-01	6.899E-01	5.560E-01	2.099E-01	5.147E-02	3.095E-03	4.049E-08
CO 60	1.647E+01	1.639E+01	1.631E+01	1.594E+01	1.542E+01	1.444E+01	1.110E+01
NI 59	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03
Ni 63	4.444E-01	4.443E-01	4.442E-01	4.436E-01	4.428E-01	4.411E-01	4.345E-01
ZN 65	3.469E-01	3.334E-01	3.204E-01	2.677E-01	2.065E-01	1.229E-01	1.544E-02
SE 79	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05
KR 85	2.320E-00	2.314E-00	2.309E-00	2.283E-00	2.246E-00	2.175E-00	1.911E-00
RB 87	5.921E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09
SR 89	1.748E+02	1.443E+02	1.190E+02	4.997E+01	1.428E+01	1.166E-00	5.189E-05

Contract No. DE-AC07-00ID13729
 Section C Attachment C-A-A

SR 90	1.951E+01	1.949E+01	1.948E+01	1.940E+01	1.928E+01	1.905E+01	1.817E+01	1.732E+01	1.538E+01	1.212E+01
Y 90	2.041E+01	1.952E+01	1.948E+01	1.940E+01	1.929E+01	1.906E+01	1.817E+01	1.733E+01	1.538E+01	1.213E+01
Y 91	2.142E+02	1.827E+02	1.548E+02	7.317E+01	2.483E+01	2.857E-00	5.010E-04	8.787E-08	3.580E-17	5.942E-36
ZR 93	5.291E-04	5.294E-04								
ZR 95	2.573E+02	2.211E+02	1.899E+02	9.574E+01	3.562E+01	4.933E-00	1.813E-03	6.666E-07	1.727E-15	1.159E-32
NB 93M	4.798E-05	4.886E-05	4.975E-05	5.372E-05	5.941E-05	7.056E-05	1.124E-04	1.503E-04	2.296E-04	3.386E-04
NB 94	5.405E-05	5.405E-05	5.405E-05	5.405E-05	5.405E-05	5.405E-05	5.404E-05	5.404E-05	5.403E-05	5.401E-05
NB 95	2.634E+02	2.573E+02	2.445E+02	1.617E+02	7.065E+01	1.072E+01	4.026E-03	1.480E-06	3.834E-15	2.574E-32
NB 95M	1.808E-00	1.633E-00	1.408E-00	7.103E-01	2.643E-01	3.659E-02	1.346E-05	4.946E-09	1.281E-17	8.601E-35
MO 93	6.225E-05	6.225E-05	6.225E-05	6.225E-05	6.225E-05	6.224E-05	6.221E-05	6.219E-05	6.213E-05	6.201E-05
TC 99	2.934E-03	2.942E-03								
RU103	1.235E+02	9.647E+01	7.536E+01	2.468E+01	4.934E-00	1.971E-01	5.017E-07	1.277E-12	1.321E-26	0.000E+01
RU106	1.894E+01	1.844E+01	1.796E+01	1.595E+01	1.343E+01	9.525E-00	2.410E-00	6.097E-01	1.963E-02	2.035E-05
RH103M	1.112E+02	8.697E+01	6.793E+01	2.225E+01	4.448E-00	1.777E-01	4.523E-07	1.152E-12	1.191E-26	0.000E+01
RH106	1.936E+01	1.844E+01	1.796E+01	1.595E+01	1.343E+01	9.525E-00	2.410E-00	6.097E-01	1.963E-02	2.035E-05
PD107	4.165E-06									
AG110	3.406E-01	1.639E-04	1.576E-04	1.323E-04	1.027E-04	6.191E-05	8.171E-06	1.079E-06	6.829E-09	2.737E-13
AG110M	1.281E-02	1.232E-02	1.185E-02	9.946E-03	7.721E-03	4.654E-03	6.144E-04	8.110E-05	5.134E-07	2.057E-11
AG111	1.437E-00	3.917E-01	1.065E-01	2.962E-04	6.091E-08	2.574E-15	0.000E+01	0.000E+01	0.000E+01	0.000E+01
CD113M	2.724E-03	2.720E-03	2.715E-03	2.693E-03	2.661E-03	2.598E-03	2.363E-03	2.149E-03	1.695E-03	1.054E-03
CD113	0.000E+01									
CD115M	6.316E-02	5.081E-02	4.088E-02	1.530E-02	3.703E-03	2.171E-04	2.564E-09	3.028E-14	1.451E-26	0.000E+01
IN114	3.824E-03	1.249E-03	1.027E-03	4.235E-04	1.181E-04	9.175E-06	3.345E-10	1.220E-14	9.789E-26	0.000E+01
IN114M	1.588E-03	1.305E-03	1.073E-03	4.426E-04	1.234E-04	9.587E-06	3.496E-10	1.274E-14	1.023E-25	0.000E+01
IN115M	6.362E-01	8.926E-03	1.174E-04	1.074E-06	2.600E-07	1.524E-08	1.800E-13	2.126E-18	1.019E-30	0.000E+01
SN119M	2.839E-00	2.730E-00	2.624E-00	2.194E-00	1.694E-00	1.012E-00	1.283E-01	1.626E-02	9.310E-05	3.052E-09
SN121M	4.134E-04	4.132E-04	4.130E-04	4.120E-04	4.106E-04	4.077E-04	3.966E-04	3.857E-04	3.599E-04	3.133E-04
SN123	3.663E-01	3.398E-01	3.152E-01	2.244E-01	1.376E-01	5.166E-02	1.028E-03	2.044E-05	1.141E-09	3.555E-18
SN125	1.553E-00	5.677E-01	2.074E-01	2.197E-03	3.107E-06	6.214E-12	0.000E+01	0.000E+01	0.000E+01	0.000E+01
SN126	8.091E-05	8.090E-05	8.090E-05							
SB124	5.053E-02	4.300E-02	3.660E-02	1.767E-02	6.180E-03	7.555E-04	1.689E-07	3.777E-11	2.823E-20	1.577E-38

