OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

CALCULATION COVER SHEET

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2. Calculation Title

Dose Rate Calculation for the 21-PWR UCF Waste Package

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9. Remarks

Revision History

10. Revision No.	11. Description of Revision
00	Initial issue
01	Sketch SK-0219 REV 01 (Attachment III) replaced sketch SK-0132 REV 03. The surface dose rates were evaluated for the waste package design concept presented in Attachment III, and Tables 17 through 40 were updated. Changes to comply with current procedures were made as nedeed. References were added. Editorial changes were made to the document as needed.

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1. PURPOSE

The objective of this calculation is to determine the maximum dose rate at the external surfaces of a 21-PWR (pressurized water reactor) uncanistered fuel (UCF) waste package (WP). The scope is limited to dose rate evaluation at the emplacement of the WP. The results of this calculation will be used to assess the shielding performance of the 21-PWR WP concept for License Application.

The planning requirements that apply to the generation of this calculation have been identified in *Technical Work Plan for: Waste Package Design Description for SR* (CRWMS M&O [Civilian Radioactive Waste Management and Operator Contractor] 2000a, Waste Package Design Methodology). This calculation is performed and documented according to AP-3.12Q,*Calculations*

2. METHOD

The Monte Carlo radiation transport method, which is implemented in the MCMP computer code (Briesmeister 1997), is used to calculate surface dose rates of waste packages. MCNP uses the continuous-energy cross sections processed from the evaluated nuclear data files (Briesmeister 1997, Appendix G).

The radiation source terms for the PWR SNF were developed in CRWMS M&O (1999a, pp. 17 and 23) for spent fuel with various combinations of burnup, enrichment, and cooling time. The initial uranium content considered in radiation source term generation is 475 kg, and the highest fuel burnup and enrichment considered are 75 GWd/MTU and 5.5 wt% ^{235}U, respectively. In this calculation, "bounding PWR SNF" is the spent fuel with a 75-GWd/MTU burnup, 5.5-wt% enrichment, 5-year cooling time, and an initial uranium content of 475 kg. These values, except the uranium content, bound the initial uranium content (477 kg), burnup (69 GWd/MTU), enrichment (5 wt% ^{235}U), and cooling time (5 year) of the assemblies in the commercial waste stream that will arrive at the repository (CRWMS M&O 2000b, Attachment III, preblend files). The characteristics of an "average PWR SNF" are defined in Assumption 3.3. Dose rate calculations for a "hypothetical bounding PWR SNF" are also included to evaluate an upper limit for the dose rate at the WP external surfaces (See Section 5.2).

The control of the electronic management of data is accomplished in accordance with the process control evaluation for the technical work plan of this calculation (CRWMS M&O 2000a).

3. ASSUMPTIONS

The following assumptions are used throughout Section 5.

3.1 It is assumed that the mechanical design parameters of a B&W 15x15 PWR fuel assembly, provided in the U.S. Department of Energy (DOE) (1987, pages 2A-31 through 2A-35), are generic characteristics of assemblies in the commercial PWR waste stream. The rationale for this assumption is that the radiation source terms were generated in

CRWMS M&O (1999a) for the B&W 15x15 PWR fuel assembly, which is considered descriptive of the commercial PWR waste stream.

3.2 The radiation source and contents of each assembly region are homogenized inside the assembly region volume. The rationale for this assumption is that the surface dose rates for a WP with this geometric representation for the fuel assemblies and for a WP with detailed geometric representation for the fuel assemblies are the same within statistical limits (CRWMS M&O 1998b, Section 6).

3.3 The PWR spent nuclear fuel (SNF) having 4.0-wt% initial ^{235}U, 48-GWd/MTU burnup, 21-year decay time, and 475 kg initial uranium is assumed to be the SNF with average characteristics. The rationale for this assumption is that the source term for the SNF with these characteristics generates conservative (higher) dose rates for an average PWR SNF. The average PWR SNF is estimated in CRWMS M&O (1999a, p. 24).

3.4 A peaking factor of 1.25 bounds the axial distribution of gamma and neutron sources in the active fuel region. This value is based on the predicted heat profile for a PWR assembly provided by Electric Power Research Institute (EPRI 1989, p. 3-26).

3.5 The length of the bottom end-fitting of the PWR assembly is not provided in DOE (1987). It is assumed that the length of the bottom end-fitting is 4 in. The rationale for this assumption is that this length leads to higher dose rates on the WP surfaces adjacent to the bottom end-fitting region of the PWR SNF assemblies.

3.6 The chemical composition of the SNF is assumed the same as that of the fresh fuel. The rationale is that small weight variations of the elements do not affect the accuracy of dose results, as long as the total weight is maintained.

3.7 The chemical composition of Neutronit A976 is assumed for Neutronit A978, which is a molybdenum alloyed Bohler Neutronit (Kugler 1996). The rationale for this assumption is that by neglecting molybdenum in the Neutronit A976 chemical composition, the balance element iron is increased, which provides conservative (higher) dose rates at the external surfaces of the WP.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE

The MCNP 4B2LV computer code is used to calculate neutron and gamma fluxes on the WP surfaces for dose rate evaluations.

- Program name: MCNP.

- Version/Revision number: Version 4B2.
- Computer Software Configuration Item (CSCI) Number: 30033 V4B2LV (CRWMS M&O 1998a).
- Computer Type: Hewlett Packard (HP) workstation "Bloom" (Tag: CRWMS-M&O 700887).
- Operating System: HP-UX (Hewlett Packard-UNIX) 10.20.
- The MCNP 4B2LV computer code is an appropriate tool to determine the dose rates on the surface and near the surface of a WP containing 21 PWR SNF assemblies.
- This software has been validated over the range it was used.
- This software was previously obtained from the Software Control Management in accordance with appropriate procedures.

The input file for each computer calculation is echoed in the output file of the calculation. The output files are described in Section 8.

4.2 MODELS

None used.

5. CALCULATION

5.1 CALCULATION INPUTS

The following sections outline the information used in calculation of dose rates on the waste package surfaces. Each MCNP calculation requires the following information: geometry, material, and source parameters. The WP consists of the UCF disposal container, 21 PWR SNF assemblies, and a basket assembly. Sketch SK-0219 REV 01, which is shown in Attachment III, provides geometry and material specifications for the 21-PWR WP concept for License Application. It should be noted that the lifting features and the welds of the waste package were not represented in the MCNP geometry since by neglecting these components the dose rates increase at the top and bottom of the waste package. Therefore, only the sheets of sketch SK-0219 REV 01 that were actually used in this calculation are included in Attachment III. The information provided by the sketch is that of the potential design of the type of WP considered in this calculation.

The number of digits in the values cited herein may be the result of a calculation or may reflect the input from another source; consequently, the number of digits should not be interpreted as an indication of accuracy.

5.1.1 UCF Disposal Container

The disposal container consists of a inner reinforcement cylinder made of stainless steel, an outer corrosion resistant shell, inner shell lids, outer shell lids, and a basket assembly. Table 1 presents the geometry and material specifications for the disposal container of 21-PWR SNF assemblies, as indicated in sketch SK-0219 REV 01. Tables 2 through 6 present the chemical compositions for the structural materials of this container.

Table 1. Geometry and Material Specifications for the Disposal Container

Component	Material	Characteristic	Dimension (mm)	Sketch Sheet
Inner shell	SA-240 S31600	Thickness	50	19, 24
Outer shell	SB-575 N06022	Thickness	20	15, 24
Inner shell bottom lid	SA-240 S31600	Thickness	88.9	19, 24
Inner shell top lid	SA-240 S31600	Thickness	50.8	24, 20
Outer shell flat bottom lid	SB-575 N06022	Thickness	25.4	24, 17
Outer shell flat closure lid	SB-575 N06022	Thickness	9.525	24, 18
Extended outer shell lid base	SB-575 N06022	Thickness	25.4	24, 17
Top upper closure gap	Air	Thickness	30.08	2
Top lower closure gap	Air	Thickness	44.225	2, 19
Bottom lid gap	Air	Thickness	70	4, 24
Cavity	Air	Length	4,585	7
		Inner diameter	1,424	19
Basket A-sideguide	SA-516 K02700	Thickness	10	24
Basket B-sideguide	SA-516 K02700	Thickness	10	24
Basket corner guide	SA-516 K02700	Thickness	10	24
Basket A-stiffener	SA-516 K02700	Thickness	10	24
Basket B-stiffener	SA-516 K02700	Thickness	10	24
Basket C-stiffener	SA-516 K02700	Thickness	10	24
Fuel basket A-plate	Neutronit A 978	Thickness	7	24
Fuel basket B-plate	Neutronit A 978	Thickness	7	24
Fuel basket C-plate	Neutronit A 978	Thickness	7	24
Fuel basket D-plate	SB-209 A96061 T4	Thickness	5	24
Fuel basket E-plate	SB-209 A96061 T4	Thickness	5	24
Fuel basket tube	SA-516 K02700	Thickness	5	24
		Length	4,575	19
		Inner transverse dimension	226	19

SOURCE: Sketch SK-0219 REV 01.

NOTE: The thicknesses of the top lids used in this calculation slightly differ from those shown in the sketch. However, the total thickness of the top lids used in this calculation is 85 mm, which is 0.725 less than the actual value indicated by the sketch, and provides higher (conservative) dose rates at the top surface of the waste package. Moreover, for conservative evaluations (higher dose rates), the thicknesses of the inner shell, the outer shell, and lids are reduced by 0.25 mm each to account for permissible variations in thickness (ASME 1998, Section II-B, SB-575 , page 762, and Section II-A, SA-480, page 877). The loose fit between the inner and outer shells is neglected to obtain slightly higher (conservative) dose rates at the external radial surface.

Table 2. Chemical Composition of SA-516 K02700

Element	Weight Percent Range[a]	Value Used
Carbon	0.27 (max)	0.27
Manganese	0.85-1.20	1.025
Phosphorus	0.035 (max)	0.035
Sulfur	0.035 (max)	0.035
Silicon	0.15-0.40	0.275
Iron	Balance	98.36
Density[b] = 7.85 g/cm^3		

SOURCE: [a] ASME 1998, Section II-A, SA-516, page 925.
[b] ASME 1998, Section II-A, SA-20, page 67.

Table 3. Chemical Composition of SA-240 S31600

Element	Weight Percent Range[a]	Value Used
Carbon	0.08 (max)	0.08
Manganese	2.00 (max)	2.00
Phosphorus	0.045 (max)	0.045
Sulfur	0.03 (max)	0.03
Silicon	0.75 (max)	0.75
Chromium	16.00-18.00	17.00
Nickel	10.00-14.00	12.00
Molybdenum	2.00-3.00	2.50
Nitrogen	0.10 (max)	0.10
Iron	Balance	65.495
Density[b] = 7.98 g/cm^3		

SOURCE: [a] ASME 1998, Section II-A, SA-240, page 366.
[b] ASTM G 1-90, page 7.

Table 4. Chemical Composition of SB-575 N06022

Element	Weight Percent Range	Value Used
Carbon	0.015 (max)	0.015
Manganese	0.50 (max)	0.50
Silicon	0.08 (max)	0.08
Chromium	20.0-22.5	21.25
Molybdenum	12.5-14.5	13.50
Cobalt	2.50 (max)	2.50
Tungsten	2.5-3.5	3.00
Vanadium	0.35 (max)	0.35
Iron	2.0-6.0	4.00
Phosphorus	0.02 (max)	0.02
Sulfur	0.02 (max)	0.02
Nickel	Balance	54.765
Density = 8.69 g/cm^3		

SOURCE: ASME 1998, Section II-B, SB-575, pages 760 and 761.

The chemical composition of Neutronit A976 is assumed for Neutronit A978 in this calculation (see Assumption 3.7).

Table 5. Chemical Composition of Neutronit A976

Element	Weight Percent Range[a]	Value Used
Carbon	0.04 (max)	0.04
Chromium	18.5	18.5
Nickel	13.0	13.0
Cobalt	0.20 (max)	0.20
Boron	According to specifications	0.75-1.74[b]
Iron	Balance	67.51 or 66.52
Density[a] = 7.76 g/cm^3		

SOURCE: [a] Kugler 1996, pages 14 and 17.
[b] ASTM A 887-89, page 2.

NOTE: The range of boron content is based on those for ASTM A887 type B3 to B6. For conservative (slightly higher) results, 0.75-wt% B is used in neutron dose rate calculation, and 1.74-wt% B is used in gamma dose rate calculations.

Table 6. Chemical Composition of SB-209 A96061

Element	Weight Percent Range[a]	Value Used
Silicon	0.4-0.8	0.6
Iron	0.7 (max)	0.7
Copper	0.15-0.4	0.275
Manganese	0.15 (max)	0.15
Magnesium	0.8-1.2	1.0
Chromium	0.04-0.35	0.195
Zinc[c]	0.25 (max)	0.25
Titanium	0.15 (max)	0.15
Others (each)	0.05 (max)	0.0
Others (total)	0.15 (max)	0.0
Aluminum	Balance	98.68
Density[b] = 2.7 g/cm^3		

SOURCE: [a] ASME 1998, Section II-B, SB-209, page 236.
[b] ASME 1998, Section II-D, Subpart 2, pages 611 and 612.
NOTE: [c] MCNP does not contain neutron cross-section tables for Zn. Al replaces Zn in this calculation because these two elements have similar neutron cross sections.

5.1.2 PWR SNF Assemblies

The PWR SNF assembly used in this calculation is a Babcock and Wilcox (B&W) 15x15 PWR SNF assembly. The mechanical design parameters for a B&W 15x15 PWR fuel assembly are provided in DOE (1987, pages 2A-31 through 2A-35). Table 7 presents these parameters. Tables 8 through 13 present the chemical compositions for the composing materials other than uranium dioxide. CRWMS M&O (1999a) provides the gamma and neutron source terms for the PWR SNF waste stream. Tables 14, 15, and 16 present the gamma and neutron sources for the bounding PWR SNF for the active fuel region, a hypothetical bounding PWR SNF for the active fuel region as well as for the hardware regions, and an average PWR SNF (see Section 5.2), respectively.

Table 7. Mechanical Design Parameters for B&W 15x15 Mark B Fuel Assembly

Design Component	Material	Zone	Characteristic	Reference Page	Value
Assembly	N/A	N/A	Width	2A-31	8.536 in. (21.68144 cm)
			Length	2A-31	165.625 in. (420.6875 cm)
Fuel pin	N/A	In core	Number per assembly	2A-33	208
			Length	2A-33	153.68 in. (390.3472 cm)
Fuel pellets	UO_2	Active fuel	Mass/pin	2A-34	5.58 lb. (2.53105 kg)
			Mass U/assembly	2A-31	0.46363 metric tons
			Diameter	2A-34	0.3686 in. (0.93624 cm)
			Stack length	2A-33	141.8 in. (360.172 cm)
Cladding	Zircaloy-4	In core	Thickness	2A-33	0.0265 in. (0.06731 cm)
			Fuel-clad gap	2A-33	0.0042 in. (0.010668 cm)
Top nozzle	SS CF3M	Top	Mass/assembly	2A-32	7.48 kg
Bottom nozzle	SS CF3M	Bottom	Mass/assembly	2A-32	8.16 kg
Guide tube	Zircaloy-4	In core	Mass/assembly	2A-32	8.0 kg
Instrument tube	Zircaloy-4	In core	Mass/assembly	2A-32	0.64 kg
Spacer-plenum	Inconel-718	Plenum	Mass/assembly	2A-32	1.04 kg
Spacer-bottom	Inconel-718	Bottom	Mass/assembly	2A-32	1.3 kg
Spacer-incore	Inconel-718	In core	Mass/assembly	2A-32	4.9 kg
Spring retainer	SS CF3M	Top	Mass/assembly	2A-32	0.91 kg
Holding spring	Inconel-718	Top	Mass/assembly	2A-32	1.8 kg
Upper end plug	SS 304	Top	Mass/assembly	2A-32	0.06 kg
Upper nut	SS 304L	Top	Mass/assembly	2A-32	0.51 kg
Lower nut	SS 304	Bottom	Mass/assembly	2A-32	0.15 kg
Grid supports	Zircaloy-4	In core	Mass/assembly	2A-32	0.64 kg
Plenum spring	SS 302	Plenum	Mass/assembly	2A-34	0.042 lb. (0.01905 kg)
Plenum region	N/A	N/A	Length[a]	N/A	30.1752 cm
Bottom end-fitting	N/A	N/A	Length[b]	N/A	4 in. (10.16 cm)

NOTES: [a] Calculated: fuel pin length – fuel pellet length = 390.3472 cm – 360.172 cm.
[b] A bottom end-fitting region of 4-in. length provides conservative (higher) dose rates for bottom region of the WP (see Assumption 3.5).

Table 8. Chemical Composition of Zircaloy-4

Element	Weight Percent Range	Value Used
Tin	1.20-1.70	1.45
Iron	0.18-0.24	0.21
Chromium	0.07-0.13	0.115
Oxygen	0.09-0.16	0.125
Iron+Chromium	0.28-0.37	N/A
Zirconium	Balance	98.1

SOURCE: ASTM B 811-90, page 2.

Table 9. Chemical Composition of Inconel-718

Element	Weight Percent Range	Value Used
Nickel	50.0-55.0[a]	51.5
Chromium	17.0-21.0	19.0
Iron	Balance	17.809
Niobium	4.75-5.50[b]	5.125
Molybdenum	2.80-3.30	3.05
Titanium	0.65-1.15	0.90
Aluminum	0.20-0.80	0.50
Cobalt	1.00 (max)	1.00
Manganese	0.35 (max)	0.35
Silicon	0.35 (max)	0.35
Copper	0.30 (max)	0.30
Carbon	0.08 (max)	0.08
Sulfur	0.015 (max)	0.015
Phosphorus	0.015 (max)	0.015
Boron	0.006 (max)	0.006

SOURCE: Inco Alloys International 1988, page 11.
NOTES: [a] Nickel plus cobalt.
[b] Niobium plus tantalum.

Table 10. Chemical Composition of SS 304

Element	Weight Percent Range	Value Used
Carbon	0.08 (max)	0.08
Chromium	18-20	19
Nickel	8-10.5	9.25
Manganese	2.00 (max)	2.00
Phosphorus	0.045 (max)	0.045
Sulfur	0.03 (max)	0.03
Silicon	0.75 (max)	0.75
Nitrogen	0.10 (max)	0.10
Iron	Balance	68.745

SOURCE: ASME 1998, Section II-A, SA-240, page 365.

Table 11. Chemical Composition of SS 304L

Element	Weight Percent Range	Value Used
Carbon	0.03 (max)	0.03
Manganese	2.0 (max)	2.0
Phosphorus	0.045 (max)	0.045
Sulfur	0.03 (max)	0.03
Silicon	0.75 (max)	0.75
Chromium	18-20	19
Nickel	8-12	10
Nitrogen	0.10	0.10
Iron	Balance	68.045

SOURCE: ASME 1998, Section II-A, SA-240, page 365.

Table 12. Chemical Composition of SS CF-3M

Element	Weight Percent Range	Value Used
Carbon	0.03 (max)	0.03
Manganese	1.50 (max)	1.50
Silicon	2.00 (max)	2.00
Chromium	17.0-21.0	19.0
Nickel	8.0-12.0	10.0
Molybdenum	2.0-3.0	2.5
Iron	Balance	64.97

SOURCE: American Society for Metals 1980, page 95.

Table 13. Chemical Composition of SS 302

Element	Weight Percent Range	Value Used
Carbon	0.15	0.15
Manganese	2.00	2.00
Phosphorus	0.045	0.045
Sulfur	0.030	0.03
Silicon	0.75	0.75
Chromium	17.00-19.00	18.00
Nickel	8.00-10.00	9.00
Nitrogen	0.10	0.10
Iron	Balance	69.925

SOURCE: ASME 1998, Section II-A, SA-240, page 365.

Table 14. Gamma and Neutron Sources per Assembly for the Bounding PWR SNF

Gamma Intensity (photons/s)					Neutron Intensity (neutrons/s)	
Upper Energy Boundary (MeV)	Bottom End-Fitting Region	Active Fuel Region	Plenum Fuel Region	Top End-Fitting Region	Upper Energy Boundary (MeV)	Active Fuel Region
5.00E-02	5.28E+11	2.26E+15	4.78E+11	3.37E+11	1.00E-08	0.0000E+00
1.00E-01	1.03E+11	6.28E+14	5.43E+10	6.60E+10	3.00E-08	0.0000E+00
2.00E-01	2.51E+10	5.08E+14	3.20E+10	1.59E+10	5.00E-08	0.0000E+00
3.00E-01	1.25E+09	1.44E+14	1.78E+09	7.92E+08	1.00E-07	0.0000E+00
4.00E-01	1.69E+09	9.63E+13	5.37E+09	1.04E+09	2.25E-07	0.0000E+00
6.00E-01	1.76E+09	1.38E+15	1.01E+11	6.59E+07	3.25E-07	0.0000E+00
8.00E-01	3.93E+09	4.37E+15	5.47E+10	2.13E+09	4.00E-07	0.0000E+00
1.00E+00	1.29E+11	6.37E+14	7.41E+09	7.21E+10	8.00E-07	0.0000E+00
1.33E+00	3.00E+13	4.12E+14	1.55E+13	1.93E+13	1.00E-06	0.0000E+00
1.66E+00	8.47E+12	1.17E+14	4.37E+12	5.44E+12	1.13E-06	0.0000E+00
2.00E+00	1.85E+03	1.34E+12	8.52E+02	1.13E+03	1.30E-06	0.0000E+00
2.50E+00	2.01E+08	2.47E+12	1.04E+08	1.29E+08	1.77E-06	0.0000E+00
3.00E+00	3.12E+05	9.97E+10	1.61E+05	2.00E+05	3.05E-06	0.0000E+00
4.00E+00	4.20E-08	1.25E+10	5.50E-09	2.28E-08	1.00E-05	0.0000E+00
5.00E+00	0.00E+00	4.68E+07	0.00E+00	0.00E+00	3.00E-05	0.0000E+00
6.50E+00	0.00E+00	1.88E+07	0.00E+00	0.00E+00	1.00E-04	0.0000E+00
8.00E+00	0.00E+00	3.69E+06	0.00E+00	0.00E+00	5.50E-04	0.0000E+00
10.00E+00	0.00E+00	7.83E+05	0.00E+00	0.00E+00	3.00E-03	0.0000E+00
Total	3.9264E+13	1.0556E+16	2.0605E+13	2.5235E+13	1.70E-02	0.0000E+00
N/A	N/A	N/A	N/A	N/A	1.00E-01	0.0000E+00
N/A	N/A	N/A	N/A	N/A	4.00E-01	5.27E+07
N/A	N/A	N/A	N/A	N/A	9.00E-01	2.69E+08
N/A	N/A	N/A	N/A	N/A	1.40E+00	2.46E+08
N/A	N/A	N/A	N/A	N/A	1.85E+00	1.81E+08
N/A	N/A	N/A	N/A	N/A	3.00E+00	3.19E+08
N/A	N/A	N/A	N/A	N/A	6.43E+00	2.91E+08
N/A	N/A	N/A	N/A	N/A	20.00E+00	2.57E+07
N/A	N/A	N/A	N/A	N/A	Total	1.3844E+09

SOURCE: CRWMS M&O 1999a, Attachment IV (compact disk), PWR.gamma.source and PWR.neutron.source files.
NOTE: Initial ^{235}U weight percent of 5.5, average burnup of 75 GWd/MTU, and decay time of 5 years.

