

SEP 30 1998

21

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

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Station 15

2. To: (Receiving Organization) B & W Hanford Company	3. From: (Originating Organization) FDNW	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: PFP/Z-361	6. Design Authority/ Design Agent/Cog. Engr.: N/A HAN 91100 / K6218 10/383/A000 KN 10/5/98	7. Purchase Order No.: N/A
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11. Receiver Remarks:		10. System/Bldg./Facility: 241-Z-361 Tank
11A. Design Baseline Document? ☐ Yes ☒ No		12. Major Assm. Dwg. No.: N/A
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		14. Required Response Date: N/A

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1	HNF-3361		0	Tank Z-361 Dose Rate Calculation	N/A			

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(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
						1	/	Peer Reviewer	J. S. Len	9/29/98	B4-44
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		Cog. Eng.	R. F. Richard	9/29/98							
1	/	Cog. Mgr.	J. P. Estrellado	9/29/98							
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		Env.	N/A								

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TANK Z-361 DOSE RATE CALCULATIONS

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Abstract: Gamma ray and neutron dose rate determination above the 6-inch riser and off the side of settling tank Z-361.

TRADEMARKS:

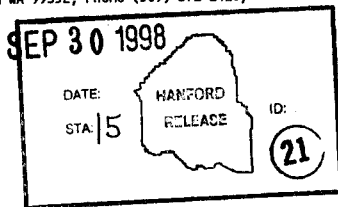
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TANK Z-361 DOSE RATE CALCULATIONS**1.0 INTRODUCTION AND SUMMARY**

Neutron and gamma ray dose rates were calculated above and around the 6-inch riser of tank Z-361 located at the Plutonium Finishing Plant. Dose rates were also determined off of one side of the tank. The largest dose rate 0.029 mrem/h was a gamma ray dose and occurred 76.2 cm (30 in.) directly above the open riser. All other dose rates were negligible.

2.0 RESULTS

The ANSI/ANS 1991 flux to dose conversion factor for neutrons and photons were used in this analysis (Reference 6). Dose rates are reported in units of mrem/h with the calculated uncertainty shown within the parentheses.

2.1 Gamma Ray Dose Rates above Tank

At 76.20 cm (30 in.) directly above the top of the uncovered 6 inch riser, over an area extending radially to the riser radius, the gamma ray dose rate is 0.029 mrem/h. At the same elevation but extending radially beyond the riser radius, the dose rate drops off by over a factor of 100. A 2.54 cm (1 in.) thick steel cap on the riser shields all gamma rays. The gamma ray dose rate 76.20 (30 in.) from the riser side is negligible. The calculational uncertainties are a few percent which indicate reliable results. All gamma ray dose rate results are shown in Table 2.1.

Table 2.1 Gamma Ray Dose Rates Above Tank (mrem/h)		
76.20 cm (30 in.) above top of 6 Inch Riser		
Dose area	uncovered	2.54 cm (1 in.) steel cover
Within radius of Riser	0.029 (0.0055)	6.3e-05 (0.0705)
Outside radius of riser	2.44e-04 (0.0087)	4.1e-06 (0.0295)
Height above ground	76.20 cm (30 in.) from side of riser	
0 to 25.4 cm	4.74e-06 (0.1013)	
25.4 to 50.8 cm	6.21e-06 (0.0601)	
50.8 to 76.2 cm	7.01e-06 (0.0696)	

2.2 Gamma Ray Dose Rates at Side of Tank

Gamma ray dose rates were calculated for regions off of a side of the tank. This calculation assumed air in place of the dirt outside the tank. The dose rates were calculated at the outside surface and 1 meter, 2 meters, and 3 meters from the side. Elevations relative to the waste in the tank were varied. The results are presented in Table 2.2.