Contract No. DE-AC07-00ID13729
 Section C Attachment C-A-A

SB125	2.000E-00	1.991E-00	1.976E-00	1.893E-00	1.779E-00	1.570E-00	9.518E-01	5.772E-01	1.653E-01	1.356E-02
SB126	4.483E-02	2.050E-02	9.377E-03	2.839E-04	1.298E-05	1.133E-05	1.133E-05	1.133E-05	1.133E-05	1.133E-05
SB126M	2.268E-02	8.091E-05	8.090E-05							
TE123M	1.303E-04	1.108E-04	7.683E-05	4.529E-05	1.573E-05	2.295E-07	3.346E-09	8.588E-14	5.659E-23	
TE125M	4.428E-01	4.453E-01	4.470E-01	4.452E-01	4.283E-01	3.824E-01	2.323E-01	1.409E-01	4.033E-02	3.309E-03
TE127	6.488E-00	1.347E-00	8.103E-01	5.148E-01	2.882E-01	9.029E-02	8.703E-04	8.388E-06	7.651E-11	6.364E-21
TE127M	9.053E-01	8.562E-01	7.856E-01	5.256E-01	2.942E-01	9.218E-02	8.885E-04	8.564E-06	7.811E-11	6.498E-21
TE129	2.638E+01	1.945E-00	1.457E-00	3.951E-01	6.015E-02	1.394E-03	4.016E-10	1.157E-16	5.160E-33	0.000E+01
TE129M	3.969E-00	2.988E-00	2.238E-00	6.070E-01	9.240E-02	2.141E-03	6.170E-10	1.778E-16	7.927E-33	0.000E+01
1129	4.876E-06	4.883E-06	4.887E-06	4.897E-06	4.900E-06	4.900E-06	4.900E-06	4.900E-06	4.900E-06	4.900E-06
1131	1.083E+02	3.328E+01	9.955E-00	4.266E-02	1.636E-05	2.405E-12	0.000E+01	0.000E+01	0.000E+01	0.000E+01
XE131M	1.202E-00	9.005E-01	5.086E-01	1.756E-02	9.076E-05	2.199E-09	7.463E-28	2.532E-46	0.000E+01	0.000E+01
XE133	2.502E+02	4.836E+01	7.620E-00	1.787E-03	1.036E-08	3.481E-19	0.000E+01	0.000E+01	0.000E+01	0.000E+01
CS134	3.229E-00	3.188E-00	3.147E-00	2.970E-00	2.731E-00	2.308E-00	1.179E-00	6.021E-01	1.123E-01	3.903E-03
CS135	2.140E-04	2.141E-04								
CS136	1.462E-00	6.972E-01	3.324E-01	1.171E-02	9.373E-05	6.008E-09	1.014E-25	1.712E-42	0.000E+01	0.000E+01
CS137	2.057E+01	2.056E+01	2.054E+01	2.046E+01	2.034E+01	2.010E+01	1.920E+01	1.833E+01	1.633E+01	1.296E+01
BA136M	2.413E-01	1.149E-01	5.478E-02	1.929E-03	1.545E-05	9.901E-10	1.671E-26	2.822E-43	0.000E+01	0.000E+01
BA137M	1.947E+01	1.945E+01	1.943E+01	1.935E+01	1.924E+01	1.902E+01	1.816E+01	1.734E+01	1.545E+01	1.226E+01
BA140	2.292E+02	1.073E+02	5.025E+01	1.631E-00	1.160E-02	5.874E-07	3.860E-24	2.536E-41	0.000E+01	0.000E+01
LA140	2.303E+02	1.234E+02	5.782E+01	1.877E-00	1.335E-02	6.760E-07	4.442E-24	2.918E-41	0.000E+01	0.000E+01
CE141	2.178E+02	1.625E+02	1.206E+02	3.131E+01	4.474E-00	9.140E-02	1.591E-08	2.771E-15	3.504E-32	0.000E+01
CE142	7.084E-09									
CE144	1.976E+02	1.910E+02	1.846E+02	1.582E+02	1.267E+02	8.117E+01	1.369E+01	9.740E-01	1.642E-01	2.770E-02
PR143	2.170E+02	1.182E+02	5.779E+01	2.281E-00	2.154E-02	1.919E-06	1.211E-22	7.636E-39	0.000E+01	0.000E+01
PR144	1.978E+02	1.910E+02	1.846E+02	1.582E+02	1.267E+02	8.117E+01	1.369E+01	2.308E-00	2.695E-02	3.675E-06
PR144M	2.373E-00	2.292E-00	2.215E-00	1.899E-00	1.520E-00	9.740E-01	1.642E-01	2.770E-02	3.234E-04	4.410E-08
ND144	2.137E-13	2.162E-13	2.185E-13	2.283E-13	2.400E-13	2.569E-13	2.819E-13	2.861E-13	2.870E-13	2.870E-13
ND147	8.428E+01	3.508E+01	1.459E+01	2.770E-01	9.097E-04	9.811E-09	1.327E-28	1.796E-48	0.000E+01	0.000E+01
PM145	6.449E-06	6.534E-06	6.617E-06	6.958E-06	7.365E-06	7.941E-06	8.530E-06	8.156E-06	4.583E-06	4.583E-06
PM147	5.137E+01	5.142E+01	5.114E+01	4.901E+01	4.588E+01	4.021E+01	2.371E+01	1.398E+01	3.735E-00	2.665E-01