Table 15. Gamma and Neutron Sources per Assembly for the Hypothetical Bounding PWR SNF

Gamma Intensity (photons/s)					Neutron Intensity[a] (neutrons/s)	
Upper Energy Boundary (MeV)	Bottom End-Fitting Region[b]	Active Fuel Region[a]	Plenum Fuel Region[b]	Top End-Fitting Region[b]	Upper Energy Boundary (MeV)	Active Fuel Region
5.00E-02	8.86E+11	2.26E+15	7.24E+11	5.66E+11	1.00E-08	0.0000E+00
1.00E-01	1.73E+11	6.28E+14	8.98E+10	1.11E+11	3.00E-08	0.0000E+00
2.00E-01	4.22E+10	5.08E+14	4.71E+10	2.68E+10	5.00E-08	0.0000E+00
3.00E-01	2.10E+09	1.44E+14	2.60E+09	1.33E+09	1.00E-07	0.0000E+00
4.00E-01	2.82E+09	9.63E+13	7.49E+09	1.74E+09	2.25E-07	0.0000E+00
6.00E-01	2.40E+09	1.38E+15	1.36E+11	1.11E+08	3.25E-07	0.0000E+00
8.00E-01	5.65E+09	4.37E+15	7.40E+10	3.12E+09	4.00E-07	0.0000E+00
1.00E+00	1.55E+11	6.37E+14	9.81E+09	8.72E+10	8.00E-07	0.0000E+00
1.33E+00	5.05E+13	4.12E+14	2.57E+13	3.24E+13	1.00E-06	0.0000E+00
1.66E+00	1.43E+13	1.17E+14	7.26E+12	9.14E+12	1.13E-06	0.0000E+00
2.00E+00	1.81E+03	1.34E+12	1.17E+03	1.09E+03	1.30E-06	0.0000E+00
2.50E+00	3.38E+08	2.47E+12	1.72E+08	2.17E+08	1.77E-06	0.0000E+00
3.00E+00	5.25E+05	9.97E+10	2.67E+05	3.36E+05	3.05E-06	0.0000E+00
4.00E+00	3.57E-07	1.25E+10	4.66E-08	1.94E-07	1.00E-05	0.0000E+00
5.00E+00	0.00E+00	4.68E+07	0.00E+00	0.00E+00	3.00E-05	0.0000E+00
6.50E+00	0.00E+00	1.88E+07	0.00E+00	0.00E+00	1.00E-04	0.0000E+00
8.00E+00	0.00E+00	3.69E+06	0.00E+00	0.00E+00	5.50E-04	0.0000E+00
10.00E+00	0.00E+00	7.83E+05	0.00E+00	0.00E+00	3.00E-03	0.0000E+00
Total	6.6070E+13	1.0556E+16	3.4051E+13	4.2338E+13	1.70E-02	0.0000E+00
N/A	N/A	N/A	N/A	N/A	1.00E-01	0.0000E+00
N/A	N/A	N/A	N/A	N/A	4.00E-01	5.27E+07
N/A	N/A	N/A	N/A	N/A	9.00E-01	2.69E+08
N/A	N/A	N/A	N/A	N/A	1.40E+00	2.46E+08
N/A	N/A	N/A	N/A	N/A	1.85E+00	1.81E+08
N/A	N/A	N/A	N/A	N/A	3.00E+00	3.19E+08
N/A	N/A	N/A	N/A	N/A	6.43E+00	2.91E+08
N/A	N/A	N/A	N/A	N/A	20.00E+00	2.57E+07
N/A	N/A	N/A	N/A	N/A	Total	1.3844E+09

SOURCE: CRWMS M&O 1999a, Attachment IV, PWR.gamma.source and PWR.neutron.source files.
NOTES: [a] Initial ^{235}U weight percent of 5.5, average burnup of 75 GWd/MTU, and decay time of 5 years.
[b] Initial ^{235}U weight percent of 0.711, average burnup of 75 GWd/MTU, and decay time of 5 years.

Table 16. Gamma and Neutron Sources per Assembly for the Average PWR SNF

Gamma Intensity (photons/s)					Neutron Intensity (neutrons/s)	
Upper Energy Boundary (MeV)	Bottom End-Fitting Region	Active Fuel Region	Plenum Fuel Region	Top End-Fitting Region	Upper Energy Boundary (MeV)	Active Fuel Region
5.00E-02	5.49E+10	7.41E+14	3.12E+10	3.53E+10	1.00E-08	0.0000E+00
1.00E-01	1.02E+10	2.16E+14	5.30E+09	6.54E+09	3.00E-08	0.0000E+00
2.00E-01	2.46E+09	1.42E+14	1.54E+09	1.58E+09	5.00E-08	0.0000E+00
3.00E-01	1.23E+08	4.34E+13	7.97E+07	7.89E+07	1.00E-07	0.0000E+00
4.00E-01	1.61E+08	2.91E+13	1.45E+08	1.03E+08	2.25E-07	0.0000E+00
6.00E-01	3.27E+07	2.57E+13	1.39E+09	6.48E+06	3.25E-07	0.0000E+00
8.00E-01	2.09E+09	1.36E+15	2.38E+09	1.44E+09	4.00E-07	0.0000E+00
1.00E+00	2.14E+09	1.52E+13	1.67E+09	1.47E+09	8.00E-07	0.0000E+00
1.33E+00	2.96E+12	4.48E+13	1.54E+12	1.90E+12	1.00E-06	0.0000E+00
1.66E+00	8.36E+11	8.32E+12	4.34E+11	5.38E+11	1.13E-06	0.0000E+00
2.00E+00	1.07E+00	7.48E+10	6.78E+01	9.62E-03	1.30E-06	0.0000E+00
2.50E+00	1.98E+07	3.96E+09	1.03E+07	1.28E+07	1.77E-06	0.0000E+00
3.00E+00	3.08E+04	3.01E+08	1.60E+04	1.98E+04	3.05E-06	0.0000E+00
4.00E+00	2.04E-11	2.32E+07	1.62E-11	1.39E-11	1.00E-05	0.0000E+00
5.00E+00	0.00E+00	7.77E+06	0.00E+00	0.00E+00	3.00E-05	0.0000E+00
6.50E+00	0.00E+00	3.12E+06	0.00E+00	0.00E+00	1.00E-04	0.0000E+00
8.00E+00	0.00E+00	6.11E+05	0.00E+00	0.00E+00	5.50E-04	0.0000E+00
10.00E+00	0.00E+00	1.30E+05	0.00E+00	0.00E+00	3.00E-03	0.0000E+00
Total	3.8681E+12	2.6256E+15	2.0177E+12	2.4845E+12	1.70E-02	0.0000E+00
N/A	N/A	N/A	N/A	N/A	1.00E-01	0.0000E+00
N/A	N/A	N/A	N/A	N/A	4.00E-01	8.68E+06
N/A	N/A	N/A	N/A	N/A	9.00E-01	4.44E+07
N/A	N/A	N/A	N/A	N/A	1.40E+00	4.07E+07
N/A	N/A	N/A	N/A	N/A	1.85E+00	3.02E+07
N/A	N/A	N/A	N/A	N/A	3.00E+00	5.40E+07
N/A	N/A	N/A	N/A	N/A	6.43E+00	4.84E+07
N/A	N/A	N/A	N/A	N/A	20.00E+00	4.24E+06
N/A	N/A	N/A	N/A	N/A	Total	2.3062E+08

SOURCE: CRWMS M&O 1999a, Attachment IV, PWR.gamma.source and PWR.neutron.source files.
NOTE: Initial ^{235}U weight percent of 4.0; average burnup of 48 GWd/MTU; and decay time of 21 years (See Assumption 3.3).

5.2 DESCRIPTION OF CALCULATIONS

5.2.1 Selection of Source Terms

This calculation provides surface dose rates for a 21-PWR WP that contains SNF with radiation source terms with the following burnup and decay characteristics:

- 5.5-wt% initial ^{235}U enrichment, 75.0-GWd/MTU burnup, and 5-year decay time. Surface dose rates for the WP without the basket assembly inside are also calculated.

- 5.5-wt% initial ^{235}U enrichment, 75.0-GWd/MTU burnup, and 5-year decay time for the active fuel region, and 0.711-wt% initial enrichment, 75.0 GWd/MTU burnup, and 5-year decay time for the hardware regions. Since for a given time and burnup the activation of the hardware regions increases with decreasing initial fuel enrichment, this hypothetical SNF provides upper limits for dose rates due to the hardware source.

- 4.0-wt% initial ^{235}U enrichment, 48-GWd/MTU burnup, and 21-year decay time. The SNF with these characteristics provides conservative dose rate estimations for the average PWR SNF (see Assumption 3.3). Surface dose rates for a WP containing average SNF are useful for estimating the radiation exposure of the surrounding equipment.

5.2.2 Geometric Representation of the Source Regions

The PWR SNF assemblies contain four distinct source regions: a bottom end-fitting region, an active fuel region, a plenum region, and a top end-fitting region. Each assembly region is homogenized inside its volume (see Figures 1 through 3), resulting in a uniform distribution of the region contents and radiation source inside the region volume (See Assumption 3.2). The study of source geometry effect (CRWMS M&O 1998b) on the surface dose rates for a WP containing 21 PWR SNF assemblies has shown that the detailed representation of the SNF assemblies and the assemblies homogenized inside their transverse dimensions give essentially the same surface dose rates. The MCNP input file specifies these four gamma sources through source distribution numbers dependent on geometric cells. Attachment II provides the fraction of gamma sampling in each assembly region, required by the source probability (sp) card, and the total gamma source intensity, required by the tally multiplier (fm) card.

5.2.3 Material Specification in the MCNP Input

MCNP requires element/isotope compositions of the materials either as weight fractions or atomic densities. The material compositions of the assembly regions are entered as atomic densities, in atoms/b·cm, in the MCNP input. Atomic density (AD) is calculated according to the following equation (Harmon et al. 1994, Appendix B):

$$AD\ (\text{atoms/b}\cdot\text{cm}) = \frac{\text{mass}_{\text{isotope}}(\text{g}) * N_A(\text{atoms/mole})}{10^{24}(\text{b/cm}^2) * \text{volume}_{\text{region}}(\text{cm}^3) * \text{atomic mass}_{\text{isotope}}(\text{g/mole})} \quad \text{(Eq. 1)}$$

In the above equation, N_A is the Avogadro constant, whose value is 6.0221367E+23 atoms per mole (Parrington et al. 1996, page 59). The element or isotope atomic masses are provided in Parrington et al. 1996. The calculation of the atomic densities for each assembly region is presented in Attachment I.

The isotopic composition, in weight percent, for commercially available enriched uranium is calculated according to the following equations (Bowman et al. 1995, page 20):

$$\text{wt\% } ^{234}U = 0.007731(\text{wt\% } ^{235}U)^{1.0837}$$

$$\text{wt\% } ^{236}U = 0.0046(\text{wt\% } ^{235}U) \quad \text{(Eq. 2)}$$

$$\text{wt\% } ^{238}U = 100 - (\text{wt\% } ^{234}U) - (\text{wt\% } ^{235}U) - (\text{wt\% } ^{236}U)$$

5.2.4 Calculation of the Total Dose Rate

MCNP estimates the gamma or the neutron flux averaged over a surface, and then calculates the surface dose rates in rem/h. The surface dose rate for a certain energy group is the product of group flux and the flux-to-dose rate conversion factor for the energy group (Briesmeister 1997, pages H-5 and H-6).

Since MCNP performs the photon and neutron transport in two separate runs, the total dose rate is the sum of gamma and neutron dose rates. The estimated relative error of the total dose rate is derived from the estimated variance of the total dose rate. The estimated variance of the total dose rate, S^2_{total}, is the sum of the estimated variances of the individual dose rates, S_i^2. The estimated relative error (Briesmeister 1997, p. 2-93) is given by:

$$DR_{total} = DR_{gamma} + DR_{neutron} \quad \text{(Eq. 3)}$$

$$S^2_{total} = S^2_{gamma} + S^2_{neutron} \quad \text{(Eq. 4)}$$

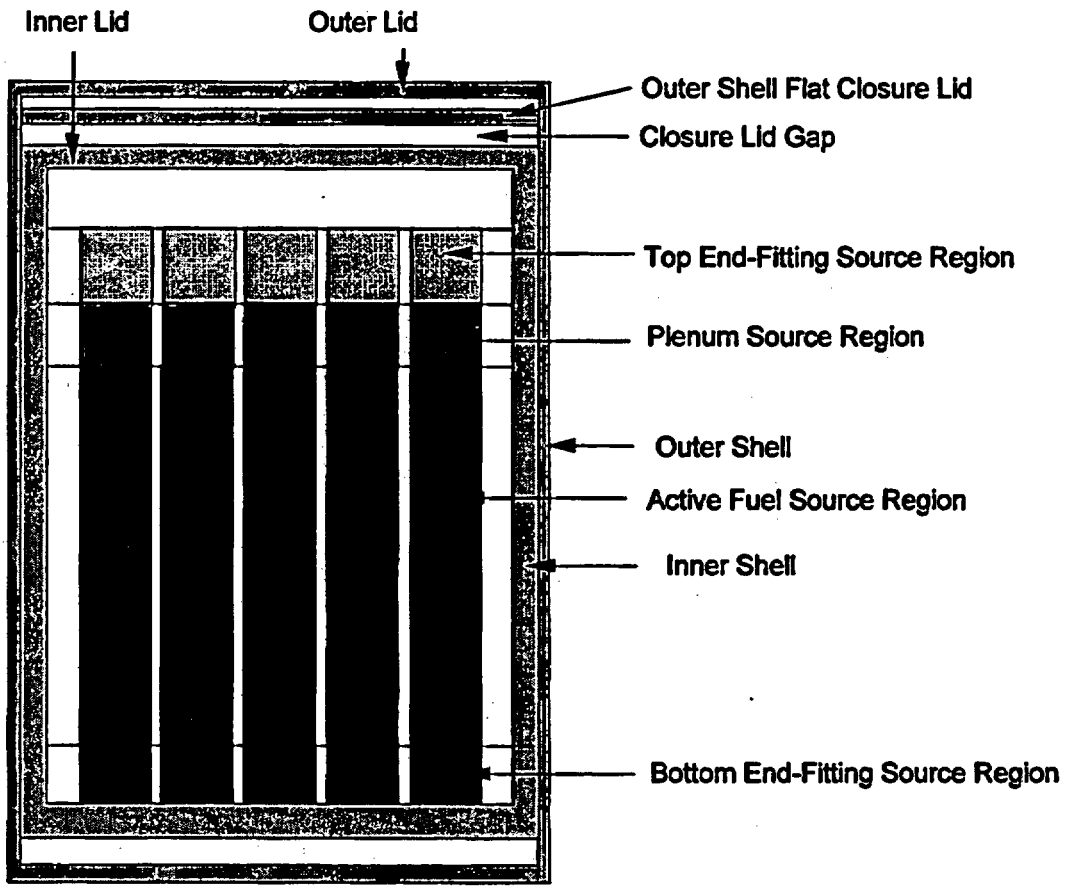
$$R = \frac{\sqrt{S^2_{total}}}{DR_{total}} \quad \text{(Eq. 5)}$$

where

DR = estimated dose rate (rem/h)
S^2 = estimated variance $(rem/h)^2$
R = estimated relative error

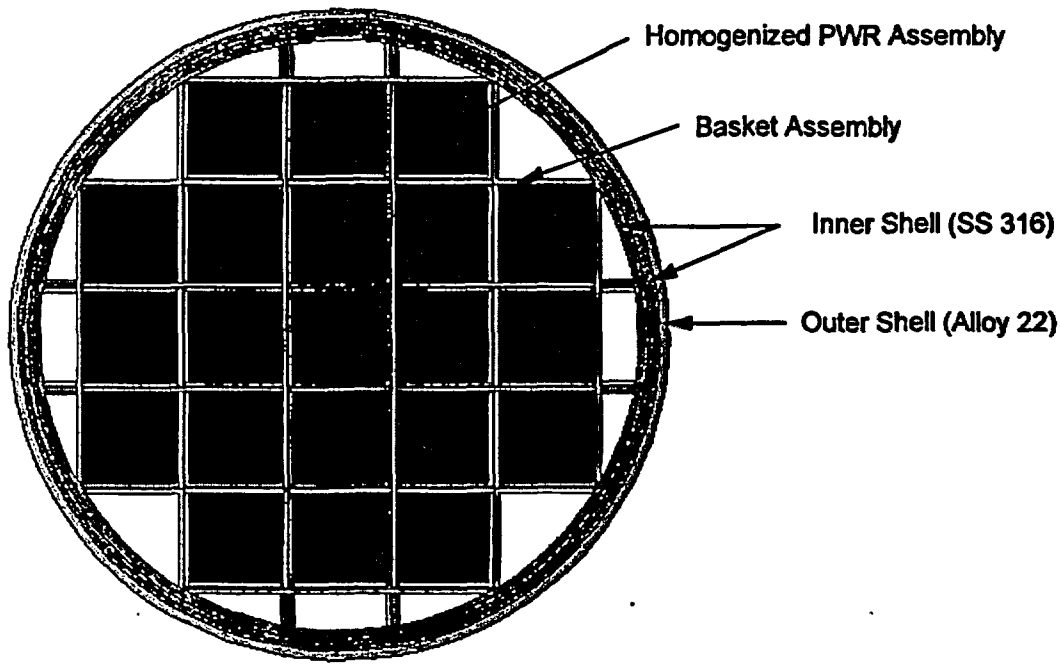
5.2.5 Segments Selected for Surface Dose Rate Calculations

Surface dose rates are calculated for the radial, top, and bottom directions of the WP. For each direction, dose rates are determined for segments (see Figures 4, 5, and 6) of the following five surfaces: inner surface of the inner shell, inner surface of the outer shell, WP outer surface, and surfaces at 1 m and 2 m from WP outer surface. Segments 1 to 9 are subdivisions of the five radial surfaces. Segment 1, 37.8125-cm tall, corresponds to the void region above fuel assemblies. Segment 2, 20.1803-cm tall, corresponds to the top end-fitting region. Segment 3, 30.1752-cm tall, corresponds to the plenum region. Five segments, Segments 4 to 8, each 72.0344-cm tall, are equal segments of the active fuel region. The last axial segment, Segment 9, 10.16-cm tall, corresponds to the bottom end-fitting region. The top surface of the WP cavity has six segments, Segments 14 to 19, as shown in Figure 5. Figure 6 shows the four segments, Segments 14, 20, 21, and 22, of the bottom surface of the upper outer lid. The bottom surface of the WP cavity, and the bottom surface of the lower inner lid are divided in two segments by a 20-cm radius. The WP top and bottom surfaces and the top and bottom surfaces 1 m from the WP have three segments: Segments 10 to 12. The top and bottom surfaces 2 m from the WP have also three segments: Segments 10, 11, and 13.



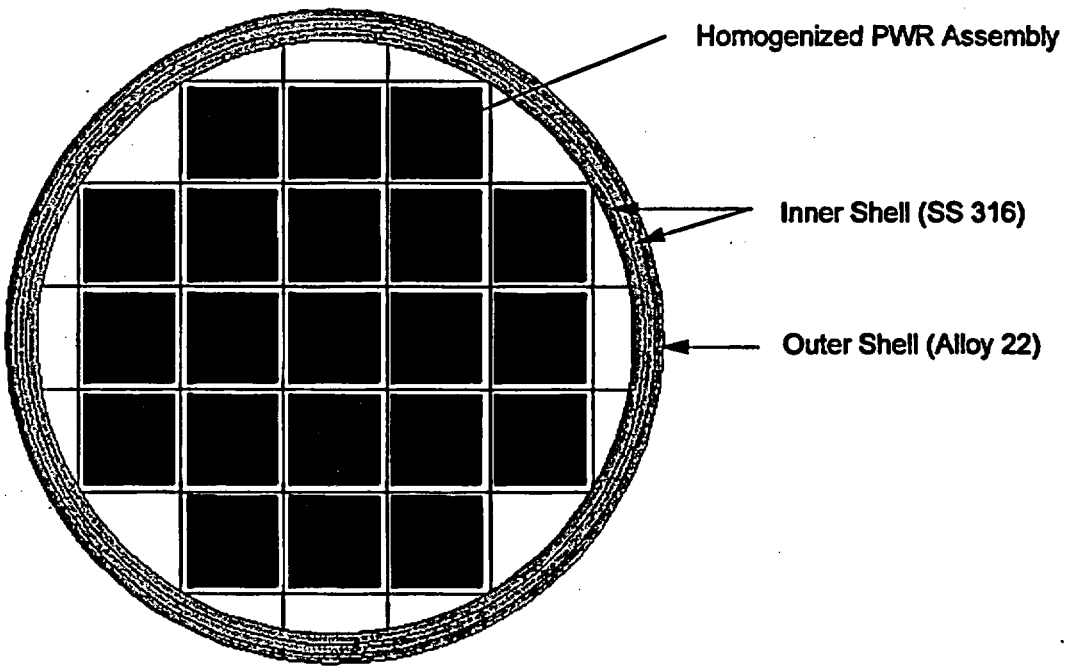
NOTE: Drawing not to scale.