Table 2.2 Gamma Ray Dose Rates off Tank Side (mrem/h)				
Location relative to tank waste	Surface	1 meter	2 meters	3 meters
centered	2.2e-03 (0.0199)	1.4e-03 (0.0129)	8.6e-04 (0.0154)	5.6e-04 (0.0185)
0 to 2 ft above top	9.5e-04 (0.0386)	9.2e-04 (0.0170)	7.3e-04 (0.0301)	5.3e-04 (0.0205)
6 to 8 ft above top	4.2e-04 (0.0655)	3.7e-04 (0.0349)	3.2e-04 (0.0329)	2.8e-04 (0.0332)

2.3 Neutron Dose Rates Above Tank

The neutron dose rates above and around the 6-inch riser are all very small. These dose rate are with the riser uncovered. Covering the riser would have no effect since 2.54 cm (1 in.) steel is essentially transparent to neutrons. The calculational uncertainties indicate reasonable results. The neutron dose rates are shown in Table 2.3.

Table 2.3 Neutron Dose Rates (mrem/h)	
76.20 cm (30 in.) above top of 6 Inch-Riser	1.5e-04 (0.0425)
Height above ground	76.20 cm (30 in.) from side of riser
0 to 25.4 cm	2.5e-04 (0.0408)
25.4 to 50.8 cm	2.2e-04 (0.0417)
50.8 to 76.2 cm	2.2e-04 (0.0709)

2.4 Neutron Dose Rates At Tank Side

Neutron dose rates were calculated for regions off a side of the tank. This calculation

assumed air in place of the dirt outside the tank. The dose rates were calculated at the outside surface and 1 meter, 2 meters, and 3 meters from the side. Elevations relative to the waste in the tank were varied. The results are presented in Table 2.4.

Table 2.4 Neutron Dose Rates off Tank Side (mrem/h)				
Location relative to tank waste	Surface	1 meter	2 meters	3 meters
centered	6.8e-03 (0.0167)	3.8e-03 (0.0193)	2.1e-03 (0.0245)	1.3e-03 (0.0355)
0 to 2 ft above top	3.1e-03 (0.0371)	2.6e-03 (0.0210)	1.7e-03 (0.0278)	1.2e-03 (0.0363)
6 to 8 ft above top	1.2e-03 (0.0683)	1.1e-03 (0.0607)	9.3e-04 (0.0769)	6.7e-04 (0.0471)

3.0 MODELING INPUTS

3.1 Geometry

The Z-361 settling tank is cubicle with inside width and length of 3.96 m (13 ft) x 7.92 m (26 ft), respectively. The tank has an inside height of 5.2 m (17 ft) at one end and 5.5 m (18 ft) at the other end. The sloped bottom runs along the 7.92 m (26 ft) length. The bottom, walls and top consist of 30.48 cm (12 in.) of concrete. Above the top of the tank is 60.96 cm (2 ft) of dirt. Dirt is also modeled below the tank and outside the walls.

A 6-inch riser extends out of the tank top to 76.2 cm (30 in.) above the ground. The riser is assumed to be a schedule 40 pipe with a 16.828 cm (6.625 in) outer diameter and a 0.711 cm (0.28 in.) wall thickness. The location of the riser was unclear from the information provided so it was centered along the 3.96 m (13 ft) width and slightly off center along the 7.92 m (26 ft) length.

The top of the sludge was modeled as being 2.9 m (9.5 ft) from the inside top of the tank, for an average depth of 2.44 m (8 ft).

Tank dimensions were obtained from References 1 and 2 and drawing no. H-2-16460 (Reference 7). Dimensions are shown in Figure 3.1 from Reference 2.

An MCNP (Reference 8) plot of the tank geometry is provided in Figure 3.2.