Contract No. DE-AC07-00ID13729
 Section C Attachment C-A-A

PM148M	1.761E-00	1.392E-00	1.100E-00	3.806E-01	8.228E-02	3.846E-03	1.835E-08	8.755E-14	4.354E-27	0.000E+01
PM148	7.820E-00	1.346E-00	2.700E-01	2.151E-02	4.635E-03	2.166E-04	1.034E-09	4.931E-15	2.453E-28	0.000E+01
SM145	6.441E-05	6.260E-05	6.083E-05	5.348E-05	4.440E-05	3.061E-05	6.912E-06	1.561E-06	3.782E-08	2.221E-11
SM147	8.599E-10	8.726E-10	8.854E-10	9.416E-10	1.018E-09	1.158E-09	1.562E-09	1.800E-09	2.052E-09	2.137E-09
SM151	1.570E-01	1.576E-01	1.575E-01	1.573E-01	1.570E-01	1.564E-01	1.541E-01	1.517E-01	1.460E-01	1.352E-01
EU152	1.260E-02	1.258E-02	1.254E-02	1.244E-02	1.228E-02	1.197E-02	1.081E-02	9.765E-03	7.570E-03	4.549E-03
EU154	1.528E-01	1.523E-01	1.519E-01	1.497E-01	1.468E-01	1.410E-01	1.200E-01	1.022E-01	6.829E-02	3.052E-02
EU155	3.916E-01	3.895E-01	3.875E-01	3.782E-01	3.652E-01	3.406E-01	2.575E-01	1.948E-01	9.689E-02	2.397E-02
EU156	1.808E-00	9.645E-01	5.091E-01	2.837E-02	4.405E-04	1.062E-07	3.586E-22	1.211E-36	0.000E+01	0.000E+01
GD153	6.373E-03	6.121E-03	5.881E-03	4.907E-03	3.778E-03	2.241E-03	2.769E-04	3.422E-05	1.837E-07	5.299E-12
TB160	1.751E-02	1.531E-02	1.339E-02	7.301E-03	3.044E-03	5.292E-04	4.834E-07	4.416E-10	1.114E-17	7.082E-33
TL206	9.810E-06	1.436E-12								
TL207	6.975E-10	6.982E-10	7.015E-10	7.443E-10	8.300E-10	1.030E-09	1.875E-09	2.817E-09	5.662E-09	1.312E-08
TL208	4.073E-08	4.137E-08	4.242E-08	4.768E-08	5.391E-08	6.476E-08	9.258E-08	1.056E-07	1.127E-07	1.051E-07
PB210	6.616E-15	6.783E-15	6.896E-15	7.137E-15	7.332E-15	7.778E-15	1.099E-14	1.703E-14	4.912E-14	2.229E-13
PB211	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
PB212	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
BI211	6.996E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
BI212	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
PO212	7.263E-08	7.378E-08	7.564E-08	8.502E-08	9.613E-08	1.155E-07	1.651E-07	1.882E-07	2.009E-07	1.875E-07
PO215	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
PO216	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
RN219	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
RN220	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
FR223	9.641E-12	9.822E-12	1.001E-11	1.084E-11	1.207E-11	1.461E-11	2.592E-11	3.893E-11	7.828E-11	1.814E-10
RA223	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
RA224	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
RA226	2.441E-14	2.497E-14	2.554E-14	2.818E-14	3.215E-14	4.074E-14	8.375E-14	1.411E-13	3.510E-13	1.087E-12
RA228	5.693E-10	5.737E-10	5.781E-10	5.977E-10	6.253E-10	6.783E-10	8.658E-10	1.018E-09	1.286E-09	1.541E-09
AC227	6.986E-10	7.118E-10	7.250E-10	7.854E-10	8.745E-10	1.059E-09	1.878E-09	2.821E-09	5.673E-09	1.314E-08
TH227	6.900E-10	6.925E-10	7.500E-10	8.363E-10	1.017E-09	1.854E-09	2.786E-09	5.600E-09	1.297E-08	