Figure 1. Source Region Representation in MCNP Calculations



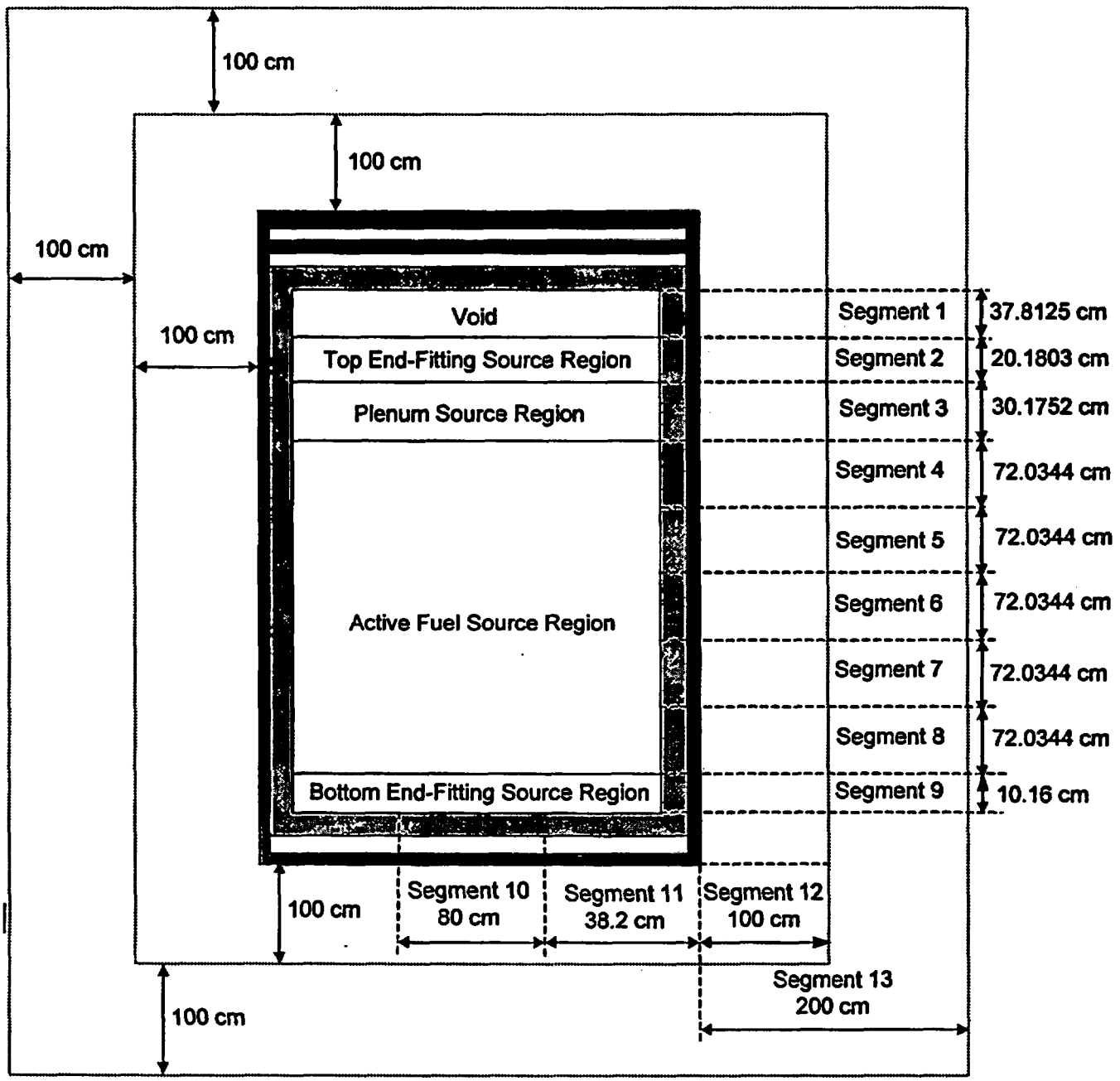
NOTE: The extra-cell shown for the inner shell has been created for geometric importance sampling in MCNP.

Figure 2. Lateral View of WP with Basket Assembly for MCNP Calculations



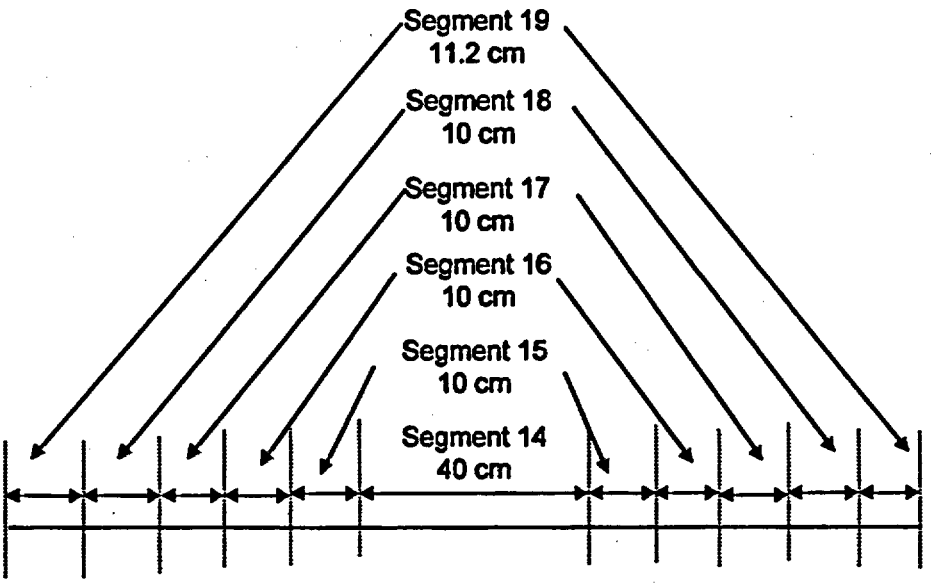
NOTE: The extra-cell shown for the inner shell has been created for geometric importance sampling in MCNP.

Figure 3. Lateral View of WP Without Basket Assembly for MCNP Calculations



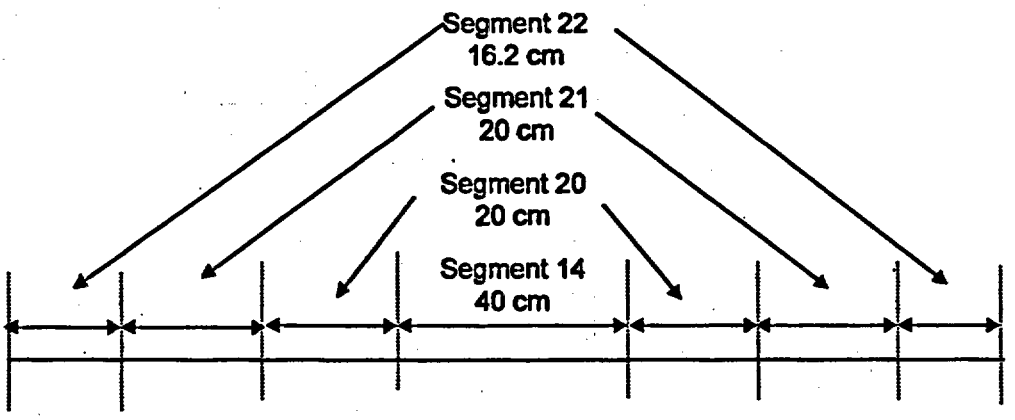
NOTES: [a] Drawing not to scale.
[b] The segments used in dose calculations for the top surface of the WP cavity and bottom surface of the outer top lid are presented in Figures 5 and 6.

Figure 4. Surface Segments Used for Dose Rate Calculations



NOTE: Drawing not to scale.

Figure 5. Segments of the Top Surface of the WP Cavity Used in Dose Rate Calculations



NOTE: Drawing not to scale.

Figure 6. Segments of the Bottom Surface of the Top Outer Lid Used in Dose Rate Calculations

6. RESULTS

The tables included in this section present the gamma and neutron surface dose rates calculated by MCNP, the total surface dose rates calculated using Equation 3, and its associated relative error calculated using Equations 4 and 5. The results presented in Tables 17 through 40 are based on unqualified information (radiation source terms) that requires confirmation.

This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the technical product input information quality may be confirmed by review of the DIRS database.

6.1 BOUNDING SOURCE FOR THE ACTIVE FUEL REGION

This section presents surface dose rates for the WP containing 21 PWR SNF assemblies with the following characteristics: 5.5-wt% initial ^{235}U, 75.0-GWd/MTU burnup, and a 5-year decay time. The source term for the PWR SNF assembly with these burnup and decay characteristics generates conservative (higher) surface dose rates only for the active fuel region.

6.1.1 Basket Assembly Inside the WP

Tables 17 through 22 present surface dose rates averaged over segments of the radial and axial surfaces of the 21-PWR WP (see Figures 4, 5, and 6 for segment locations). The WP contains the basket assembly.

Table 17. Dose Rates on the Inner Surface of the Inner Shell: Bounding PWR SNF

Axial Location	Gamma[a]		Neutron[b]		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	6.5877E+03	0.0331	7.3385E+00	0.0137	6.5950E+03	0.0331
Segment 2	1.5935E+04	0.0267	1.2722E+01	0.0136	1.5947E+04	0.0267
Segment 3	2.2217E+04	0.0190	2.3748E+01	0.0089	2.2241E+04	0.0190
Segment 4	4.3278E+04	0.0083	5.3964E+01	0.0043	4.3332E+04	0.0083
Segment 5	4.6468E+04	0.0080	6.7436E+01	0.0037	4.6536E+04	0.0080
Segment 6	4.6887E+04	0.0080	6.8477E+01	0.0037	4.6955E+04	0.0080
Segment 7	4.4414E+04	0.0081	6.7377E+01	0.0037	4.4481E+04	0.0081
Segment 8	4.6216E+04	0.0080	5.4960E+01	0.0042	4.6271E+04	0.0080
Segment 9	3.0339E+04	0.0252	2.9516E+01	0.0122	3.0369E+04	0.0252

Table 18. Dose Rates on the Inner Surface of the Outer Shell: Bounding PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	6.3766E+02	0.0436	3.3658E+00	0.0169	6.4103E+02	0.0434
Segment 2	1.7493E+03	0.0375	6.0258E+00	0.0179	1.7553E+03	0.0374
Segment 3	1.9677E+03	0.0271	1.1578E+01	0.0111	1.9793E+03	0.0269
Segment 4	3.3709E+03	0.0121	2.6628E+01	0.0050	3.3975E+03	0.0120
Segment 5	3.5530E+03	0.0118	3.3158E+01	0.0044	3.5861E+03	0.0117
Segment 6	3.5251E+03	0.0118	3.3669E+01	0.0043	3.5588E+03	0.0117
Segment 7	3.3951E+03	0.0121	3.3005E+01	0.0044	3.4281E+03	0.0120
Segment 8	3.6357E+03	0.0118	2.7356E+01	0.0049	3.6630E+03	0.0117
Segment 9	2.7274E+03	0.0384	1.3997E+01	0.0167	2.7414E+03	0.0382

Table 19. Dose Rates on the WP Outer Radial Surface: Bounding PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	2.1261E+02	0.0480	1.4306E+00	0.0166	2.1404E+02	0.0477
Segment 2	6.0833E+02	0.0425	2.6056E+00	0.0188	6.1093E+02	0.0423
Segment 3	6.3316E+02	0.0315	5.1482E+00	0.0108	6.3831E+02	0.0312
Segment 4	9.8058E+02	0.0147	1.2046E+01	0.0047	9.9263E+02	0.0145
Segment 5	1.0388E+03	0.0143	1.4862E+01	0.0042	1.0537E+03	0.0141
Segment 6	1.0239E+03	0.0142	1.5137E+01	0.0041	1.0390E+03	0.0140
Segment 7	9.8414E+02	0.0146	1.4905E+01	0.0042	9.9904E+02	0.0144
Segment 8	1.0699E+03	0.0144	1.2318E+01	0.0046	1.0822E+03	0.0142
Segment 9	8.9412E+02	0.0439	6.0482E+00	0.0158	9.0017E+02	0.0436

Table 20. Dose Rates on a Radial Surface 1 m from the WP: Bounding PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.2649E+02	0.0249	1.2212E+00	0.0094	1.2771E+02	0.0247
Segment 2	1.7489E+02	0.0255	1.6506E+00	0.0106	1.7654E+02	0.0253
Segment 3	2.2713E+02	0.0195	2.1220E+00	0.0075	2.2925E+02	0.0193
Segment 4	3.1085E+02	0.0122	3.0847E+00	0.0039	3.1393E+02	0.0121
Segment 5	3.5970E+02	0.0109	4.0257E+00	0.0033	3.6373E+02	0.0108
Segment 6	3.6800E+02	0.0108	4.3073E+00	0.0032	3.7231E+02	0.0107
Segment 7	3.6075E+02	0.0112	4.0280E+00	0.0033	3.6478E+02	0.0111
Segment 8	2.9843E+02	0.0128	3.0013E+00	0.0039	3.0143E+02	0.0127
Segment 9	2.1134E+02	0.0295	2.1623E+00	0.0127	2.1350E+02	0.0292

Table 21. Dose Rates on a Radial Surface 2 m from the WP: Bounding PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	8.9559E+01	0.0192	9.5328E-01	0.0078	9.0512E+01	0.0190
Segment 2	1.1168E+02	0.0231	1.1377E+00	0.0095	1.1282E+02	0.0229
Segment 3	1.3414E+02	0.0184	1.3055E+00	0.0072	1.3545E+02	0.0182
Segment 4	1.6863E+02	0.0117	1.6335E+00	0.0041	1.7026E+02	0.0116
Segment 5	2.0085E+02	0.0107	1.9927E+00	0.0036	2.0284E+02	0.0106
Segment 6	2.0818E+02	0.0102	2.1178E+00	0.0035	2.1030E+02	0.0101
Segment 7	2.0032E+02	0.0109	1.9944E+00	0.0036	2.0231E+02	0.0108
Segment 8	1.5763E+02	0.0121	1.5827E+00	0.0041	1.5921E+02	0.0120
Segment 9	1.2258E+02	0.0288	1.3143E+00	0.0123	1.2389E+02	0.0285

Table 22. Dose Rates on Segments of the Axial Surfaces: Bounding PWR SNF

Surface	Segment	Gamma		Neutron		Total	
		Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Top of the WP cavity (See Figure 5)	Segment 14	1.0287E+04	0.0748	8.9274E+00	0.0357	1.0296E+04	0.0747
	Segment 15	1.1414E+04	0.0681	8.9805E+00	0.0312	1.1423E+04	0.0680
	Segment 16	1.1035E+04	0.0582	8.4184E+00	0.0255	1.1044E+04	0.0582
	Segment 17	7.8592E+03	0.0578	7.7124E+00	0.0220	7.8669E+03	0.0577
	Segment 18	7.4234E+03	0.0594	6.9999E+00	0.0210	7.4304E+03	0.0593
	Segment 19	4.3328E+03	0.0650	6.3164E+00	0.0213	4.3391E+03	0.0649
Bottom of the outer upper lid (See Figure 6)	Segment 14	8.0595E+02	0.1151	4.0465E+00	0.0458	8.1000E+02	0.1145
	Segment 20	9.8864E+02	0.0672	4.0000E+00	0.0286	9.9264E+02	0.0669
	Segment 21	7.2880E+02	0.0584	3.4559E+00	0.0236	7.3226E+02	0.0581
	Segment 22	3.2513E+02	0.0732	2.2543E+00	0.0298	3.2739E+02	0.0727
Top of WP (See Figure 4)	Segment 10	2.9210E+02	0.0698	1.7080E+00	0.0298	2.9381E+02	0.0694
	Segment 11	1.6032E+02	0.0592	1.1328E+00	0.0224	1.6145E+02	0.0588
	Segment 12	6.2105E+01	0.0349	6.2362E-01	0.0111	6.2728E+01	0.0346
1 m from the WP top (See Figure 4)	WP top surface	8.3589E+01	0.0566	3.1502E-01	0.0228	8.3904E+01	0.0564
	Segment 13	2.3050E+01	0.0246	2.9580E-01	0.0075	2.3346E+01	0.0243
2 m from the WP top (See Figure 4)	WP top surface	4.3352E+01	0.0703	1.2710E-01	0.0350	4.3479E+01	0.0701
	Segment 13	1.3830E+01	0.0339	1.4924E-01	0.0099	1.3979E+01	0.0335
Bottom of WP cavity (See Figure 4)	Segment 10	1.1857E+05	0.0189	7.7908E+01	0.0081	1.1864E+05	0.0189
	# Segment 10[a]	6.7493E+04	0.0170	2.5792E+01	0.0081	6.7519E+04	0.0170
Bottom of inner lower lid (See Figure 4)	Segment 10	1.6838E+03	0.0355	1.8015E+01	0.0126	1.7018E+03	0.0351
	# Segment 10[b]	9.4299E+02	0.0285	1.0543E+01	0.0105	9.5353E+02	0.0282
Bottom of WP (See Figures 4 and 6)	Segment 14	3.9305E+02	0.0787	7.8112E+00	0.0278	4.0086E+02	0.0772
	Segment 20	4.6951E+02	0.0485	7.0439E+00	0.0178	4.7656E+02	0.0478
	Segment 11	2.3810E+02	0.0360	4.0395E+00	0.0129	2.4214E+02	0.0354
	Segment 12	1.4410E+02	0.0247	1.7803E+00	0.0075	1.4588E+02	0.0244
Surface 1 m from the WP bottom (See Figure 4)	WP bottom surface	1.2402E+02	0.0347	1.1952E+00	0.0120	1.2521E+02	0.0344
	Segment 13	3.5535E+01	0.0175	6.4069E-01	0.0054	3.6175E+01	0.0172
Surface 2 m from the WP bottom (See Figure 4)	WP bottom surface	5.6697E+01	0.0451	4.6232E-01	0.0185	5.7159E+01	0.0447
	Segment 13	2.1279E+01	0.0229	3.4441E-01	0.0068	2.1623E+01	0.0225

NOTE: [a] The segment outside Segment 10 and delimited by the radius of the WP cavity.
[b] The segment outside Segment 10 and delimited by the inner surface of the outer shell.

6.1.2 No Basket Assembly Inside the WP

Tables 23 through 28 present surface dose rates averaged over segments of the radial and axial surfaces of the 21-PWR WP (see Figures 4, 5, and 6 for segment locations). The WP basket assembly is neglected.

Table 23. Dose Rates on the Inner Surface of the Inner Shell: Bounding PWR SNF, No Basket

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	2.8472E+04	0.0182	1.5853E+01	0.0103	2.8488E+04	0.0182
Segment 2	4.8562E+04	0.0177	2.3317E+01	0.0106	4.8585E+04	0.0177
Segment 3	7.3327E+04	0.0117	3.5146E+01	0.0075	7.3362E+04	0.0117
Segment 4	1.2079E+05	0.0056	7.0632E+01	0.0038	1.2086E+05	0.0056
Segment 5	1.2836E+05	0.0055	9.0366E+01	0.0034	1.2845E+05	0.0055
Segment 6	1.2808E+05	0.0055	9.3491E+01	0.0033	1.2817E+05	0.0055
Segment 7	1.2852E+05	0.0055	9.1498E+01	0.0034	1.2861E+05	0.0055
Segment 8	1.1996E+05	0.0055	7.3992E+01	0.0038	1.2004E+05	0.0055
Segment 9	7.8954E+04	0.0173	4.4752E+01	0.0102	7.8999E+04	0.0173

Table 24. Dose Rates on the Inner Surface of the Outer Shell: Bounding PWR SNF, No Basket

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	2.4730E+03	0.0232	6.6649E+00	0.0134	2.4797E+03	0.0231
Segment 2	4.7447E+03	0.0227	1.0152E+01	0.0144	4.7548E+03	0.0227
Segment 3	6.4571E+03	0.0154	1.5906E+01	0.0096	6.4730E+03	0.0154
Segment 4	9.1288E+03	0.0074	3.3948E+01	0.0045	9.1627E+03	0.0074
Segment 5	9.2883E+03	0.0073	4.3281E+01	0.0040	9.3316E+03	0.0073
Segment 6	9.2021E+03	0.0073	4.4589E+01	0.0039	9.2466E+03	0.0073
Segment 7	9.3455E+03	0.0073	4.3726E+01	0.0039	9.3892E+03	0.0073
Segment 8	9.1127E+03	0.0075	3.5348E+01	0.0044	9.1480E+03	0.0075
Segment 9	7.0661E+03	0.0242	2.0323E+01	0.0139	7.0864E+03	0.0241

Table 25. Dose Rates on the WP Outer Radial Surface: Bounding PWR SNF, No Basket

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	8.2257E+02	0.0261	2.9195E+00	0.0125	8.2548E+02	0.0260
Segment 2	1.6479E+03	0.0257	4.6997E+00	0.0144	1.6526E+03	0.0256
Segment 3	2.1271E+03	0.0178	7.2166E+00	0.0092	2.1343E+03	0.0177
Segment 4	2.6652E+03	0.0089	1.5606E+01	0.0043	2.6808E+03	0.0088
Segment 5	2.6964E+03	0.0087	1.9876E+01	0.0037	2.7163E+03	0.0086
Segment 6	2.6503E+03	0.0087	2.0218E+01	0.0037	2.6705E+03	0.0086
Segment 7	2.6928E+03	0.0087	1.9979E+01	0.0037	2.7128E+03	0.0086
Segment 8	2.6774E+03	0.0089	1.6290E+01	0.0042	2.6937E+03	0.0088
Segment 9	2.3162E+03	0.0281	9.2463E+00	0.0143	2.3254E+03	0.0280

Table 26. Dose Rates on a Radial Surface 1 m from the WP: Bounding PWR SNF, No Basket

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	3.9102E+02	0.0141	1.7270E+00	0.0081	3.9275E+02	0.0140
Segment 2	5.1765E+02	0.0148	2.3147E+00	0.0092	5.1996E+02	0.0147
Segment 3	6.4614E+02	0.0118	2.8991E+00	0.0066	6.4904E+02	0.0117
Segment 4	8.4277E+02	0.0074	4.1310E+00	0.0035	8.4690E+02	0.0074
Segment 5	9.5402E+02	0.0067	5.3537E+00	0.0030	9.5938E+02	0.0067
Segment 6	9.6447E+02	0.0065	5.7627E+00	0.0029	9.7023E+02	0.0065
Segment 7	9.3652E+02	0.0067	5.3291E+00	0.0030	9.4185E+02	0.0067
Segment 8	7.6794E+02	0.0078	4.0424E+00	0.0035	7.7198E+02	0.0078
Segment 9	5.6561E+02	0.0200	2.9492E+00	0.0112	5.6856E+02	0.0199

Table 27. Dose Rates on a Radial Surface 2 m from the WP: Bounding PWR SNF, No Basket

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	2.6330E+02	0.0118	1.2983E+00	0.0069	2.6460E+02	0.0117
Segment 2	3.1362E+02	0.0143	1.5311E+00	0.0085	3.1515E+02	0.0142
Segment 3	3.6561E+02	0.0106	1.7514E+00	0.0064	3.6736E+02	0.0105
Segment 4	4.5438E+02	0.0071	2.1981E+00	0.0036	4.5658E+02	0.0071
Segment 5	5.3030E+02	0.0065	2.6713E+00	0.0032	5.3297E+02	0.0065
Segment 6	5.4980E+02	0.0063	2.8228E+00	0.0031	5.5262E+02	0.0063
Segment 7	5.0886E+02	0.0068	2.6505E+00	0.0032	5.1151E+02	0.0068
Segment 8	4.1060E+02	0.0075	2.1368E+00	0.0037	4.1274E+02	0.0075
Segment 9	3.2849E+02	0.0191	1.7882E+00	0.0109	3.3028E+02	0.0190