Figure 3.1 Settling Tank Z-361

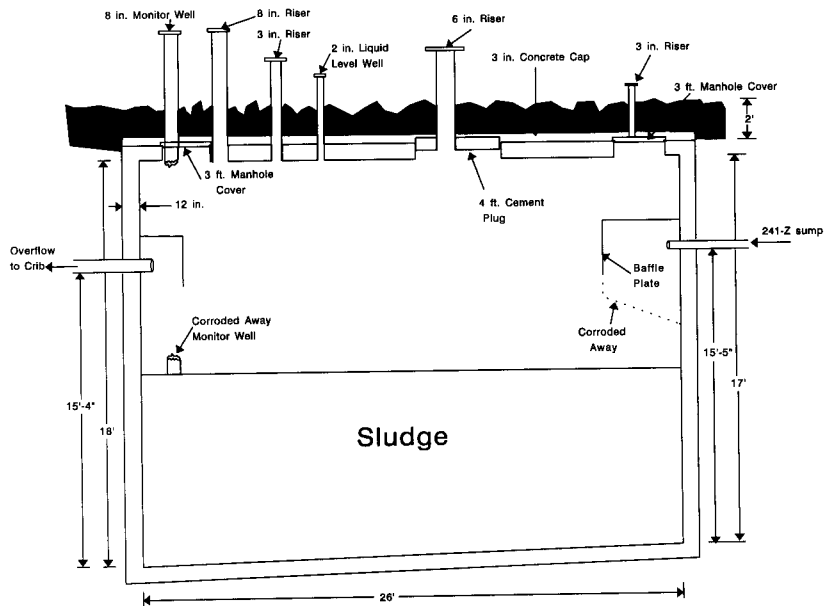
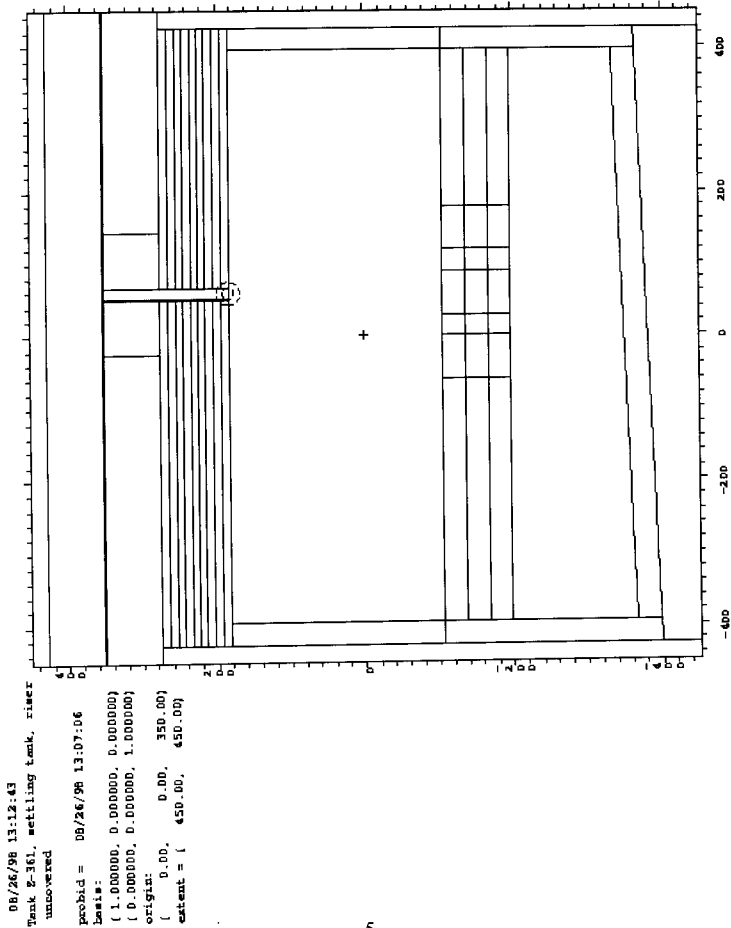


Figure 3.2 MCNP Plot of Settling Tank Z-361



3.2 Materials

The sludge material has a density of 1.14 g/cm³ for a total volume of 75,000 liters and contains 30 kg of plutonium. Sludge composition is from reference 1. Ordinary concrete was used for the tank top, bottom and sides at a density of 2.258 g/cm³. Hanford dirt has a density of 1.67 g/cm³. Material compositions as input into MCNP are given in Table 3.1. The table provides the material constituents in g/cm³ which were normalized by MCNP to the material density.