Contract No. DE-AC07-00ID13729
 Section C Attachment C-A-A

TH228	1.132E-07	1.162E-07	1.192E-07	1.321E-07	1.494E-07	1.796E-07	2.572E-07	2.931E-07	3.133E-07	2.925E-07
TH229	1.466E-10	1.495E-10	1.524E-10	1.655E-10	1.846E-10	2.229E-10	3.760E-10	5.291E-10	9.117E-10	1.677E-09
TH230	3.384E-11	3.414E-11	3.443E-11	3.578E-11	3.774E-11	4.168E-11	5.791E-11	7.485E-11	1.203E-10	2.238E-10
TH231	1.407E-04	6.688E-05	6.687E-05	6.686E-05						
TH232	1.681E-09									
TH234	5.263E-05	5.248E-05	5.239E-05	5.223E-05	5.220E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05
PA231	1.146E-08	1.153E-08	1.159E-08	1.184E-08	1.220E-08	1.291E-08	1.575E-08	1.858E-08	2.565E-08	3.978E-08
PA233	5.538E-02	3.869E-02	2.701E-02	5.333E-03	5.199E-04	1.297E-05	8.244E-06	8.248E-06	8.264E-06	8.315E-06
PA234M	8.792E-05	5.249E-05	5.239E-05	5.223E-05	5.220E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05
PA234	7.562E-05	6.823E-08	6.811E-08	6.789E-08	6.785E-08	6.785E-08	6.785E-08	6.785E-08	6.785E-08	6.785E-08
U232	3.306E-07	3.314E-07	3.313E-07	3.312E-07	3.308E-07	3.281E-07	3.241E-07	3.113E-07	2.836E-07	
U233	7.854E-07	7.932E-07	7.986E-07	8.087E-07	8.110E-07	8.112E-07	8.113E-07	8.114E-07	8.115E-07	8.119E-07
U234	8.616E-07	8.624E-07	8.631E-07	8.666E-07	8.716E-07	8.817E-07	9.220E-07	9.617E-07	1.058E-06	1.241E-06
U235	6.686E-05									
U236	8.440E-05	8.441E-05	8.441E-05							
U237	1.284E+01	3.050E-00	7.245E-01	1.095E-03	2.998E-07	2.016E-07	1.831E-07	1.663E-07	1.308E-07	8.083E-08
U238	5.219E-05									
NP237	8.130E-06	8.214E-06	8.234E-06	8.241E-06	8.241E-06	8.244E-06	8.244E-06	8.248E-06	8.264E-06	8.315E-06
PU236	3.025E-07	3.007E-07	2.979E-07	2.856E-07	2.688E-07	2.381E-07	1.464E-07	9.008E-08	2.673E-08	2.356E-09
PU237	1.070E-06	8.646E-07	6.989E-07	2.672E-07	6.675E-08	4.166E-09	6.318E-14	9.582E-19	8.583E-31	0.000E+01
PU238	6.941E-03	6.994E-03	7.003E-03	7.035E-03	7.064E-03	7.085E-03	7.013E-03	6.905E-03	6.638E-03	6.135E-03