Table 28. Dose Rates on Segments of the Axial Surfaces: .Bounding PWR SNF, No Basket

Surface	Segment	Gamma		Neutron		Total	
		Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Top of the WP cavity (See Figure 5)	Segment 14	3.6020E+04	0.0415	1.7504E+01	0.0250	3.6037E+04	0.0415
	Segment 15	3.5432E+04	0.0376	1.6693E+01	0.0209	3.5449E+04	0.0376
	Segment 16	3.1165E+04	0.0334	1.5870E+01	0.0170	3.1180E+04	0.0334
	Segment 17	2.6872E+04	0.0314	1.6142E+01	0.0174	2.6889E+04	0.0314
	Segment 18	2.6201E+04	0.0296	1.4995E+01	0.0156	2.6215E+04	0.0296
	Segment 19	2.3091E+04	0.0282	1.4685E+01	0.0139	2.3105E+04	0.0282
Bottom of the outer upper lid (See Figure 6)	Segment 14	3.1671E+03	0.0641	8.8197E+00	0.0398	3.1759E+03	0.0639
	Segment 20	2.9101E+03	0.0370	8.5763E+00	0.0220	2.9186E+03	0.0369
	Segment 21	2.1535E+03	0.0327	7.4794E+00	0.0177	2.1610E+03	0.0326
	Segment 22	1.4723E+03	0.0371	5.4538E+00	0.0214	1.4778E+03	0.0370
Top of WP (See Figure 4)	Segment 10	9.2903E+02	0.0400	3.5739E+00	0.0217	9.3260E+02	0.0398
	Segment 11	5.0145E+02	0.0310	2.6328E+00	0.0155	5.0408E+02	0.0308
	Segment 12	2.4799E+02	0.0210	1.0612E+00	0.0097	2.4905E+02	0.0209
1 m from the WP top (See Figure 4)	WP top surface	2.3184E+02	0.0321	7.1204E-01	0.0162	2.3256E+02	0.0320
	Segment 13	7.7448E+01	0.0142	4.8035E-01	0.0063	7.7928E+01	0.0141
2 m from the WP top (See Figure 4)	WP top surface	1.0479E+02	0.0392	2.9464E-01	0.0244	1.0508E+02	0.0391
	Segment 13	4.6329E+01	0.0193	2.5538E-01	0.0080	4.6584E+01	0.0192
Bottom of WP cavity (See Figure 4)	Segment 10	1.8324E+05	0.0153	1.1248E+02	0.0067	1.8336E+05	0.0153
	# Segment 10[a]	1.0021E+05	0.0142	2.9898E+01	0.0066	1.0024E+05	0.0142
Bottom of inner lower lid (See Figure 4)	Segment 10	2.0679E+03	0.0309	2.2935E+01	0.0113	2.0908E+03	0.0306
	# Segment 10[b]	1.2541E+03	0.0241	1.4183E+01	0.0093	1.2682E+03	0.0238
Bottom of WP (See Figures 4 and 6)	Segment 14	5.8124E+02	0.0721	9.9708E+00	0.0255	5.9121E+02	0.0709
	Segment 20	5.1550E+02	0.0457	9.2230E+00	0.0155	5.2472E+02	0.0449
	Segment 11	3.0678E+02	0.0311	5.4329E+00	0.0106	3.1221E+02	0.0306
	Segment 12	3.7256E+02	0.0154	2.4583E+00	0.0065	3.7501E+02	0.0153
Surface 1 m from the WP bottom (See Figure 4)	WP bottom surface	1.4620E+02	0.0304	1.5652E+00	0.0107	1.4777E+02	0.0301
	Segment 13	7.6153E+01	0.0114	8.7358E-01	0.0048	7.7027E+01	0.0113
Surface 2 m from the WP bottom (See Figure 4)	WP bottom surface	6.6501E+01	0.0396	6.0111E-01	0.0166	6.7102E+01	0.0392
	Segment 13	3.5157E+01	0.0161	4.6829E-01	0.0060	3.5626E+01	0.0159

NOTE: [a] The segment outside Segment 10 and delimited by the radius of the WP cavity.
[b] The segment outside Segment 10 and delimited by the inner surface of the outer shell.

6.2 HYPOTHETICAL BOUNDING SOURCE

Tables 29 through 34 present surface dose rates averaged over segments of the WP radial and axial surfaces for a hypothetical PWR SNF (see Figures 4, 5, and 6 for segment locations). The source terms have the following characteristics: 5.5-wt% initial ^{235}U, 75.0-GWd/MTU burnup, and a 5-year decay time for the active fuel, and 0.711-wt% initial ^{235}U, 75.0-GWd/MTU burnup, and a 5-year decay time for the hardware. These source terms generate conservative (higher) surface dose rates for the hardware regions. The WP contains the basket assembly inside.

Table 29. Dose Rates on the Inner Surface of the Inner Shell: Hypothetical PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.0820E+04	0.0256	7.3385E+00	0.0137	1.0828E+04	0.0256
Segment 2	2.3793E+04	0.0212	1.2722E+01	0.0136	2.3805E+04	0.0212
Segment 3	2.9800E+04	0.0165	2.3748E+01	0.0089	2.9824E+04	0.0165
Segment 4	4.3890E+04	0.0083	5.3964E+01	0.0043	4.3944E+04	0.0083
Segment 5	4.6422E+04	0.0080	6.7436E+01	0.0037	4.6490E+04	0.0080
Segment 6	4.6849E+04	0.0081	6.8477E+01	0.0037	4.6917E+04	0.0081
Segment 7	4.4453E+04	0.0081	6.7377E+01	0.0037	4.4520E+04	0.0081
Segment 8	4.7264E+04	0.0079	5.4960E+01	0.0042	4.7319E+04	0.0079
Segment 9	3.9690E+04	0.0221	2.9516E+01	0.0122	3.9720E+04	0.0221

Table 30. Dose Rates on the Inner Surface of the Outer Shell: Hypothetical PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.0476E+03	0.0347	3.3658E+00	0.0169	1.0509E+03	0.0346
Segment 2	2.7438E+03	0.0300	6.0258E+00	0.0179	2.7498E+03	0.0299
Segment 3	2.8639E+03	0.0230	1.1578E+01	0.0111	2.8754E+03	0.0229
Segment 4	3.4319E+03	0.0121	2.6628E+01	0.0050	3.4585E+03	0.0120
Segment 5	3.5528E+03	0.0118	3.3158E+01	0.0044	3.5860E+03	0.0117
Segment 6	3.5222E+03	0.0118	3.3669E+01	0.0043	3.5559E+03	0.0117
Segment 7	3.3986E+03	0.0121	3.3005E+01	0.0044	3.4316E+03	0.0120
Segment 8	3.7543E+03	0.0117	2.7356E+01	0.0049	3.7817E+03	0.0116
Segment 9	3.8148E+03	0.0335	1.3997E+01	0.0167	3.8288E+03	0.0334

Table 31. Dose Rates on the WP Outer Radial Surface: Hypothetical PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	3.4524E+02	0.0387	1.4306E+00	0.0166	3.4667E+02	0.0385
Segment 2	9.6981E+02	0.0341	2.6056E+00	0.0188	9.7242E+02	0.0340
Segment 3	9.3571E+02	0.0266	5.1482E+00	0.0108	9.4085E+02	0.0265
Segment 4	1.0013E+03	0.0147	1.2046E+01	0.0047	1.0134E+03	0.0145
Segment 5	1.0398E+03	0.0143	1.4862E+01	0.0042	1.0546E+03	0.0141
Segment 6	1.0235E+03	0.0142	1.5137E+01	0.0041	1.0386E+03	0.0140
Segment 7	9.8526E+02	0.0146	1.4905E+01	0.0042	1.0002E+03	0.0144
Segment 8	1.1113E+03	0.0142	1.2318E+01	0.0046	1.1236E+03	0.0140
Segment 9	1.2847E+03	0.0385	6.0482E+00	0.0158	1.2908E+03	0.0383

Table 32. Dose Rates on a Radial Surface 1 m from the WP: Hypothetical PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.6773E+02	0.0218	1.2212E+00	0.0094	1.6895E+02	0.0216
Segment 2	2.2517E+02	0.0238	1.6506E+00	0.0106	2.2682E+02	0.0236
Segment 3	2.7372E+02	0.0182	2.1220E+00	0.0075	2.7584E+02	0.0181
Segment 4	3.3980E+02	0.0118	3.0847E+00	0.0039	3.4289E+02	0.0117
Segment 5	3.6648E+02	0.0109	4.0257E+00	0.0033	3.7050E+02	0.0108
Segment 6	3.7057E+02	0.0108	4.3073E+00	0.0032	3.7487E+02	0.0107
Segment 7	3.6630E+02	0.0111	4.0280E+00	0.0033	3.7033E+02	0.0110
Segment 8	3.1454E+02	0.0127	3.0013E+00	0.0039	3.1754E+02	0.0126
Segment 9	2.3131E+02	0.0288	2.1623E+00	0.0127	2.3347E+02	0.0285

Table 33. Dose Rates on a Radial Surface 2 m from the WP: Hypothetical PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.0543E+02	0.0183	9.5328E-01	0.0078	1.0639E+02	0.0181
Segment 2	1.3069E+02	0.0220	1.1377E+00	0.0095	1.3183E+02	0.0218
Segment 3	1.5366E+02	0.0174	1.3055E+00	0.0072	1.5497E+02	0.0173
Segment 4	1.8328E+02	0.0114	1.6335E+00	0.0041	1.8491E+02	0.0113
Segment 5	2.0931E+02	0.0106	1.9927E+00	0.0036	2.1130E+02	0.0105
Segment 6	2.1373E+02	0.0101	2.1178E+00	0.0035	2.1585E+02	0.0100
Segment 7	2.0593E+02	0.0108	1.9944E+00	0.0036	2.0793E+02	0.0107
Segment 8	1.6495E+02	0.0120	1.5827E+00	0.0041	1.6653E+02	0.0119
Segment 9	1.2998E+02	0.0286	1.3143E+00	0.0123	1.3130E+02	0.0283

Table 34. Dose Rates on Segments of the Axial Surfaces: Hypothetical PWR SNF

Surface	Segment	Gamma		Neutron		Total	
		Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Top of the WP cavity (See Figure 5)	Segment 14	1.6939E+04	0.0590	8.9274E+00	0.0357	1.6948E+04	0.0590
	Segment 15	1.8944E+04	0.0527	8.9805E+00	0.0312	1.8953E+04	0.0527
	Segment 16	1.8202E+04	0.0444	8.4184E+00	0.0255	1.8210E+04	0.0444
	Segment 17	1.3169E+04	0.0463	7.7124E+00	0.0220	1.3177E+04	0.0463
	Segment 18	1.2351E+04	0.0485	6.9999E+00	0.0210	1.2358E+04	0.0485
	Segment 19	7.2536E+03	0.0531	6.3164E+00	0.0213	7.2599E+03	0.0531
Bottom of the outer upper lid (See Figure 6)	Segment 14	1.3209E+03	0.0901	4.0465E+00	0.0458	1.3249E+03	0.0898
	Segment 20	1.6123E+03	0.0519	4.0000E+00	0.0286	1.6163E+03	0.0518
	Segment 21	1.1904E+03	0.0463	3.4559E+00	0.0236	1.1939E+03	0.0462
	Segment 22	5.6902E+02	0.0593	2.2543E+00	0.0298	5.7127E+02	0.0591
Top of WP (See Figure 4)	Segment 10	4.7389E+02	0.0555	1.7080E+00	0.0298	4.7560E+02	0.0553
	Segment 11	2.5816E+02	0.0460	1.1328E+00	0.0224	2.5929E+02	0.0458
	Segment 12	9.0831E+01	0.0298	6.2362E-01	0.0111	9.1454E+01	0.0296
1 m from the WP top (See Figure 4)	WP top surface	1.3174E+02	0.0450	3.1502E-01	0.0228	1.3205E+02	0.0449
	Segment 13	3.3052E+01	0.0218	2.9580E-01	0.0075	3.3348E+01	0.0216
2 m from the WP top (See Figure 4)	WP top surface	6.7609E+01	0.0575	1.2710E-01	0.0350	6.7736E+01	0.0574
	Segment 13	2.1250E+01	0.0289	1.4924E-01	0.0099	2.1399E+01	0.0287
Bottom of WP cavity (See Figure 4)	Segment 10	1.8666E+05	0.0159	7.7908E+01	0.0081	1.8674E+05	0.0159
	# Segment 10[a]	1.0610E+05	0.0141	2.5792E+01	0.0081	1.0613E+05	0.0141
Bottom of inner lower lid (See Figure 4)	Segment 10	2.5715E+03	0.0289	1.8015E+01	0.0126	2.5895E+03	0.0287
	# Segment 10[b]	1.4798E+03	0.0232	1.0543E+01	0.0105	1.4903E+03	0.0230
Bottom of WP (See Figures 4 and 6)	Segment 14	6.1087E+02	0.0663	7.8112E+00	0.0278	6.1868E+02	0.0655
	Segment 20	7.2222E+02	0.0391	7.0439E+00	0.0178	7.2927E+02	0.0387
	Segment 11	3.7737E+02	0.0293	4.0395E+00	0.0129	3.8141E+02	0.0290
	Segment 12	1.6716E+02	0.0239	1.7803E+00	0.0075	1.6894E+02	0.0236
Surface 1 m from the WP bottom (See Figure 4)	WP bottom surface	1.9024E+02	0.0285	1.1952E+00	0.0120	1.9143E+02	0.0283
	Segment 13	4.4843E+01	0.0161	6.4069E-01	0.0054	4.5484E+01	0.0159
Surface 2 m from the WP bottom (See Figure 4)	WP bottom surface	8.6245E+01	0.0374	4.6232E-01	0.0185	8.6707E+01	0.0372
	Segment 13	3.0210E+01	0.0201	3.4441E-01	0.0068	3.0555E+01	0.0199

NOTE: [a] The segment outside Segment 10 and delimited by the radius of the WP cavity.
[b] The segment outside Segment 10 and delimited by the inner surface of the outer shell.

6.3 AVERAGE SOURCE

Tables 35 through 40 present surface dose rates averaged over segments of radial and axial surfaces of the WP containing the PWR SNF with the following characteristics: 4.0-wt% initial ^{235}U, 48.0-GWd/MTU burnup, and a 21-year decay time (see Figures 4, 5, and 6 for segment locations). The WP contains the basket assembly inside.

Table 35. Dose Rates on the Inner Surface of the Inner Shell: Average PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	6.4071E+02	0.0381	1.1672E+00	0.0143	6.4187E+02	0.0380
Segment 2	1.7478E+03	0.0287	2.0171E+00	0.0138	1.7498E+03	0.0287
Segment 3	3.2348E+03	0.0172	3.7777E+00	0.0091	3.2385E+03	0.0172
Segment 4	8.6028E+03	0.0062	8.4802E+00	0.0043	8.6112E+03	0.0062
Segment 5	9.4102E+03	0.0061	1.0393E+01	0.0038	9.4206E+03	0.0061
Segment 6	9.5141E+03	0.0061	1.0622E+01	0.0038	9.5247E+03	0.0061
Segment 7	9.0752E+03	0.0062	1.0378E+01	0.0038	9.0856E+03	0.0062
Segment 8	9.2268E+03	0.0061	8.6192E+00	0.0043	9.2354E+03	0.0061
Segment 9	4.7992E+03	0.0227	4.6195E+00	0.0125	4.8038E+03	0.0227

Table 36. Dose Rates on the Inner Surface of the Outer Shell: Average PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	6.3278E+01	0.0508	5.2729E-01	0.0181	6.3805E+01	0.0504
Segment 2	1.6628E+02	0.0422	9.3010E-01	0.0184	1.6721E+02	0.0420
Segment 3	2.5671E+02	0.0252	1.8145E+00	0.0114	2.5852E+02	0.0250
Segment 4	6.1094E+02	0.0092	4.2068E+00	0.0051	6.1514E+02	0.0091
Segment 5	6.5053E+02	0.0089	5.1237E+00	0.0046	6.5566E+02	0.0088
Segment 6	6.5587E+02	0.0089	5.2092E+00	0.0045	6.6108E+02	0.0088
Segment 7	6.3421E+02	0.0090	5.1183E+00	0.0046	6.3932E+02	0.0089
Segment 8	6.4939E+02	0.0090	4.2535E+00	0.0051	6.5364E+02	0.0089
Segment 9	3.8586E+02	0.0345	2.1790E+00	0.0166	3.8804E+02	0.0343

Table 37. Dose Rates on the WP Outer Radial Surface: Average PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	2.1114E+01	0.0569	2.2931E-01	0.0175	2.1344E+01	0.0563
Segment 2	5.8748E+01	0.0489	4.1322E-01	0.0190	5.9161E+01	0.0486
Segment 3	7.8494E+01	0.0297	8.1307E-01	0.0111	7.9307E+01	0.0294
Segment 4	1.6445E+02	0.0112	1.8815E+00	0.0048	1.6633E+02	0.0111
Segment 5	1.7404E+02	0.0107	2.2848E+00	0.0043	1.7632E+02	0.0106
Segment 6	1.7615E+02	0.0107	2.3235E+00	0.0042	1.7847E+02	0.0106
Segment 7	1.7106E+02	0.0108	2.2877E+00	0.0043	1.7334E+02	0.0107
Segment 8	1.7698E+02	0.0108	1.9289E+00	0.0048	1.7890E+02	0.0107
Segment 9	1.1587E+02	0.0413	9.8920E-01	0.0177	1.1686E+02	0.0410

Table 38. Dose Rates on a Radial Surface 1 m from the WP: Average PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.6346E+01	0.0225	1.8969E-01	0.0098	1.6535E+01	0.0222
Segment 2	2.4576E+01	0.0217	2.6074E-01	0.0110	2.4836E+01	0.0215
Segment 3	3.3185E+01	0.0159	3.3109E-01	0.0078	3.3516E+01	0.0157
Segment 4	5.0121E+01	0.0094	4.8259E-01	0.0040	5.0604E+01	0.0093
Segment 5	6.0437E+01	0.0083	6.2404E-01	0.0034	6.1061E+01	0.0082
Segment 6	6.2701E+01	0.0079	6.6373E-01	0.0033	6.3365E+01	0.0078
Segment 7	6.1308E+01	0.0083	6.2190E-01	0.0034	6.1930E+01	0.0082
Segment 8	4.9022E+01	0.0096	4.6804E-01	0.0041	4.9490E+01	0.0095
Segment 9	3.4005E+01	0.0226	3.3621E-01	0.0132	3.4341E+01	0.0224

Table 39. Dose Rates on a Radial Surface 2 m from the WP: Average PWR SNF

Axial Location	Gamma		Neutron		Total	
	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Segment 1	1.3229E+01	0.0161	1.4785E-01	0.0082	1.3376E+01	0.0159
Segment 2	1.7257E+01	0.0185	1.7540E-01	0.0100	1.7433E+01	0.0183
Segment 3	2.0562E+01	0.0148	2.0182E-01	0.0075	2.0764E+01	0.0147
Segment 4	2.7365E+01	0.0090	2.5361E-01	0.0042	2.7619E+01	0.0089
Segment 5	3.3287E+01	0.0080	3.0994E-01	0.0037	3.3597E+01	0.0079
Segment 6	3.5288E+01	0.0077	3.2733E-01	0.0036	3.5616E+01	0.0076
Segment 7	3.3287E+01	0.0081	3.0762E-01	0.0038	3.3595E+01	0.0080
Segment 8	2.6232E+01	0.0091	2.4828E-01	0.0043	2.6480E+01	0.0090
Segment 9	1.9513E+01	0.0222	2.0291E-01	0.0130	1.9716E+01	0.0220

Table 40. Dose Rates on Segments of the Axial Surfaces: Average PWR SNF

Surface	Segment	Gamma		Neutron		Total	
		Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error	Dose Rate (rem/h)	Relative Error
Top of the WP cavity (See Figure 5)	Segment 14	1.2384E+03	0.0791	1.4379E+00	0.0323	1.2398E+03	0.0790
	Segment 15	1.0065E+03	0.0780	1.4738E+00	0.0318	1.0080E+03	0.0779
	Segment 16	1.0838E+03	0.0640	1.3657E+00	0.0271	1.0852E+03	0.0639
	Segment 17	7.6861E+02	0.0817	1.2015E+00	0.0238	7.6982E+02	0.0816
	Segment 18	6.9977E+02	0.0643	1.1801E+00	0.0226	7.0095E+02	0.0642
	Segment 19	4.5093E+02	0.0707	9.5332E-01	0.0233	4.5188E+02	0.0706
Bottom of the outer upper lid (See Figure 6)	Segment 14	1.0557E+02	0.1152	7.0742E-01	0.0528	1.0628E+02	0.1144
	Segment 20	8.7727E+01	0.0795	6.3960E-01	0.0297	8.8366E+01	0.0789
	Segment 21	6.7886E+01	0.0667	5.4583E-01	0.0245	6.8432E+01	0.0662
	Segment 22	3.0679E+01	0.0874	3.6829E-01	0.0320	3.1047E+01	0.0864
Top of WP (See Figure 4)	Segment 10	3.0467E+01	0.0791	2.7165E-01	0.0329	3.0739E+01	0.0784
	Segment 11	1.3836E+01	0.0663	1.7467E-01	0.0211	1.4010E+01	0.0655
	Segment 12	7.1895E+00	0.0351	9.8137E-02	0.0118	7.2877E+00	0.0346
1 m from the WP top (See Figure 4)	WP top surface	8.4382E+00	0.0623	4.8245E-02	0.0238	8.4865E+00	0.0619
	Segment 13	2.7893E+00	0.0230	4.6412E-02	0.0078	2.8357E+00	0.0226
2 m from the WP top (See Figure 4)	WP top surface	4.2112E+00	0.0752	1.9957E-02	0.0362	4.2311E+00	0.0748
	Segment 13	1.5511E+00	0.0335	2.3453E-02	0.0103	1.5745E+00	0.0330
Bottom of WP cavity (See Figure 4)	Segment 10	1.4068E+04	0.0176	1.2052E+01	0.0083	1.4080E+04	0.0176
	# Segment 10[a]	8.0525E+03	0.0161	4.0046E+00	0.0082	8.0565E+03	0.0161
Bottom of inner lower lid (See Figure 4)	Segment 10	1.7072E+02	0.0364	2.8501E+00	0.0131	1.7357E+02	0.0358
	# Segment 10[b]	1.0243E+02	0.0298	1.6737E+00	0.0109	1.0410E+02	0.0293
Bottom of WP (See Figure 4 and 6)	Segment 14	4.2094E+01	0.0889	1.2499E+00	0.0280	4.3344E+01	0.0863
	Segment 20	4.5341E+01	0.0507	1.1318E+00	0.0177	4.6473E+01	0.0495
	Segment 11	2.5198E+01	0.0383	6.2965E-01	0.0126	2.5828E+01	0.0374
	Segment 12	2.1645E+01	0.0198	2.7888E-01	0.0077	2.1924E+01	0.0195
Surface 1 m from the WP bottom (See Figure 4)	WP bottom surface	1.2102E+01	0.0373	1.8850E-01	0.0124	1.2290E+01	0.0367
	Segment 13	4.8586E+00	0.0148	9.9952E-02	0.0056	4.9586E+00	0.0145
Surface 2 m from the WP bottom (See Figure 4)	WP bottom surface	5.5744E+00	0.0493	7.1209E-02	0.0193	5.6456E+00	0.0487
	Segment 13	2.5247E+00	0.0212	5.4372E-02	0.0070	2.5791E+00	0.0208

NOTE: [a] The segment outside Segment 10 and delimited by the radius of the WP cavity.
[b] The segment outside Segment 10 and delimited by the inner surface of the outer shell.