Element	source ^a	steel	concrete	dirt
aluminum	0.304	-	0.0607	0.08326
calcium	0.460	-	0.1306	0.0717
iron	0.5622	5.1009	0.0788	0.1091
sodium	0.0405	-	0.0182	0.02022
silicon	0.0104	0.0587	0.2157	0.2782
oxygen	0.200	-	0.4407	0.511
hydrogen	0.060	-	0.0031	-
carbon	0.0872	0.0023	-	-
chlorine	0.0342	-	-	-
fluorine	0.0039	-	-	-
chromium	-	1.566	-	-
nickel	-	0.9396	-	-
manganese	-	0.1566	-	0.001781
phosphorus	-	0.0035	0.0009	0.0024
magnesium	-	-	0.0376	0.03142
sulfur	-	0.0023	0.0009	-
krypton	-	-	0.0066	-
titanium	-	-	0.0049	0.01655
potassium	-	-	-	0.01155

a) source composition (sludge) is from reference 1.

difficult to achieve in this particular problem. This is due to the fact that the dose region of interest is located far from the source and the particles must pass through a small riser. As a result, particle sampling efficiency is poor. A powerful but demanding method called DXTRAN Sphere was used, under the guidance of Dr. Lee Carter, to overcome this difficulty and achieve credible results. The details of his sample model, review comments and directions throughout the task are included in Appendix B.

5.0 REFERENCES

1. *Engineering Study of the Criticality Issues Associated with Hanford Tank 241-Z-361*, HNF-2012, Rev. 0, E.J. Lipke, C.A. Rogers, E.M. Miller, Prepared by the PHMC Companies for the Department of Energy, December 1997.
2. *Consequence Analysis-Hydrogen Explosion in the Z-361 Settling Tank*, HNF-SD-CP-CN-004, Rev.0, B.W. Hall, Fluor Daniel Northwest, September 1997.
3. *Radiological Dose Assessment for Vault Storage Concepts*, HNF-SD-W460-ER-001, Rev. 0, R.F. Richard, Fluor Daniel Northwest, February 1997.
4. *Certification of MCNP Version 4A for WHC Computer Platforms*, L.L. Carter, WHC-MP-SD-30001, Rev. 5, Westinghouse Hanford Company, Richland Washington, May 1995.
5. *Conversion of ORIGEN2 to SUN Workstations*, F.A. Schmittroth, WHC-SD-NR-SWD-006, Westinghouse Hanford Company, Richland, Washington, September 1993.
6. American Nuclear Society, "Neutron and Gamma-ray Fluence-to-Dose Factors", ANSI/ANS-6.1.1-1991.
7. *Waste Disposal Facilities 241-Z-361 Settling Tank Arrgt. & Details*, Drawing No. H-2-16460.
8. Breisemeister, J. F., 1993, Editor, *MCNP - A General Monte Carlo N-Particle Transport Code, Version 4A*, LA-12625, Los Alamos National Laboratory, Los Alamos, New Mexico.

APPENDIX A
MCNP Input Files

This appendix contains the MCNP input files used to generate the dose rates reported in this document. Each input file is identified by name and the dose rates calculated are identified.

File name: ilpo361 - Used to calculate the gamma ray dose rates above and around the open riser.