PU239	3.665E-02	3.678E-02	3.678E-02	3.678E-02	3.678E-02	3.678E-02	3.677E-02	3.677E-02	3.677E-02	3.676E-02
PU240	1.416E-02	1.416E-02	1.416E-02	1.416E-02	1.416E-02	1.416E-02	1.415E-02	1.415E-02	1.414E-02	1.413E-02
PU241	8.624E-01	8.608E-01	8.592E-01	8.521E-01	8.419E-01	8.219E-01	7.465E-01	6.780E-01	5.331E-01	3.295E-01
PU242	1.538E-06									
PU244	2.551E-15									
AM241	1.332E-03	1.385E-03	1.438E-03	1.675E-03	2.013E-03	2.678E-03	5.177E-03	7.438E-03	1.219E-02	1.872E-02
AM242M	9.613E-06	9.611E-06	9.609E-06	9.602E-06	9.591E-06	9.569E-06	9.482E-06	9.396E-06	9.185E-06	8.775E-06
AM242	7.841E-02	9.601E-06	9.561E-06	9.554E-06	9.543E-06	9.521E-06	9.435E-06	9.349E-06	9.139E-06	8.732E-06
AM243	9.820E-07	9.830E-07	9.829E-07	9.829E-07	9.827E-07	9.829E-07	9.825E-07	9.820E-07	9.811E-07	
CM242	3.838E-02	3.431E-02	3.642E-02	2.623E-02	1.781E-02	8.206E-03	3.769E-04	2.437E-05	7.568E-06	7.221E-06

Contract No. DE-AC07-00ID13729
 Section C Attachment C-A-A

CM243	1.348E-06	1.346E-06	1.345E-06	1.340E-06	1.331E-06	1.315E-06	1.253E-06	1.193E-06	1.057E-06	8.289E-07	
CM244	1.364E-05	1.364E-05	1.362E-05	1.353E-05	1.340E-05	1.314E-05	1.218E-05	1.128E-05	9.315E-06	6.355E-06	
CM245	1.102E-10	1.102E-10	1.102E-10	1.102E-10	1.102E-10	1.101E-10	1.101E-10	1.101E-10	1.101E-10	1.100E-10	
CM246	3.145E-12	3.145E-12	3.145E-12	3.145E-12	3.145E-12	3.144E-12	3.143E-12	3.142E-12	3.140E-12	3.135E-12	
CM247	6.602E-19										
Subtotal	3.219E+03	2.272E+03	1.793E+03	9.998E+02	6.124E+02	3.604E+02	1.562E+02	1.086E+02	7.508E+01	5.270E+01	
Ci**											
Total Ci***	2.311E+04	2.325E+03	1.807E+03	1.007E+03	6.163E+02	3.617E+02	1.562E+02	1.086E+02	7.509E+01	5.271E+01	

* Decay time following fuel element exposure.

** Subtotal Ci (Curies): Total Activity of the 145 isotopes listed here in the table.

*** Total Ci (Curies): Total Activity of the ORIGEN output isotopes.