7. REFERENCES

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7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

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8. ATTACHMENTS

The attachments of this calculation are listed in Table 41. Electronic output files are provided on a compact disk, and are listed in Table 42. Each output file is identified by its name, size (in bytes), and the date and time of last access. The input files used are echoed in the output files. It should be noted that for files transferred from the HP to the personal computer, the date and time will reflect the time of transfer. The actual date and time of run completion can be found in the file.

Table 41. List of Attachments

Description	Attachment Number	No. of Pages
Atomic density calculation for the homogenized assembly regions	I	8
Total source intensity and source region fractions	II	2
SK-0219 REV 01 21-PWR Waste Package Concept for License Application (selected sheets)	III	10
MCNP electronic output files (compact disk)	IV	N/A

Table 42. File Attributes for the Contents of Electronic Media

File Name	Calculation	File Size (bytes)	File Date	File Time
abg.io	Gamma dose rates for the WP containing the average PWR SNF source	260,341	01/16/2001	2:16 p.m.
abn.io	Neutron dose rates for the WP containing the average PWR SNF source	227,347	01/16/2001	9:56 a.m.
bbg.io	Gamma dose rates for the WP containing bounding PWR SNF source for the active fuel region	256,122	01/16/2001	9:56 a.m.
bbn.io	Neutron dose rates for the WP containing bounding PWR SNF source for the active fuel region	227,821	01/16/2001	9:56 a.m.
b2bg.io	Gamma dose rates for the WP containing the bounding PWR SNF source for the hardware regions	249,736	01/16/2001	9:56 a.m.
bg.io	Gamma dose rates for the WP containing bounding PWR SNF source (basket assembly neglected)	173,658	01/16/2001	9:56 a.m.
bn.io	Neutron dose rates for the WP containing bounding PWR SNF source (basket assembly neglected)	157,007	01/16/2001	9:56 a.m.

NOTE: The MCNP output files listed in the table are text files.

This attachment presents the atomic density calculations for the homogenized assembly regions using Equations 1 and 2 in Section 5.2.3.

1. Bottom End-Fitting Region

Table I-1. Total Mass by Material in the Bottom End-Fitting Region

Component	Material	Mass (kg)
Bottom nozzle	SS CF3M	8.16
Spacer-bottom	Inconel-718	1.3
Lower nut	SS 304	0.15
Total		9.61

Table I-2. Element Mass by Material

SS CF-3M			Inconel-718			SS 304		
Element	wt%	Mass (g)	Element	wt%	Mass (g)	Element	wt%	Mass (g)
C	0.03	2.448	Ni	51.5	669.5	C	0.08	0.12
Mn	1.5	122.4	Cr	19	247	Cr	19	28.5
Si	2	163.2	Fe	17.809	231.517	Ni	9.25	13.875
Cr	19	1550.4	Nb	5.125	66.625	Mn	2	3
Ni	10	816	Mo	3.05	39.65	P	0.045	0.0675
Mo	2.5	204	Ti	0.9	11.7	S	0.03	0.045
Fe	64.97	5301.552	Al	0.5	6.5	Si	0.75	1.125
Total	100	8160	Co	1	13	N	0.1	0.15
			Mn	0.35	4.55	Fe	68.495	102.7425
			Si	0.35	4.55	Total	100	150
			Cu	0.3	3.9			
			C	0.08	1.04			
			S	0.015	0.195			
			P	0.015	0.195			
			B	0.006	0.078			
			Total	100	1300			

Table I-3. Atomic Density by Element in the Bottom End-Fitting Region

Element/Isotope	Mass (g)	Nuclide ID[a]	Atomic Mass[b] (g)	Atomic Density (atoms/b•cm)
C	3.608	6000.50c	12.0107	3.7877E-05
Mn	129.95	25055.50c	54.93805	2.9825E-04
P	0.2625	15031.50c	30.97376	1.0686E-06
S	0.24	16000.60c	32.066	9.4373E-07
Si	168.875	14000.50c	28.0855	7.5817E-04
Cr	1825.9	24000.50c	51.9961	4.4278E-03
Ni	1499.375	28000.50c	58.6934	3.2211E-03
N[d]	0.15	7014.50c	14.003074	1.3507E-06
Fe	5636.1865	26000.55c	55.845	1.2726E-02
Mo	243.65	42000.50c	95.94	3.2022E-04
Nb	66.625	41093.50c	92.90638	9.0422E-05
Ti	11.7	22000.50c	47.867	3.0820E-05
Al	6.5	13027.50c	26.98154	3.0376E-05
Co	13	27059.50c	58.9332	2.7814E-05
Cu	3.9	29000.50c	63.546	7.7385E-06
B	0.078		10.811	9.0972E-07
^{10}B (19.9 at%)[c]		5010.50c		1.8103E-07
^{11}B (80.1 at%)[c]		5011.50c		7.2869E-07
Total	9610			2.1981E-02

SOURCE: [a] Briesmeister 1997, Appendix G.
[b] Parrington et al. 1996.
[c] Parrington et al. 1996, page 18.
[d] Neutron cross-section tables for ^{14}N are used in this calculation.

NOTES: [a] Nuclide identifier in the MCNP neutron data tables. The identifier for each element in the MCNP photon data tables is ZZZ000.01p, where ZZZ is the atomic number (Briesmeister 1997, pages 2-16 through 2-22).
[b] Region volume used for material homogenization (cm^3): region height * assembly transverse^2 = 10.16 * 21.68144^2 =4776.062.

2. Active Fuel Region

Table I-4. Total Mass by Material in the Active Fuel Region

Component	Material	Mass (kg)
Fuel	U	463.63
	O	62.8284
Cladding	Zircaloy-4	Density*volume = 106.5079794
Guide tube	Zircaloy-4	Mass/assembly*fraction in active fuel region = 7.3815721
Instrument tube	Zircaloy-4	Mass/assembly*fraction in active fuel region = 0.5905258
Grid supports	Zircaloy-4	0.64
Total	Zircaloy-4	115.12008
Spacer-incore	Inconel-718	4.9
Total		648.47848

Table I-5. Uranium Isotope Composition (5.5- and 4.0-wt% ^{235}U)

Isotope	wt%	Mass (kg)	wt%	Mass (kg)
^{235}U	5.5	25.49965	4.0	18.5452
^{234}U	0.0490	0.2273727	0.0347	0.1610
^{236}U	0.0253	0.1172984	0.0184	0.0853
^{238}U	94.4257	437.78568	95.9469	444.8385
Total	100	463.63	100	463.63

NOTE: The isotopic composition for the enriched uranium is calculated according to the equations provided in Bowman et al. (1995) (see Section 5.2).

Table I-6. Element Mass by Material in the Active Fuel Region

Zircaloy-4			Inconel-718			Fuel		
Element	wt%	Mass (g)	Element	wt%	Mass (g)	Isotope	Mass (g)	
							5.5-wt% ^{235}U	4.0-wt% ^{235}U
Sn	1.45	1669.2411	Ni	51.5	2523.5	U235	25499.65	18545.2
Fe	0.21	241.75216	Cr	19	931	U234	227.37266	161.0125
Cr	0.115	132.3881	Fe	17.809	872.641	U236	117.29839	85.30792
O	0.125	143.9001	Nb	5.125	251.125	U238	437785.68	444838.5
Zr	98.1	112932.8	Mo	3.05	149.45	O	62828.4	62828.4
Total	100	115120.1	Ti	0.9	44.1	Total	526458.4	526458.4
			Al	0.5	24.5			
			Co	1	49			
			Mn	0.35	17.15			
			Si	0.35	17.15			
			Cu	0.3	14.7			
			C	0.08	3.92			
			S	0.015	0.735			
			P	0.015	0.735			
			B	0.006	0.294			
			Total	100	4900			

Table I-7. Atomic Density by Element in the Active Fuel Region

Element/ Isotope	Nuclide ID[a]	Atomic Mass[b] (g)	5.5-wt% ^{235}U		4.0-wt% ^{235}U	
			Mass (g)	Atomic Density (atoms/b•cm)	Mass (g)	Atomic Density (atoms/b•cm)
Ni	28000.50c	58.6934	2523.5	1.5292E-04	2523.5	1.5292E-04
Cr	24000.50c	51.9961	1063.388	7.2742E-05	1063.388	7.2742E-05
Fe	26000.55c	55.845	1114.3932	7.0977E-05	1114.3932	7.0977E-05
Nb	41093.50c	92.90638	251.125	9.6141E-06	251.125	9.6141E-06
Mo	42000.50c	95.94	149.45	5.5406E-06	149.45	5.5406E-06
Ti	22000.50c	47.867	44.1	3.2769E-06	44.1	3.2769E-06
Al	13027.50c	26.98154	24.5	3.2297E-06	24.5	3.2297E-06
Co	27059.50c	58.9332	49	2.9573E-06	49	2.9573E-06
Mn	25055.50c	54.93805	17.15	1.1103E-06	17.15	1.1103E-06
Si	14000.50c	28.0855	17.15	2.1719E-06	17.15	2.1719E-06
Cu	29000.50c	63.546	14.7	8.2280E-07	14.7	8.2280E-07
C	6000.50c	12.0107	3.92	1.1609E-06	3.92	1.1609E-06
S	16000.60c	32.066	0.735	8.1528E-08	0.735	8.1528E-08
P	15031.50c	30.97376	0.735	8.4403E-08	0.735	8.4403E-08
B		10.811	0.294	9.6727E-08	0.294	9.6727E-08
^{10}B (19.9 at%)[c]	5010.50c			1.9249E-08		1.9249E-08
^{11}B (80.1 at%)[c]	5011.55c			7.7478E-08		7.7478E-08
Sn	50000.35c	118.71	1669.2411	5.0015E-05	1669.2411	5.0015E-05
Zr	40000.50c	91.224	112932.8	4.4033E-03	112932.8	4.4033E-03
O	8016.50c	15.99491	62972.3	1.4003E-02	62972.3	1.4003E-02
^{235}U	92235.50c	235.04392	25499.65	3.8588E-04	18545.2	2.8064E-04
^{234}U	92234.50c	234.04095	227.37266	3.4555E-06	161.01251	2.4470E-06
^{236}U	92236.50c	236.04556	117.29839	1.7675E-06	85.30792	1.2855E-06
^{238}U	92238.50c	238.05079	437785.68	6.5412E-03	444838.48	6.6466E-03
Total			646478.5	2.5716E-02	646478.5	2.5714E-02

SOURCE: [a] Briesmeister 1997, Appendix G.
[b] Parrington et al. 1996.
[c] Parrington et al. 1996, page 18.

NOTES: [a] Nuclide identifier in the MCNP neutron data tables. The identifier for each element in the MCNP photon data tables is ZZZ000.01p, where ZZZ is the atomic number (Briesmeister 1997, pages 2-16 through 2-22).
[b] Region volume used for material homogenization (cm^3): region height * assembly transverse^2 = 360.172 * 21.68144^2 = 169311.4.

3. Plenum

Table I-8. Total Mass by Material in the Plenum Region

Component	Material	Mass (kg)
Cladding	Zircaloy-4	Density * volume = 8.923235512
Guide tube	Zircaloy-4	mass/assembly * fraction in plenum region = 0.6184279
Instrument tube	Zircaloy-4	mass/assembly * fraction in plenum region = 0.0494742
Total	Zircaloy-4	9.5911376
Plenum spring	SS 302	0.01905
Spacer-plenum	Inconel-718	1.04
Total		10.650188

Table I-9. Element Mass by Material in the Plenum Region

Zircaloy-4			SS 302			Inconel-718		
Element	wt%	Mass (g)	Element	wt%	Mass (g)	Element	wt%	Mass (g)
Sn	1.45	139.0715	C	0.15	0.028575	Ni	51.5	535.6
Fe	0.21	20.141389	Mn	2	0.381	Cr	19	197.6
Cr	0.115	11.029808	P	0.045	0.0085725	Fe	17.809	185.2136
O	0.125	11.988922	S	0.03	0.005715	Nb	5.125	53.3
Zr	98.1	9408.906	Si	0.75	0.142875	Mo	3.05	31.72
Total	100	9591.1376	Cr	18	3.429	Ti	0.9	9.36
			Ni	9	1.7145	Al	0.5	5.2
			N	0.1	0.01905	Co	1	10.4
			Fe	69.925	13.320713	Mn	0.35	3.64
			Total	100	19.05	Si	0.35	3.64
						Cu	0.3	3.12
						C	0.08	0.832
						S	0.015	0.156
						P	0.015	0.156
						B	0.006	0.0624
						Total	100	1040

Table I-10. Atomic Density by Element in the Plenum Region

Element/Isotope	Mass (g)	Nuclide ID[a]	Atomic Mass[b] (g)	Atomic Density (atoms/b•cm)
Ni	537.3145	28000.50c	58.6934	3.8865E-04
Cr	212.05881	24000.50c	51.9961	1.7314E-04
Fe	218.6757	26000.55c	55.845	1.6624E-04
Nb	53.3	41093.50c	92.90638	2.4356E-05
Mo	31.72	42000.50c	95.94	1.4036E-05
Ti	9.36	22000.50c	47.867	8.3016E-06
Al	5.2	13027.50c	26.981538	8.1820E-06
Co	10.4	27059.50c	58.9332	7.4920E-06
Mn	4.021	25055.50c	54.938049	3.1073E-06
Si	3.782875	14000.50c	28.0855	5.7183E-06
Cu	3.12	29000.50c	63.546	2.0844E-06
C	0.860575	6000.50c	12.0107	3.0419E-06
S	0.161715	16000.60c	32.066	2.1411E-07
P	0.1645725	15031.50c	30.973761	2.2557E-07
B	0.0624		10.811	2.4504E-07
^{10}B (19.9 at%)[c]		5010.50c		4.8764E-08
^{11}B (80.1 at%)[c]		5011.55c		3.9060E-08
Sn	139.0715	50000.35c	118.71	4.9736E-05
O	11.988922	8016.50c	15.994915	3.1822E-05
Zr	9408.906	40000.50c	91.224	4.3788E-03
N[d]	0.01905	7014.50c	14.003074	5.7741E-08
Total				5.2653E-03

SOURCE: [a] Briesmeister 1997, Appendix G.
[b] Parrington et al. 1996.
[c] Parrington et al. 1996, page 18.
[d] Neutron cross-section tables for ^{14}N are used in this calculation.

NOTES: [a] Nuclide identifier in the MCNP neutron data tables. The identifier for each element in the MCNP photon data tables is ZZZ000.01p, where ZZZ is the atomic number (Briesmeister 1997, pages 2-16 through 2-22).
[b] Region volume used for atomic densities calculation (cm^3): region length * assembly transverse^2 = 30.1752 * 21.68144^2=14184.904.

4. Top End-Fitting Region

Table I-11. Total Mass by Material in the Top End-Fitting Region

Component	Material	Mass (kg)
Top nozzle	SS CF3M	7.48
Spring retainer	SS CF3M	0.91
Total	SS CF3M	8.39
Holding spring	Inconel-718	1.8
Upper end plug	SS 304	0.06
Upper nut	SS 304L	0.51
Total		10.76

Table I-12. Element Mass by Material in the Top End-Fitting Region

SS CF3M			Inconel-718			SS 304			SS 304L		
Element	wt%	Mass (g)	Element	wt%	Mass (g)	Element	wt%	Mass (g)	Element	wt%	Mass (g)
C	0.03	2.517	Ni	51.5	927	C	0.08	0.048	C	0.03	0.153
Mn	1.5	125.85	Cr	19	342	Cr	19	11.4	Mn	2	10.2
Si	2	167.8	Fe	17.809	320.562	Ni	9.25	5.55	P	0.045	0.2295
Cr	19	1594.1	Nb	5.125	92.25	Mn	2	1.2	S	0.03	0.153
Ni	10	839	Mo	3.05	54.9	P	0.045	0.027	Si	0.75	3.825
Mo	2.5	209.75	Ti	0.9	16.2	S	0.03	0.018	Cr	19	96.9
Fe	64.97	5450.983	Al	0.5	9	Si	0.75	0.45	Ni	10	51
Total	100	8390	Co	1	18	N	0.1	0.06	N	0.1	0.51
			Mn	0.35	6.3	Fe	68.745	41.247	Fe	68.045	347.0295
			Si	0.35	6.3	Total	100	60	Total	100	510
			Cu	0.3	5.4						
			C	0.08	1.44						
			S	0.015	0.27						
			P	0.015	0.27						
			B	0.006	0.108						
			Total	100	1800						

Table I-13. Atomic Density by Element in the Top End-Fitting Region

Element/Isotope	Mass (g)	Nuclide ID[a]	Atomic Mass[b] (g)	Atomic Density (atoms/b•cm)
C	4.158	6000.50c	12.0107	2.1977E-05
Mn	143.55	25055.50c	54.93805	1.6587E-04
P	0.5265	15031.50c	30.97376	1.0791E-06
S	0.441	16000.60c	32.066	8.7305E-07
Si	178.375	14000.50c	28.0855	4.0318E-04
Cr	2044.4	24000.50c	51.9961	2.4960E-03
Ni	1822.55	28000.50c	58.6934	1.9712E-03
N[d]	0.57	7014.50c	14.003074	2.5840E-06
Fe	6159.8215	26000.55c	55.845	7.0021E-03
Mo	264.65	42000.50c	95.94	1.7511E-04
Nb	92.25	41093.50c	92.90638	6.3033E-05
Ti	16.2	22000.50c	47.867	2.1485E-05
Al	9	13027.50c	26.98154	2.1175E-05
Co	18	27059.50c	58.9332	1.9389E-05
Cu	5.4	29000.50c	63.546	5.3945E-06
B	0.108		10.811	6.3417E-07
^{10}B (19.9 at%)[c]		5010.50c		1.2620E-07
^{11}B (80.1 at%)[c]		5011.50c		5.0797E-07
Total	10760			1.2371E-02

SOURCE: [a] Briesmeister 1997, Appendix G.
[b] Parrington et al. 1996.
[c] Parrington et al. 1996, page 18.
[d] Neutron cross-section tables for ^{14}N are used in this calculation.

NOTES: [a] Nuclide identifier in the MCNP neutron data tables. The identifier for each element in the MCNP photon data tables is ZZZ000.01p, where ZZZ is the atomic number (Briesmeister 1997, pages 2-16 through 2-22).
[b] Region height (cm): assembly length - pin length - bottom end-fitting length = 420.6875-390.3472-10.16 = 20.1803. Region volume used for atomic densities calculation (cm^3): region length * assembly transverse^2 = 20.1803 * 21.68144^2 = 9486.4531.

This attachment presents the calculations of total neutron and gamma intensities and gamma source region fractions.

The peaking factor for the gamma and neutron sources in the active fuel region is 1.25 (Electric Power Research Institute 1998, p. 3-26).

1. Bounding PWR SNF: Gamma Source

Total intensity per assembly (photons/s) = Peaking factor * Gamma intensity in the fuel region (photons/s) + Gamma intensity in the bottom end-fitting region (photons/s) + Gamma intensity in the plenum region (photons/s) + Gamma intensity in the top end-fitting region (photons/s) = 1.25 * 1.0556E+16 + 3.9264E+13 + 2.0605E+13 + 2.5235E+13 = 1.3280E+16

Total intensity per WP (photons/s) = 21 * Total intensity per assembly (photons/s) = 21 * 1.3280E+16 = 2.7889E+17

Intensity fraction for each assembly region to be entered on the sp (source probability) card = Gamma source intensity for each assembly region in the WP (photons/s) / Total intensity per WP (photons/s).

Intensity fraction for the active fuel region = 21 * 1.25 *1.0556E+16 / 2.7889E+17 = 9.9359E-01
Intensity fraction for the bottom end-fitting region = 21 * 3.9264E+13 / 2.7889E+17 = 2.9565E-03
Intensity fraction for the plenum region = 21 * 2.0605E+13 / 2.7889E+17 = 1.5515E-03
Intensity fraction for the top end-fitting region = 21 * 2.5235E+13 / 2.7889E+17 = 1.9002E-03

2. Hypothetical PWR SNF: Hardware and Active Fuel Region Gamma Sources

Total intensity per assembly (photons/s) = Peaking factor * Gamma intensity in the fuel region (photons/s) + Gamma intensity in the bottom end-fitting region (photons/s) + Gamma intensity in the plenum region (photons/s) + Gamma intensity in the top end-fitting region (photons/s) = 1.25 * 1.0556E+16 + 6.6070E+13 + 3.4051E+13 + 4.2338E+13 = 1.3338E+16

Total intensity per WP (photons/s) = 21 * Total intensity per assembly (photons/s) = 21 * 1.3338E+16 = 2.8009E+17

Intensity fraction for each assembly region to be entered on the sp (source probability) card = Gamma source intensity for each assembly region in the WP (photons/s) / Total intensity per WP (photons/s).

Intensity fraction for the active fuel region = 21 * 1.25 *1.0556E+16 / 2.8009E+17 = 9.8932E-01
Intensity fraction for the bottom end-fitting region = 21 * 6.6070E+13 / 2.8009E+17 = 4.9536E-03
Intensity fraction for the plenum region = 21 * 3.4051E+13 / 2.8009E+17 = 2.5530E-03
Intensity fraction for the top end-fitting region = 21 * 4.2338E+13 / 2.8009E+17 = 3.1743E-03

3. Bounding PWR SNF: Neutron Source

Total intensity per WP (neutrons/s) = 21 * Peaking factor * Total intensity per active fuel region (neutrons/s) = 21 * 1.25 * 1.3844E+09 = 3.6341E+10

4. Average PWR SNF: Gamma Source

Total intensity per assembly (photons/s) = Peaking factor * Gamma intensity in the fuel region (photons/s) + Gamma intensity in the bottom end-fitting region (photons/s) + Gamma intensity in the plenum region (photons/s) + Gamma intensity in the top end-fitting region (photons/s) = 1.25 * 2.6256E+15 + 3.8681E+12 + 2.0177E+12 + 2.4845E+12 = 3.2904E+15

Total intensity per WP (photons/s) = 21 * Total intensity per assembly (photons/s) = 21 * 3.2904E+15 = 6.9098E+16

Intensity fraction for each assembly region to be entered on the sp (source probability) card = Gamma source intensity for each assembly region in the WP (photons/s) / Total intensity per WP (photons/s).

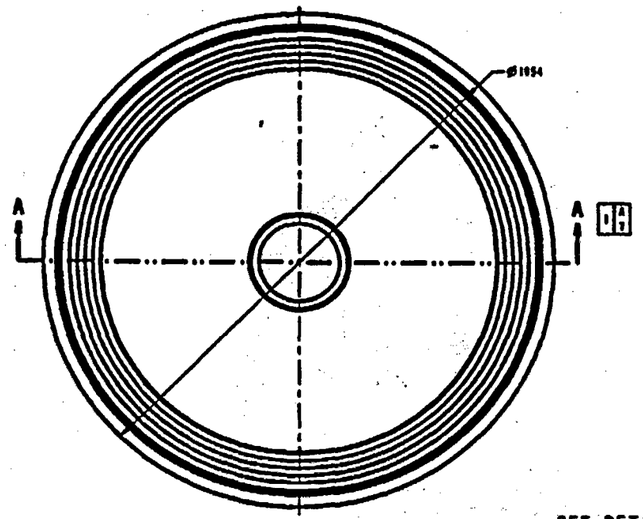
Intensity fraction for the active fuel region = 21 * 1.25 * 2.6256E+15 / 6.9098E+16 = 9.9746E-01
Intensity fraction for the bottom end-fitting region = 21 * 3.8681E+12 / 6.9098E+16 = 1.1756E-03
Intensity fraction for the plenum region = 21 * 2.0177E+12 / 6.9098E+16 = 6.1322E-04
Intensity fraction for the top end-fitting region = 21 * 2.4845E+12 / 6.9098E+16 = 7.5509E-04

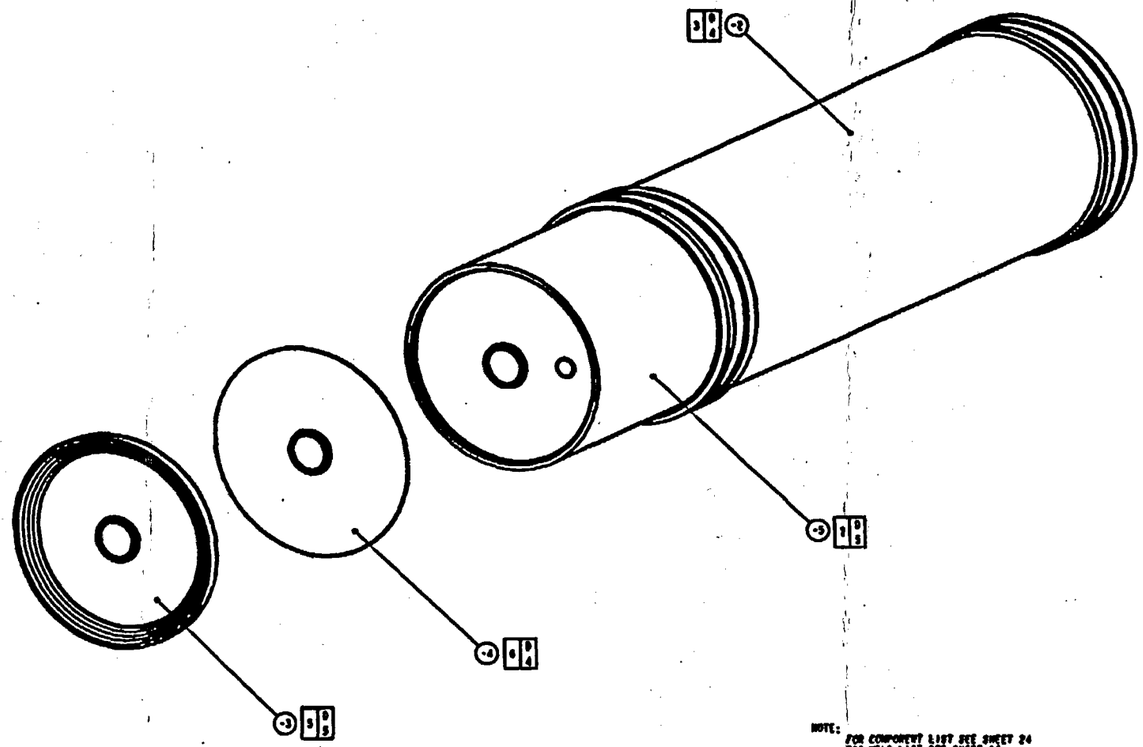
5. Average PWR SNF: Neutron Source

Total intensity per WP (neutrons/s) = 21 * Peaking factor * Total intensity per active fuel region (neutrons/s) = 21 * 1.25 * 2.3062E+08 = 6.0538E+09

ALL SHEETS ARE THE SAME REVISION STATUS

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	01	5129 WAS 5000 IN ZONES B8-1 AND B8-3	02/22/01	SMB
C4-2	01	172 WASTE PACKAGE TOP END TO INNER SHELL TOP LID WAS 290	02/22/01	SMB
C4-2	01	30.08 EXTENDED LID TO CLOSURE LID GAP WAS 38	02/22/01	SMB
C4-2	01	7 CLOSURE LID TO INNER SHELL GAP WAS 35	02/22/01	SMB
B8-2	01	109 OUTER SHELL BOTTOM LID TO LOWER TRUNNION COLLAR SLEEVE WAS ADDED TO DETAIL B	02/22/01	SMB
B2-2	01	ADDED 4 GAP	02/22/01	SMB
A2-5	01	DETAIL BB WAS ADDED	02/22/01	SMB
-	01	ITEM 14 WAS ITEM 13 IN ZONES B3-6, C5-12, B8-13, C6-16, AND C8-24	02/22/01	SMB
A8-5	01	ADDED DETAIL BB CALLOUT	02/22/01	SMB
A2-6	01	DETAIL CC WAS ADDED	02/22/01	SMB
B3-24	-	CONTINUED ON SHEET 24	02/22/01	SMB





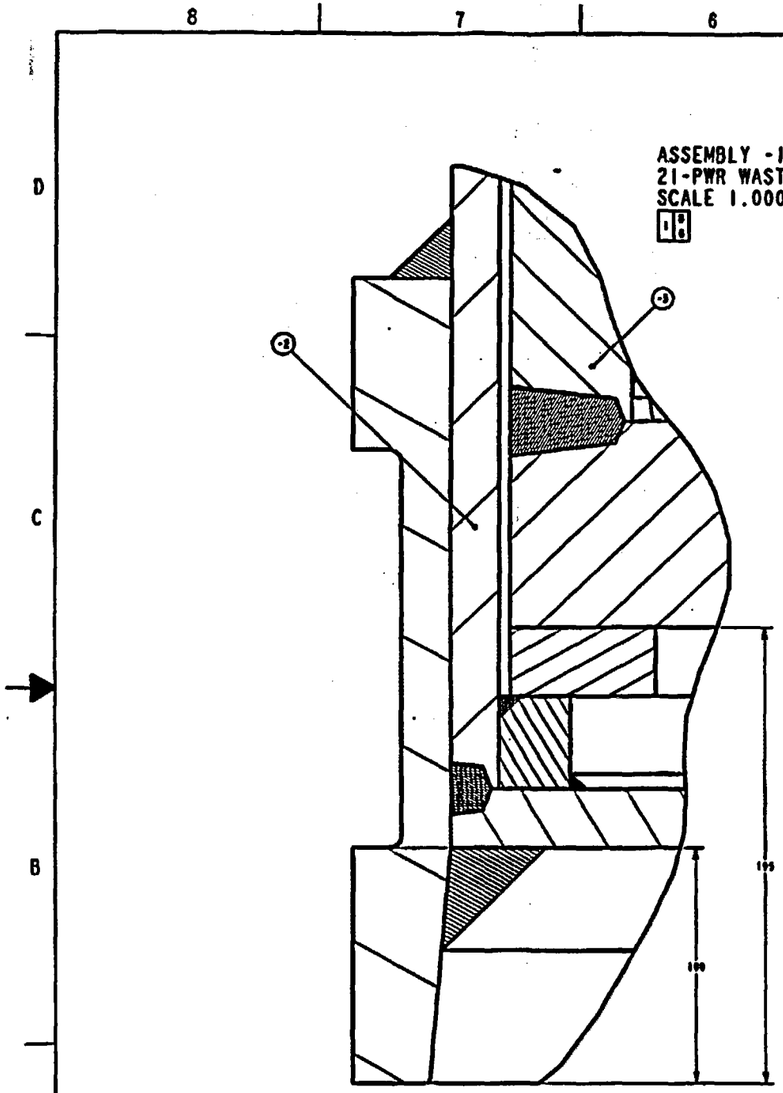
NOTE:
FOR COMPONENT LIST SEE SHEET 24
FOR WELD LIST SEE SHEET 23
FOR REFERENCE NOTE LIST SEE SHEET 25

"FOR INFORMATION ONLY"	APPROVALS	INITIAL/DATE
THIRD ANGLE PROJECTION	DRAWN BY BRYAN MARRIS	BM 02/22/01
DIMENSIONS ARE IN MILLIMETERS AND DEGREES UNLESS OTHERWISE NOTED	STRUCTURAL LEAD SCOTT DEPRETT	SMB 02/22/01
DO NOT SCALE FROM SKETCH	MANUFACTURING REP JERRY COBAR	JDC 2/22/01
	DESIGN GROUP REP MICHAEL ANDERSON	[illegible] 2/22/01

WASTE PACKAGE DEPARTMENT
M&O Civilian Radioactive Waste Management System Management & Operating Contractor

TITLE
21-PWR WASTE PACKAGE CONCEPT FOR LICENSE APPLICATION

SKETCH NUMBER SK-0219 | REVISION 01
SCALE 0.125 | SHEET 1 OF 25



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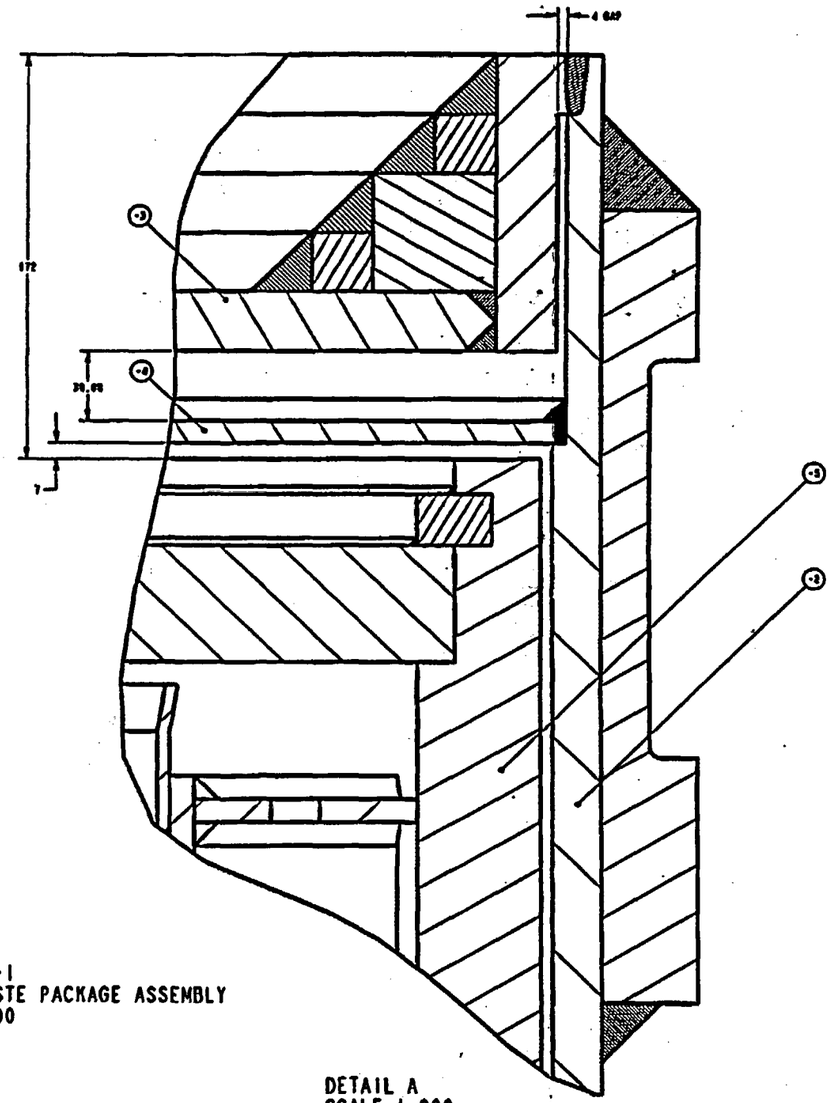
SCALE 1.000



ASSEMBLY -1
21-PWR WASTE PACKAGE ASSEMBLY
SCALE 1.000

DETAIL A
SCALE 1.000

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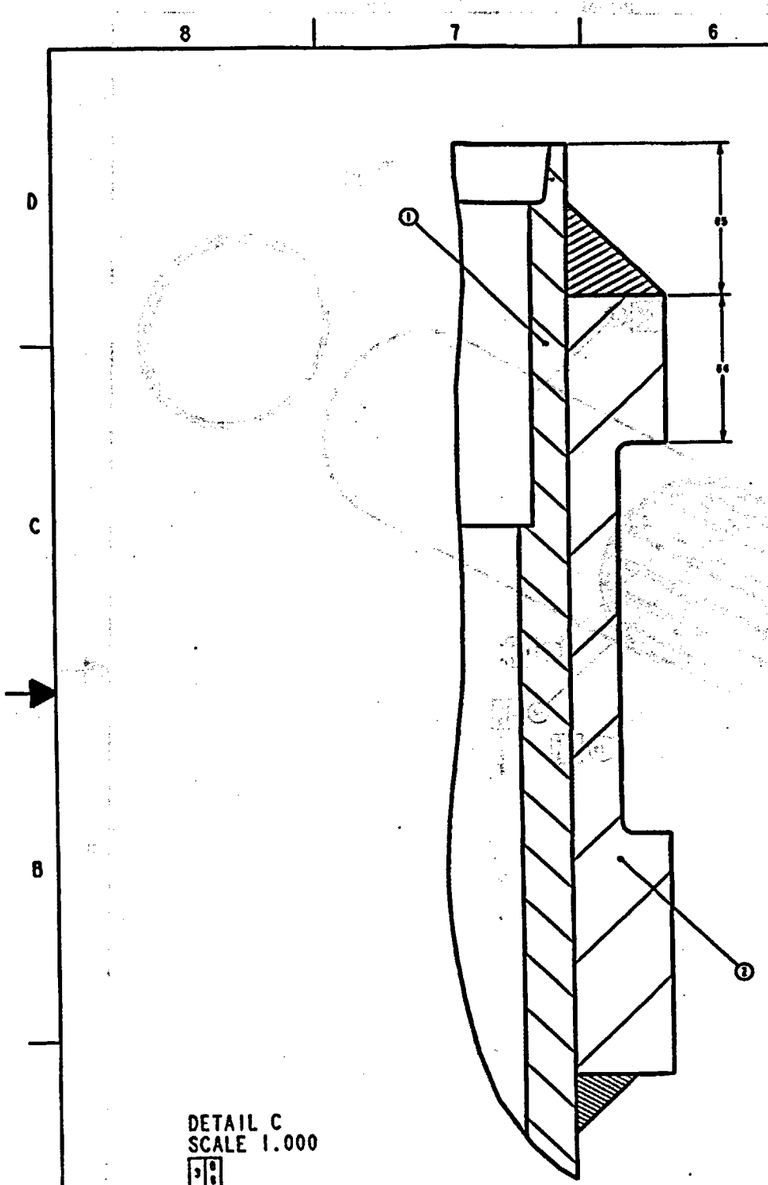
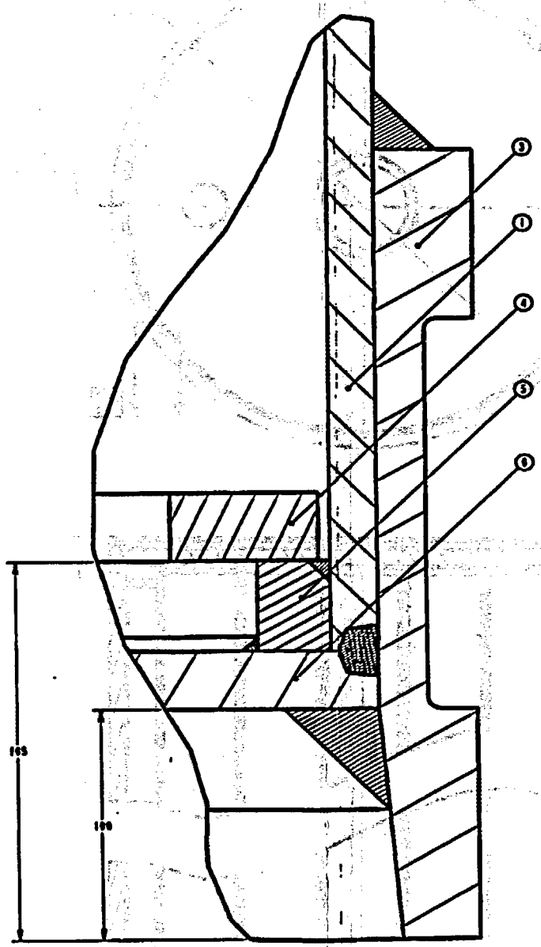
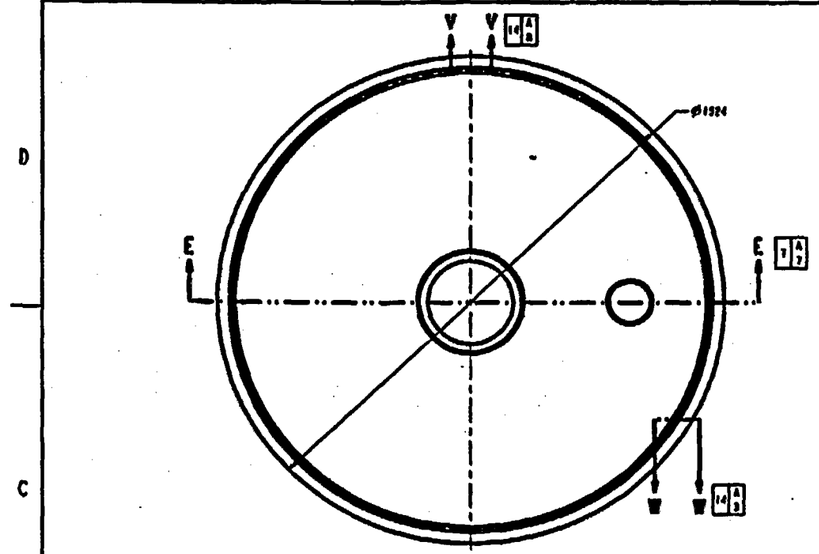
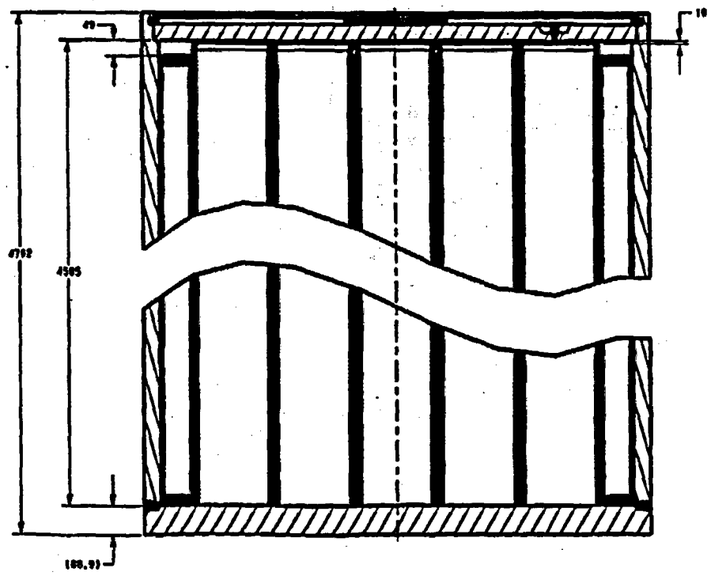
M&O Yucca Mountain Waste Management System MANAGEMENT & OPERATING CONTRACTOR	
DRAWING NUMBER SK-0219	REVISION 01
SCALE 0.125	SHEET 2 OF 23





WASTE PACKAGE DEPARTMENT
Civilian Radioactive Waste Management System
MANAGEMENT & OPERATING CONTRACTOR
SK-0219
REVISION 01
SCALE 0.125
SHEET 4 OF 21





SECTION E-E
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INNER SHELL ASSEMBLY
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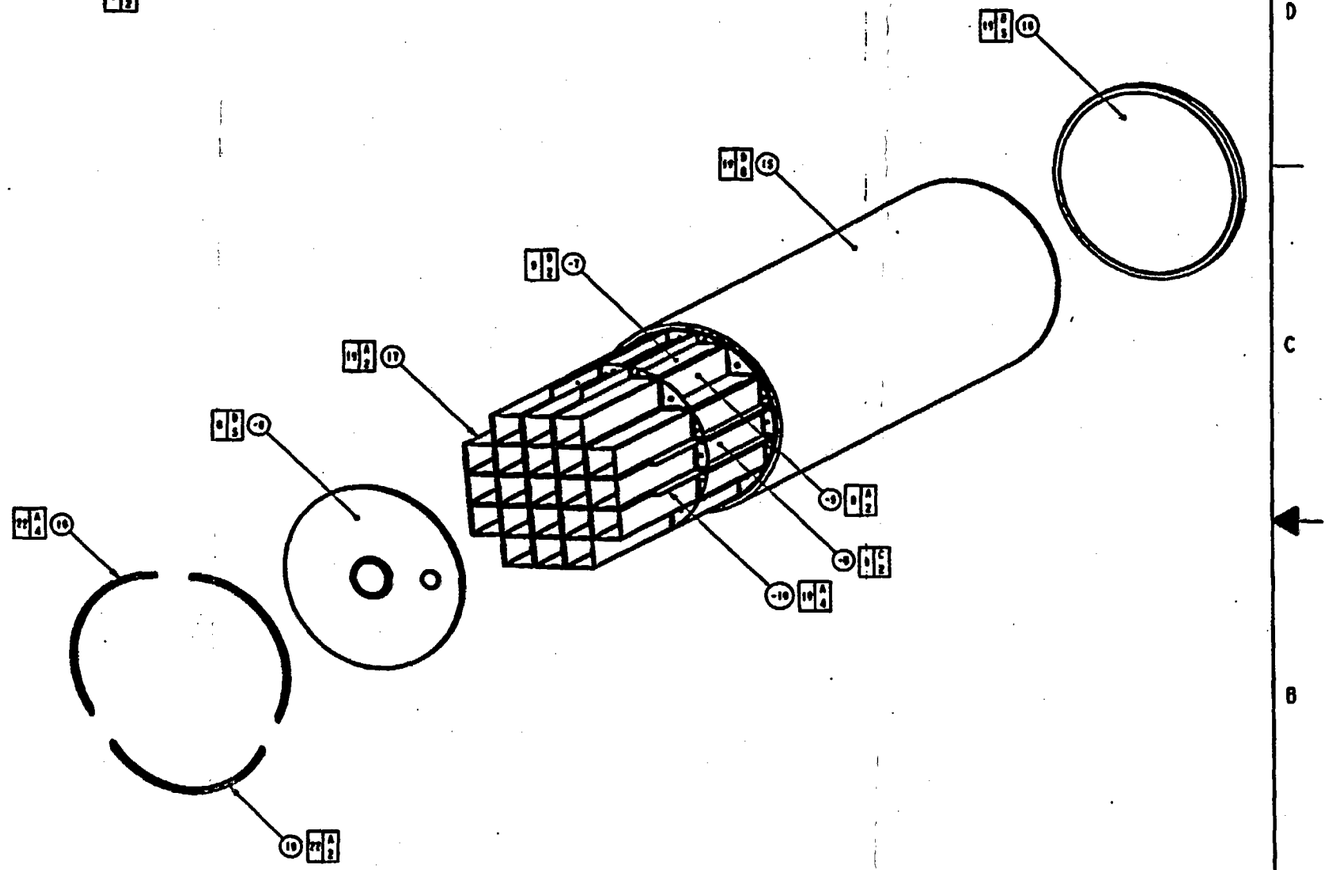

WASTE PACKAGE DEPARTMENT	
M&O Civilian Radioactive Waste Management System Management & Operating Contractor	
SKETCH NUMBER SK-0219	REVISION 01
SCALE 0.125	SHEET 1 OF 25

ITEM 1
OUTER SHELL
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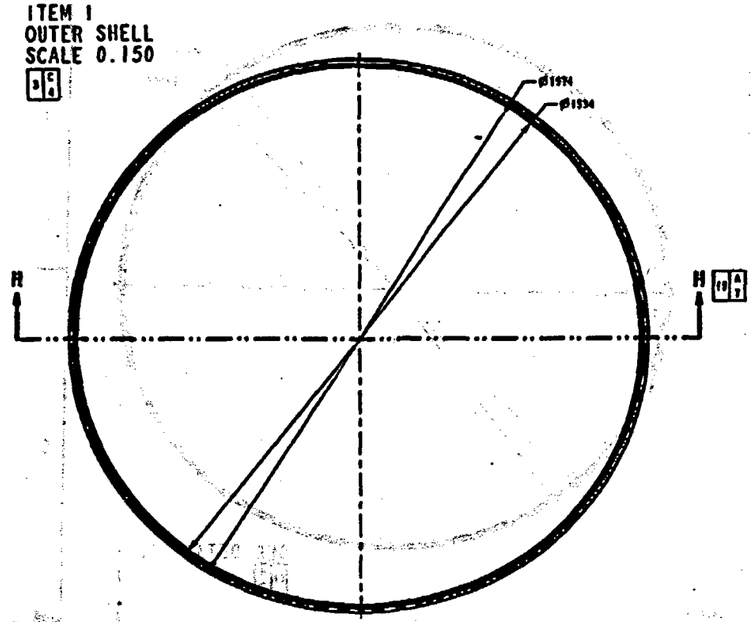
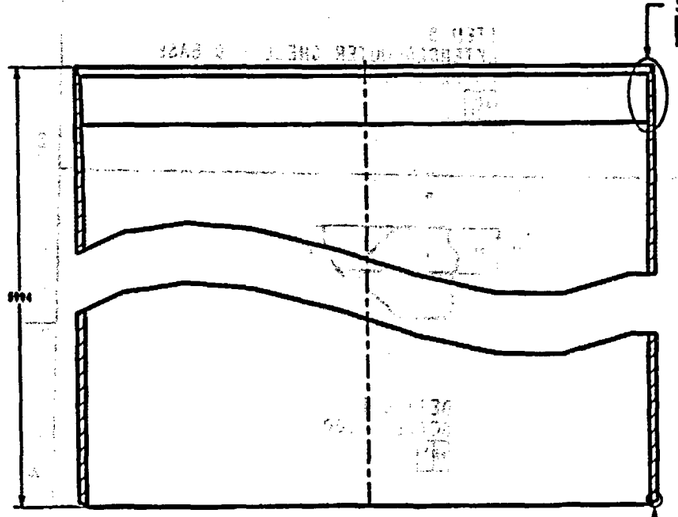
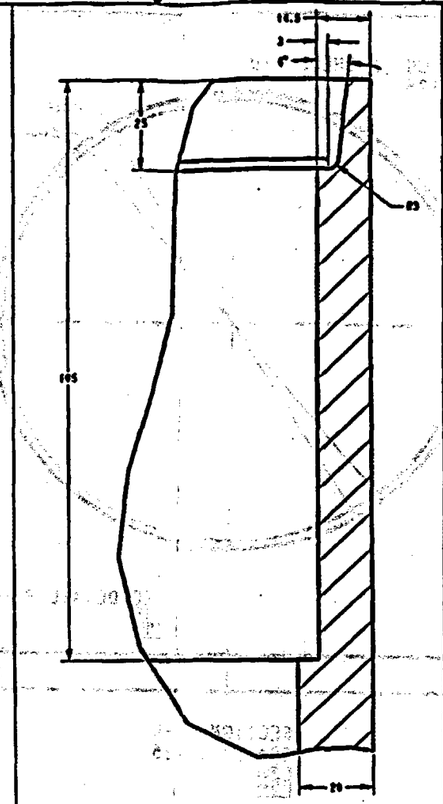


SEE DETAIL L

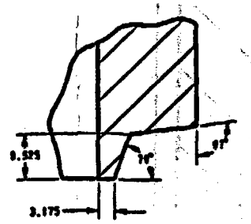


SECTION H-H
SCALE 0.150

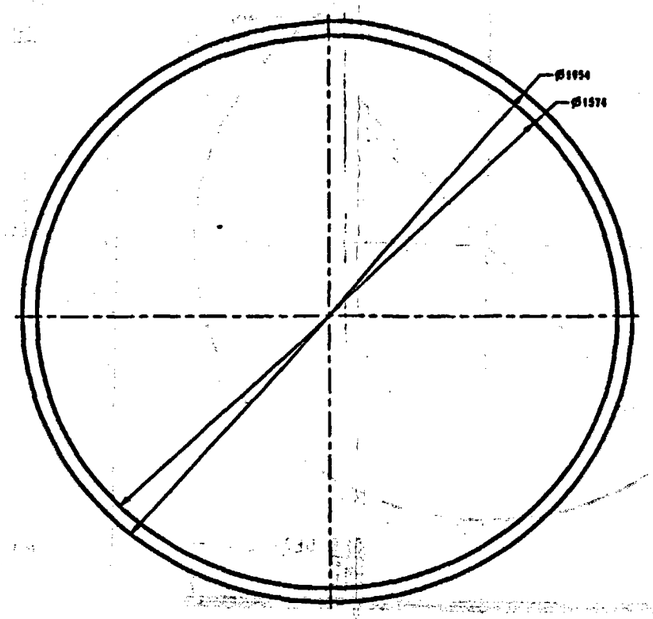
SEE DETAIL M

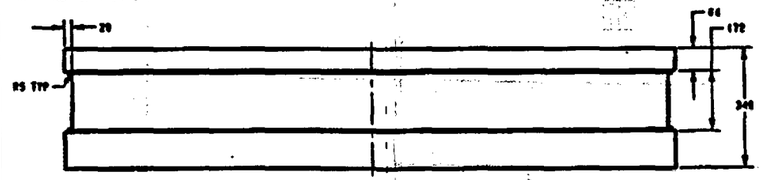


DETAIL L
SCALE 1.500



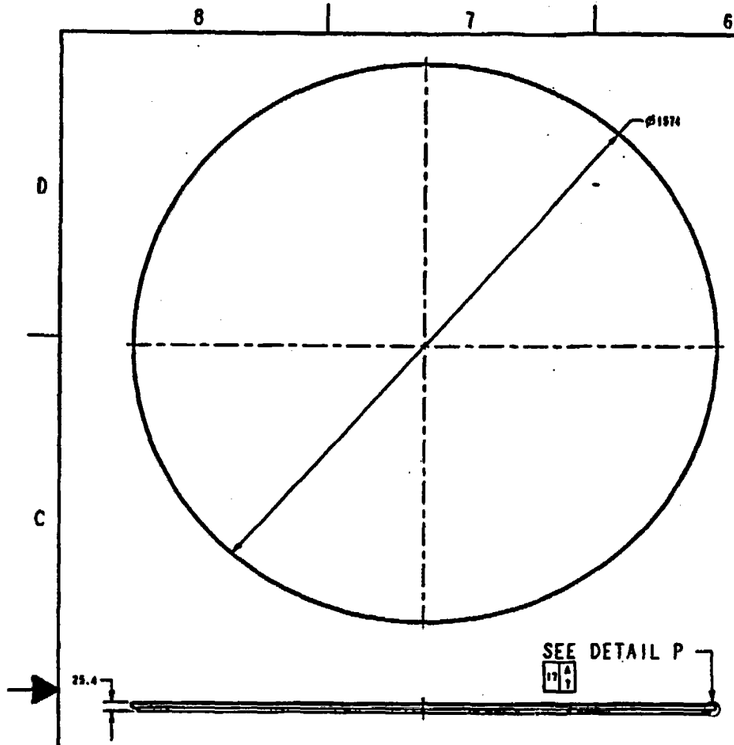
DETAIL M
SCALE 2.000



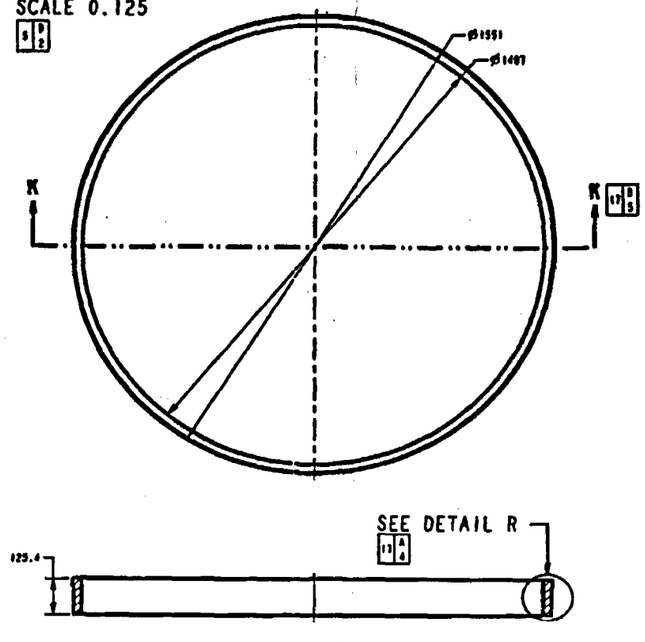


ITEM 2
UPPER TRUNNION COLLAR SLEEVE
SCALE 0.150

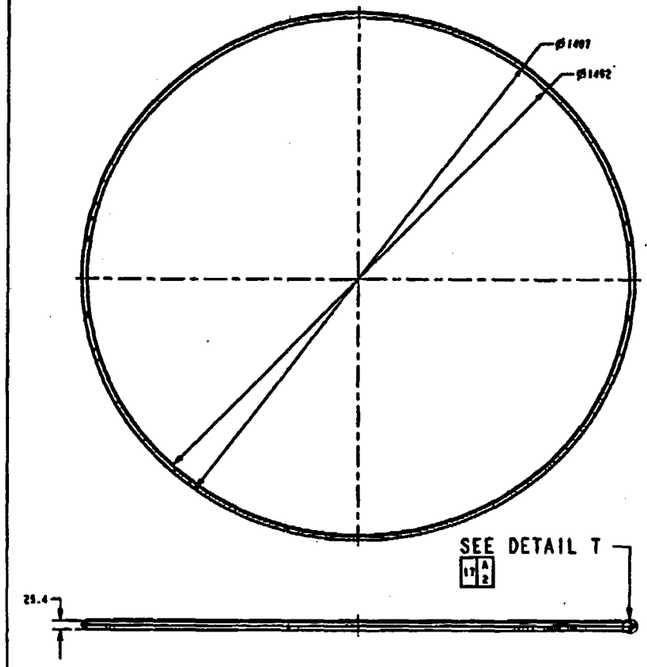
WASTE PACKAGE DEPARTMENT	
M&O Civilian Radioactive Waste Management System Management & Operating Contractor	
SECTION NUMBER SK-0219	REVISION 01
SCALE 0.125	SHEET 15 OF 25



ITEM 6
OUTER SHELL FLAT BOTTOM LID
SCALE 0.150
[3 D 2]

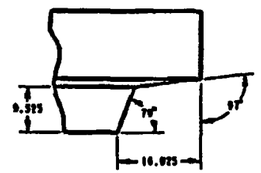


SECTION K-K
SCALE 0.125
[17 D 3]

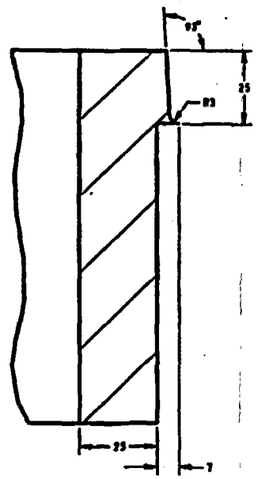


ITEM 8
EXTENDED OUTER SHELL LID BASE
SCALE 0.150
[3 D 2]

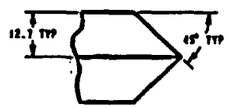
ITEM 7
EXTENDED OUTER SHELL LID
SCALE 0.125
[3 D 2]



DETAIL P
SCALE 2.000
[17 C 1]



DETAIL R
SCALE 1.250
[17 C 4]



DETAIL T
SCALE 1.500
[17 C 1]

WASTE PACKAGE DEPARTMENT	
M&O Civilian Radioactive Waste Management System MANAGEMENT & OPERATING CONTRACTOR	
SKETCH NUMBER SK-0219	REVISION 01
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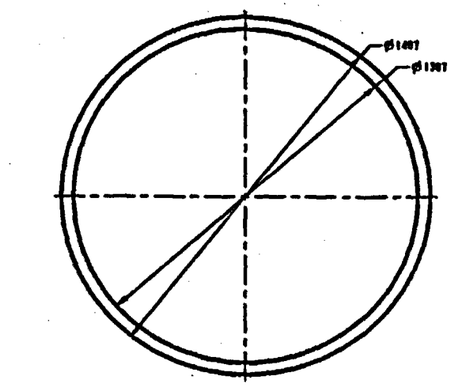

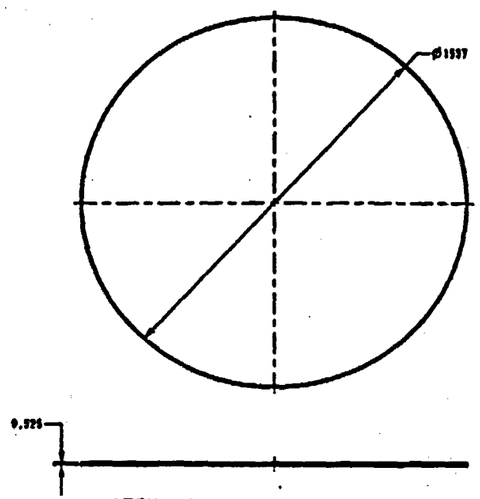

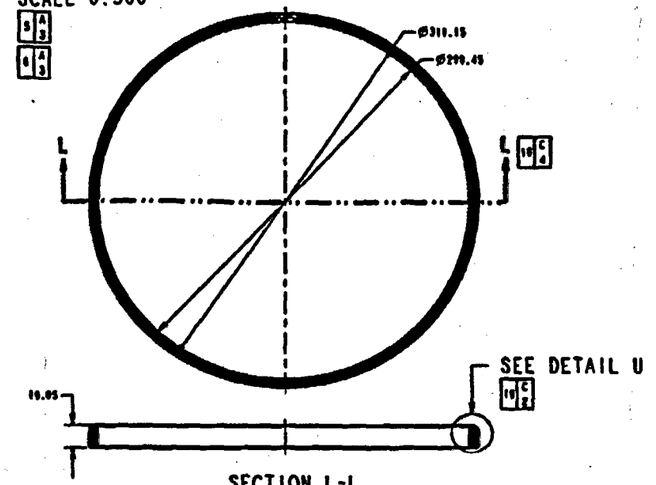

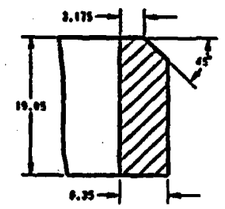

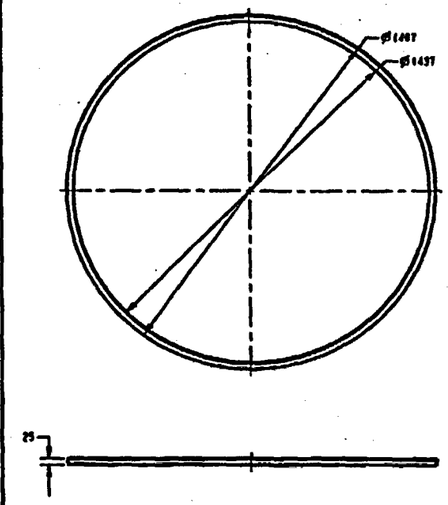

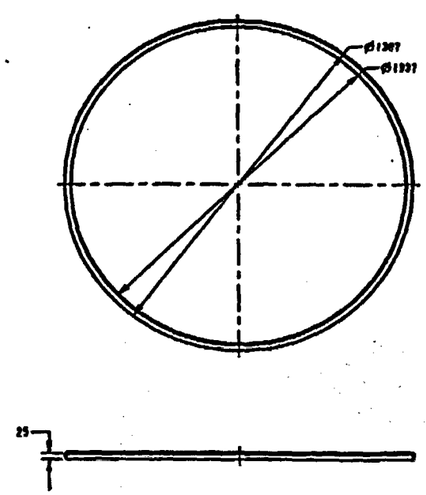

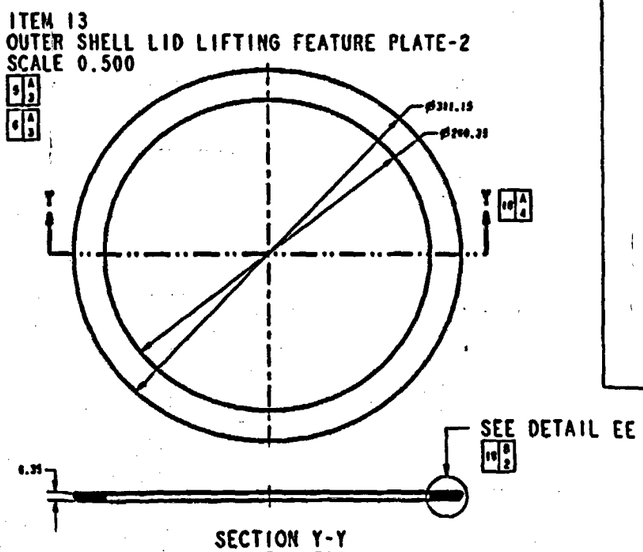

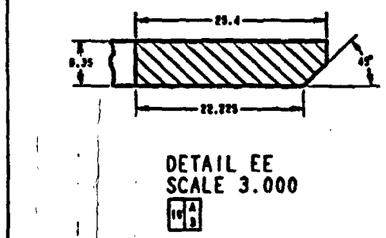

WASTE PACKAGE DEPARTMENT
M&O Civilian Radioactive Waste Management System Management & Operating Contractor

SKETCH NUMBER	REVISION
SK-0219	01
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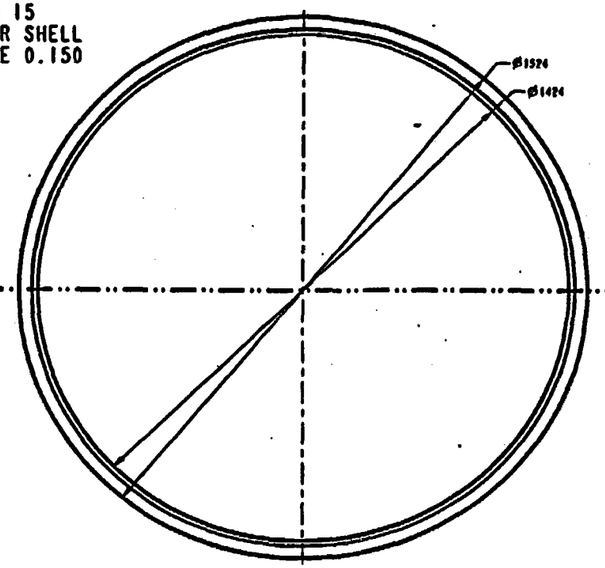
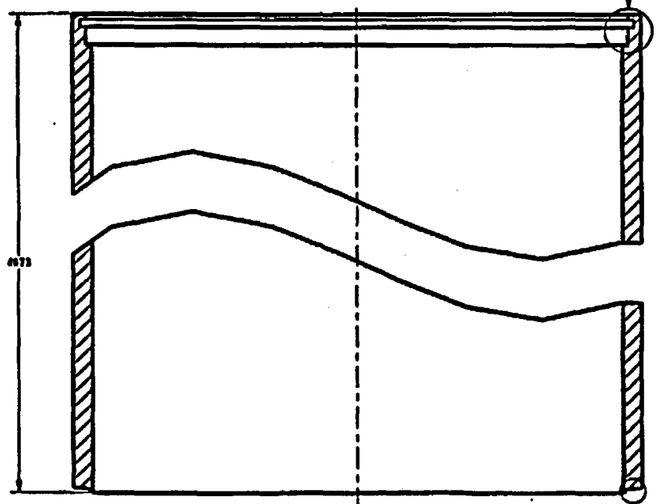
ITEM 15
INNER SHELL
SCALE 0.150

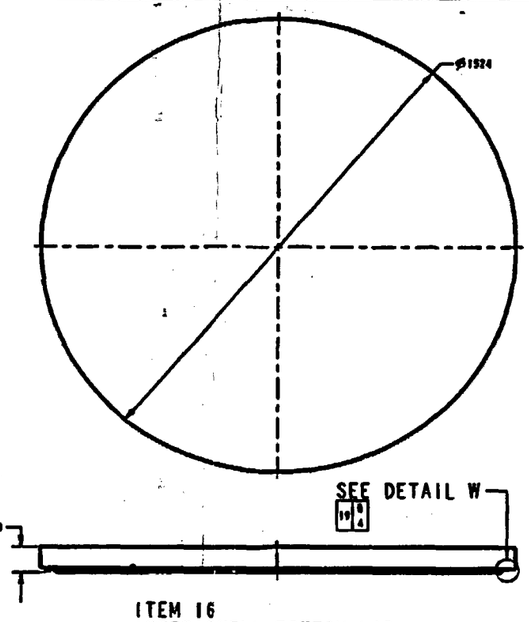


SEE DETAIL V

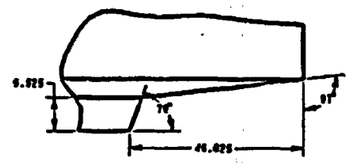


SECTION M-M
SCALE 0.150

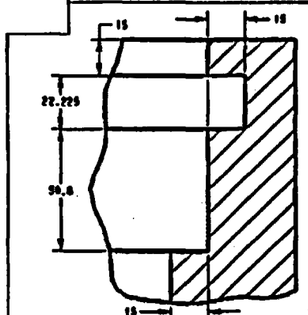
SEE DETAIL BB



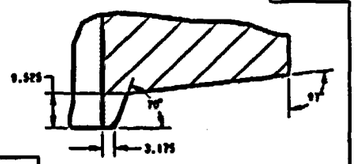
ITEM 16
INNER SHELL BOTTOM LID
SCALE 0.125



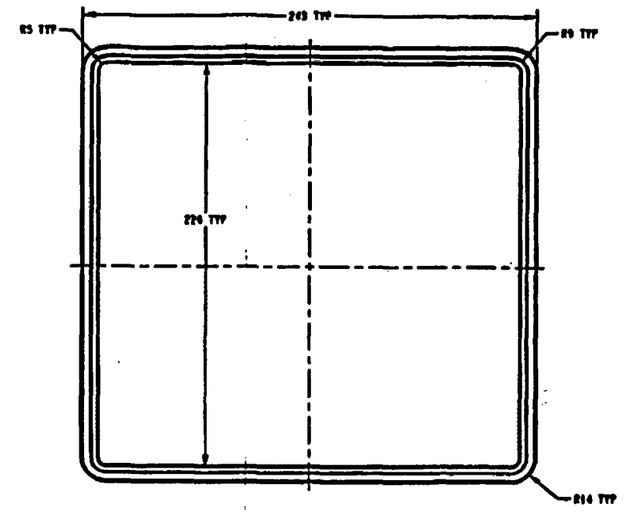
DETAIL W
SCALE 1.500

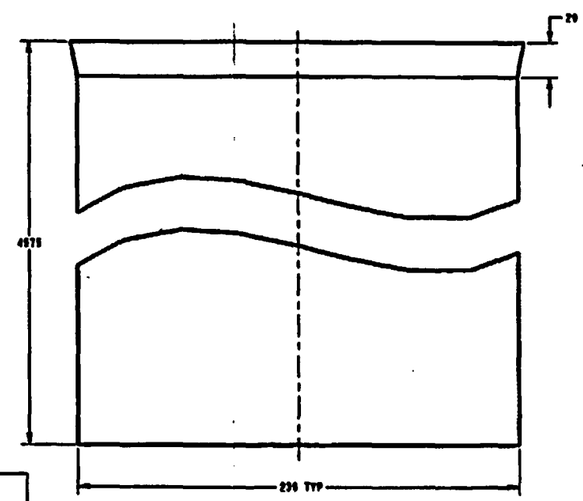


DETAIL V
SCALE 1.000



DETAIL BB
SCALE 1.500

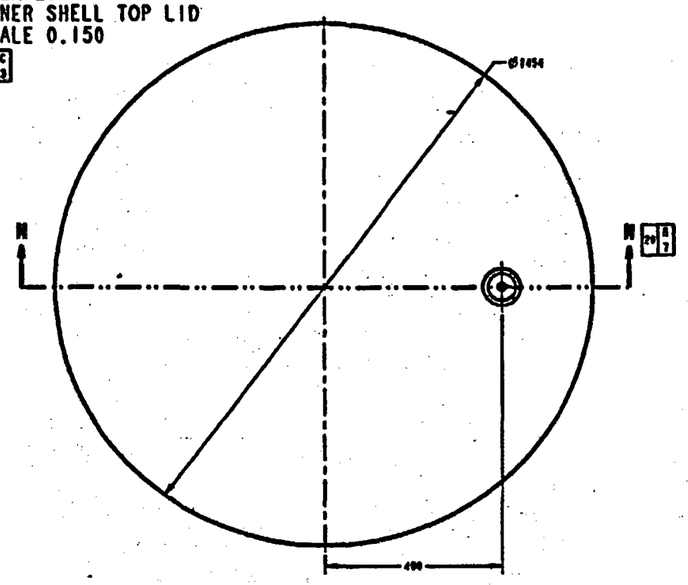


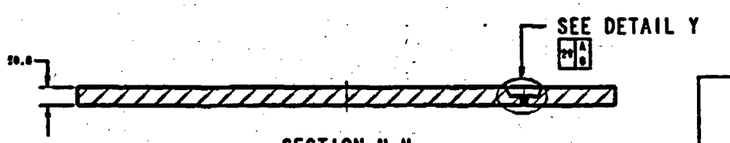


ITEM 17
FUEL BASKET TUBE
SCALE 0.750

WASTE PACKAGE DEPARTMENT	
M&O CRWMS Management & Operating Contractor	
SKETCH NUMBER: SK-0219	REVISION: 01
SCALE: 0.125	SHEET 19 OF 25

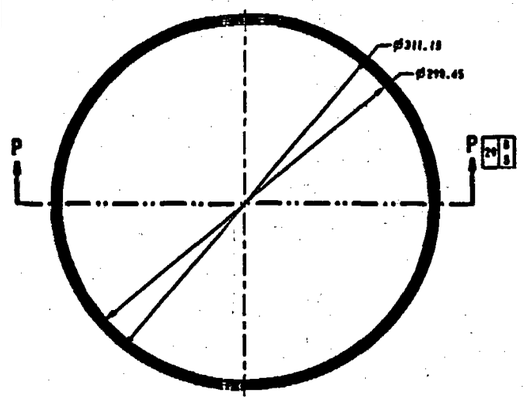
ITEM 20
INNER SHELL TOP LID
SCALE 0.150

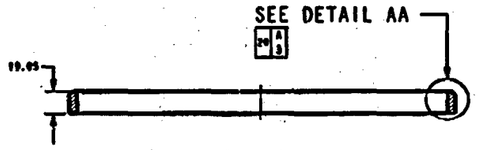




SECTION N-N
SCALE 0.150

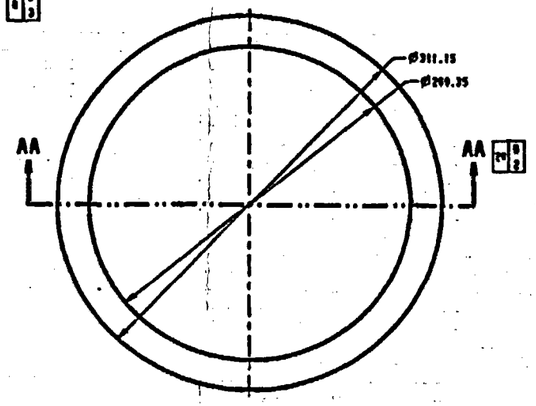
ITEM 21
INNER LID LIFTING FEATURE PLATE-1
SCALE 0.500

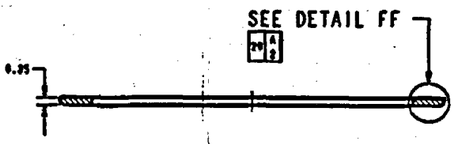




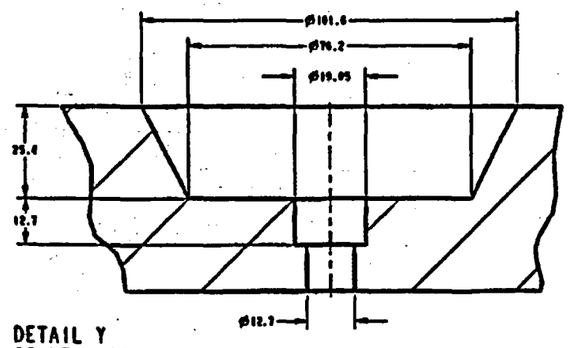
SECTION P-P
SCALE 0.500

ITEM 22
INNER LID LIFTING FEATURE PLATE-2
SCALE 0.500

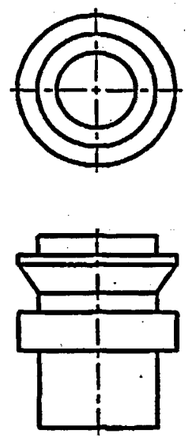




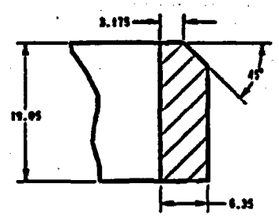
SECTION AA-AA
SCALE 0.500



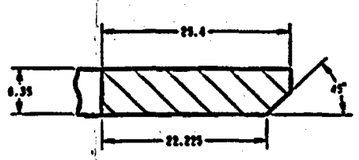
DETAIL Y
SCALE 1.500



ITEM 23
EVACUATION-BACKFILL QUICK RELEASE VALVE
SCALE 2.500



DETAIL AA
SCALE 3.000



DETAIL FF
SCALE 3.000

WASTE PACKAGE DEPARTMENT	
M&O Civilian Radioactive Waste Management System Management & Operating Contractor	
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SCALE 0.125	SHEET 20 OF 29

8 7 6 5 4 3 2 1

COMPONENT LIST

ITEM NUMBER	ASSEMBLY	SUBASSEMBLY	SUBASSEMBLY	SUBASSEMBLY	COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY REQD
-1	21-PWR WASTE PACKAGE ASSEMBLY	-	-	-	-	-	-	29333	1
		-	-	-	-	-	-	29357	1
-2	-	OUTER SHELL ASSEMBLY	-	-	-	-	-	5728	1
1	-	-	-	-	OUTER SHELL	SB-575 N06022	20	4194	1
2	-	-	-	-	UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	446	1
3	-	-	-	-	LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	436	1
4	-	-	-	-	SHELL INTERFACE RING	SA-240 S31600	30	88	1
5	-	-	-	-	INNER SHELL SUPPORT RING	SB-575 N06022	40	67	1
6	-	-	-	-	OUTER SHELL FLAT BOTTOM LID	SB-575 N06022	25.4	423	1
-3	-	EXTENDED OUTER SHELL LID ASSEMBLY	-	-	-	-	-	713	1
7	-	-	-	-	EXTENDED OUTER SHELL LID	SB-575 N06022	25	193	1
8	-	-	-	-	EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25.4	377	1
9	-	-	-	-	LARGE REINFORCEMENT RING	SB-575 N06022	50	98	1
10	-	-	-	-	SMALL REINFORCEMENT RING - TOP	SB-575 N06022	25	25	1
11	-	-	-	-	SMALL REINFORCEMENT RING - BOTTOM	SB-575 N06022	25	23	1
12	-	-	-	-	OUTER SHELL LID LIFTING FEATURE PLATE-1	SB-575 N06022	0.35	0.99	1
13	-	-	-	-	OUTER SHELL LID LIFTING FEATURE PLATE-2	SB-575 N06022	0.35	1.2	1
-4	-	OUTER SHELL FLAT CLOSURE LID ASSEMBLY	-	-	-	-	-	195	1
14	-	-	-	-	OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	9.525	154	1
15	-	-	-	-	OUTER SHELL LID LIFTING FEATURE PLATE-1	SB-575 N06022	0.35	0.99	1
16	-	-	-	-	OUTER SHELL LID LIFTING FEATURE PLATE-2	SB-575 N06022	0.35	1.2	1
-5	-	INNER SHELL ASSEMBLY	-	-	-	-	-	10725	1
	-	-	-	-	-	-	-	10749	1
15	-	-	-	-	INNER SHELL	SA-240 S31600	50	8554	1
16	-	-	-	-	INNER SHELL BOTTOM LID	SA-240 S31600	88.9	1274	1
17	-	-	-	-	FUEL BASKET TUBE	SA-516 K02700	5	104	21
18	-	-	-	-	SHEAR RING SECTION-1	SA-240 S31600	22.225	8.2	2
19	-	-	-	-	SHEAR RING SECTION-2	SA-240 S31600	22.225	7.8	1
-6	-	-	INNER SHELL TOP LID ASSEMBLY	-	-	-	-	675	1
20	-	-	-	-	INNER SHELL TOP LID	SA-240 S31600	50.8	672	1
21	-	-	-	-	INNER LID LIFTING FEATURE PLATE-1	SA-240 S31600	0.35	0.99	1
22	-	-	-	-	INNER LID LIFTING FEATURE PLATE-2	SA-240 S31600	0.35	1.1	1
23	-	-	-	-	EVACUATION-BACKFILL QUICK RELEASE VALVE	SA-240 S31600	12.7	0.86	1
24	-	-	-	-	EVACUATION-BACKFILL PORT COVER PLATE	SA-240 S31600	6.35	0.82	1
-7	-	-	END SIDEGUIDE ASSEMBLY	-	-	-	-	29	32
25	-	-	-	-	BASKET A-SIDEGUIDE	SA-516 K02700	10	27	32
26	-	-	-	-	BASKET A-STIFFENER	SA-516 K02700	10	0.72	96
-8	-	-	SIDEGUIDE ASSEMBLY	-	-	-	-	39	16
27	-	-	-	-	BASKET B-SIDEGUIDE	SA-516 K02700	10	36	16
28	-	-	-	-	BASKET B-STIFFENER	SA-516 K02700	10	1.5	32
-9	-	-	CORNERGUIDE ASSEMBLY	-	-	-	-	47	16
29	-	-	-	-	BASKET C-STIFFENER	SA-516 K02700	10	2.3	32
30	-	-	-	-	BASKET CORNERGUIDE	SA-516 K02700	10	42	16
-10	-	-	FUEL PLATE ASSEMBLY	-	-	-	-	999	4
	-	-	-	-	-	-	-	995	4
31	-	-	-	-	FUEL BASKET C-PLATE	NEUTRONIT A 978	7	64	16
	-	-	-	-		SA-516 K02700	7	65	16
-11	-	-	-	FUEL PLATE A-B ASSEMBLY	-	-	-	199	8
	-	-	-		-	-	-	197	8
32	-	-	-	-	FUEL BASKET A-PLATE	NEUTRONIT A 978	7	85	8
	-	-	-	-		SA-516 K02700	7	86	8
33	-	-	-	-	FUEL BASKET B-PLATE	SB-209 A96061 T6	5	21	8
-12	-	-	-	FUEL PLATE B-E ASSEMBLY	-	-	-	199	8
	-	-	-		-	-	-	197	8
34	-	-	-	-	FUEL BASKET B-PLATE	NEUTRONIT A 978	7	85	8
	-	-	-	-		SA-516 K02700	7	86	8
35	-	-	-	-	FUEL BASKET E-PLATE	SB-209 A96061 T6	5	21	8
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	TOTAL CARBON STEEL WELDS	SFA-5.18 K10726	-	34	-
-	-	-	-	-	TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	102	-
-	-	-	-	-	TOTAL 316 WELDS	SFA-5.9 S31600	-	41	-
-	-	-	-	-	-	-	-	-	-
-	-	-	PWR FUEL ASSEMBLY	-	-	-	-	773.4	21
-	21-PWR WP ASSEMBLY WITH SNF	-	-	-	-	-	-	41574	1
		-	-	-	-	-	-	41999	1

REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPROVED
D3-1	-	CONTINUED FROM SHEET 1	02/22/01	SMB
A4-6	01	34.9 WAS 37	02/22/01	SMB
A4-6	01	ADDED DETAIL CC CALLOUT	02/22/01	SMB
C6-7	01	ADDED SECTION W	02/22/01	SMB
D7-7	01	ADDED SECTION V	02/22/01	SMB
-	01	ADDED ITEM 10 IN ZONES C5-7, D7-13, C8-24, AND A4-22	02/22/01	SMB
-	01	ADDED ITEM 19 IN ZONES D4-7, C8-24, AND A2-22	02/22/01	SMB
C3-7	01	INNER SHELL ASSEMBLY PERSPECTIVE VIEW MODIFIED TO SHOW EXPLODED FUEL BASKET TUBES AND PLATE ASSEMBLY	02/22/01	SMB
-	01	ITEM 13 WAS ITEM 14 IN ZONES C2-7, C5-13, D3-13, D6-19, AND C8-24	02/22/01	SMB
-	01	ITEM 16 WAS ITEM 15 IN ZONES D1-7, C5-13, C5-19, AND C8-24	02/22/01	SMB
-	01	ITEM 17 WAS ITEM 19 IN ZONES C4-7, A2-19, AND C8-24	02/22/01	SMB
B8-7	01	4712 WAS 4112	02/22/01	SMB
-	01	88.9 WAS 90 IN ZONES A8-7, C5-10, AND C4-24	02/22/01	SMB
-	01	ITEM 20 WAS ITEM 17 IN ZONES C8-8, C1-12, B8-13, A4-12, B8-20, AND C8-24	02/22/01	SMB
A4-8	01	ADDED DETAIL BB TO SHOW CALLOUTS OF ITEM 21 AND ITEM 22	02/22/01	SMB
B7-8	01	ADDED DETAIL BB CALLOUT	02/22/01	SMB
A3-8	01	ADDED ITEM 20 CALLOUT	02/22/01	SMB
C2-12	01	ADDED ITEM 22	02/22/01	SMB
-	01	ITEM 23 WAS ITEM 19 IN ZONES A2-8, A4-12, A8-20, AND B8-24	02/22/01	SMB
-	01	ITEM 24 WAS ITEM 20 IN ZONES B2-8, B5-12, B2-21, AND B8-24	02/22/01	SMB
A8-8	01	76.2 WAS 77	02/22/01	SMB
B5-8	01	1454 WAS 1439	02/22/01	SMB
B8-8	01	ADDED SECTION R	02/22/01	SMB
-	01	DELETED 19 TYP 10 ZONES B5-8, C5-8, AND B5-8	02/22/01	SMB
-	01	ADDED 20 TYP 10 ZONES B5-8, C5-8, AND B5-8	02/22/01	SMB
-	01	ITEM 20 WAS ITEM 22 IN ZONES B7-8, A7-21, AND B8-24	02/22/01	SMB
-	01	ITEM 25 WAS ITEM 21 IN ZONES B6-8, C7-21, AND B8-24	02/22/01	SMB
-	01	ITEM 26 WAS ITEM 24 IN ZONES C7-8, B1-21, AND B8-24	02/22/01	SMB
-	01	ITEM 27 WAS ITEM 23 IN ZONES B7-21, C8-8, AND B8-24	02/22/01	SMB
C8-8	01	ADDED SECTION T	02/22/01	SMB
-	01	ITEM 30 WAS ITEM 26 IN ZONES B8-8, B3-22, AND B8-24	02/22/01	SMB
-	01	ITEM 29 WAS ITEM 25 IN ZONES B6-22, B7-8, AND B8-24	02/22/01	SMB
B8-8	01	ADDED SECTION U	02/22/01	SMB
-	01	ITEM 31 WAS ITEM 27 IN ZONES C4-19, A8-22, AND B8-24	02/22/01	SMB
-	01	ITEM 33 WAS ITEM 29 IN ZONES C4-11, C2-23, AND B8-24	02/22/01	SMB
-	01	ITEM 32 WAS ITEM 28 IN ZONES B2-11, C8-23, AND B8-24	02/22/01	SMB
-	01	ITEM 35 WAS ITEM 31 IN ZONES B4-11, B1-23, AND A8-24	02/22/01	SMB
-	01	ITEM 34 WAS ITEM 30 IN ZONES B2-11, A6-23, AND A8-24	02/22/01	SMB
-	01	0.35 WAS 12.7 IN ZONES B4-12 AND B2-12	02/22/01	SMB
B3-12	01	ADDED W5 IN 2 PLACES	02/22/01	SMB
B8-25	01	ADDED WELD 8	02/22/01	SMB
B3-12	01	ADDED W7 IN 2 PLACES	02/22/01	SMB
B4-12	01	ADDED W10	02/22/01	SMB
-	01	ADDED ITEM 13 CALLOUT IN ZONES B2-12 AND B5-12	02/22/01	SMB
C2-12	01	ITEM 21 WAS ITEM 18	02/22/01	SMB
C8-25	01	ADDED WELD 19	02/22/01	SMB
C4-12	01	W16 WAS W14	02/22/01	SMB
C8-25	01	WELD 18 WAS WELD 14	02/22/01	SMB
C4-12	01	0.35 WAS 12.7	02/22/01	SMB
C3-12	01	W17 WAS W13	02/22/01	SMB
C8-25	01	WELD 17 WAS WELD 13	02/22/01	SMB
C4-12	01	ADDED W17	02/22/01	SMB
B1-12	01	W21 WAS W16	02/22/01	SMB
C8-25	01	WELD 21 WAS WELD 16	02/22/01	SMB
A2-12	01	W20 WAS W15	02/22/01	SMB
C8-25	01	WELD 20 WAS WELD 15	02/22/01	SMB
C8-13	01	W19 WAS W9	02/22/01	SMB
C8-25	01	WELD 19 WAS WELD 9	02/22/01	SMB
C8-13	01	12.7 WAS 12.5 IN 3 PLACES	02/22/01	SMB
-	01	TYP WAS REMOVED FROM DIMENSIONS IN ZONES A3-13 AND B4-13	02/22/01	SMB
-	01	REFERENCE NOTE 1 CALLOUT WAS REMOVED IN ZONES A3-13 AND B4-13	02/22/01	SMB
C8-25	01	ADDED WELD 13 AND WELD 14	02/22/01	SMB
D3-25	-	CONTINUED ON SHEET 25	02/22/01	SMB

WASTE PACKAGE DEPARTMENT
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