Tank Z-361, settling tank, riser uncovered, ilpo361

c photon dose

```

1 1 -1.14 2 -5 4 -3 1 -28
2 4 -2.258 2 -5 -3 4 -1 7
3 4 -2.258 -2 8 -5 4 -6 7
4 4 -2.258 -9 3 -5 4 -6 7
5 4 -2.258 5 -10 8 -9 -6 7
6 4 -2.258 -4 11 8 -9 -6 7
7 4 -2.258 -2 8 -5 4 -12 6
8 4 -2.258 -9 3 -5 4 -12 6
9 4 -2.258 5 -10 8 -9 -12 6
10 4 -2.258 8 -9 11 -4 6 -12
11 2 -0.00129 -5 2 4 -3 6 -12
12 4 -2.258 8 -10 -9 11 14 34 -13
13 5 -1.67 -10 8 11 -9 39 -16 14
16 2 -0.00129 -15 12 -17
17 5 -1.67 20 -8 -10 11 22 -16
18 5 -1.67 -21 9 -10 11 22 -16
19 5 -1.67 20 10 -18 -21 -16 22
20 5 -1.67 20 -11 19 -21 -16 22
21 5 -1.67 -9 8 -10 11 -7 22
22 3 -7.86 15 -14 -17 12
23 2 -0.00129 14 -23 16 -17
24 2 -0.00129 -17 23 16 -18 20 19 -21
25 2 -0.00129 20 -18 -21 19 32 -24
26 2 -0.00129 20 -18 -21 19 24 -25
27 0 (((((18);(-19));(21 -18 19));(-18 19 -20 ))):
    (20 -18 -21 19 25 ));(20 -18 -21 19 -22 )
28 1 -1.14 -6 26 -40
29 1 -1.14 -26 27 -40
30 1 -1.14 -27 28 -40
31 1 -1.14 -6 26 40 -41

```

HNF-3361, Rev.0

```

32 1 -1.14 -26 27 40 -41
33 1 -1.14 -27 28 40 -41
34 1 -1.14 -6 26 41 -42
35 1 -1.14 -26 27 41 -42
36 1 -1.14 -27 28 41 -42
37 1 -1.14 2 -5 4 -3 -6 26 42
38 1 -1.14 2 -5 4 -3 -26 27 42
39 1 -1.14 2 -5 4 -3 -27 28 42
40 2 -0.00129 20 -18 -21 19 17 -32 14
41 2 -0.00129 17 -32 -14
42 4 -2.258 8 -10 -9 11 14 12 -33
43 4 -2.258 8 -10 -9 11 14 33 -34
44 5 -1.67 -10 8 11 -9 14 13 -35
45 5 -1.67 -10 8 11 -9 14 35 -36
46 5 -1.67 -10 8 11 -9 14 36 -37
47 5 -1.67 -10 8 11 -9 14 37 -38
48 5 -1.67 -10 8 11 -9 14 38 -39

```

1	p	-3.8460000e-02	0.0000000	0.9615400	0.0000000
2	px	-396.24000			
3	px	396.24000			
4	py	-198.12000			
5	py	198.12000			
6	pz	243.84000			
7	p	-3.8460000e-02	0.0000000	0.9615400	-30.480000
8	px	-426.72000			
9	px	426.74000			
10	py	228.60000			
11	py	-228.60000			
12	pz	533.40000			
13	pz	563.88000			
14	c/z	59.436000	0.0000000	8.4137500	
15	c/z	59.436000	0.0000000	7.7025500	
16	pz	624.84000			
17	pz	701.04000			
18	py	1752.6000			
19	py	-1752.6000			
20	px	-1950.7200			
21	px	1950.7200			
22	pz	-1600.0000			
23	c/z	59.436000	0.0000000	84.613750	

HNF-3361, Rev.0

24	pz	777.24000		
25	pz	2301.2400		
26	pz	213.36000		
27	pz	182.88000		
28	pz	152.40000		
32	pz	703.550		
33	pz	543.56		
34	pz	553.72		
35	pz	574.04		
36	pz	584.20		
37	pz	594.36		
38	pz	604.52		
39	pz	614.68		
40	c/z	59.436	0.000	30.00
41	c/z	59.436	0.000	60.00
42	c/z	59.436	0.000	120.00
50	pz	650.24		
51	pz	675.64		

mode p

m1 13000.01p -0.304 20000.01p -0.460 26000.01p -0.5622 \$source 1.14g/cc
 11000.01p -0.0405 14000.01p -0.0104 8000.01p -0.200
 1000.01p -0.060 6000.01p -0.0872 17000.01p -0.0342
 9000.01p -0.0039

m2 7000.01p 0.79000 8000.01p 0.21000 \$ air 0.00129 g/cc

m3 26000.01p -5.1009 24000.01p -1.566 28000.01p -0.9396 \$ steel 7.86 g/cc
 25000.01p -0.1566 14000.01p -0.0587 15000.01p -0.0035
 16000.01p -0.0023 6000.01p -0.0023

m4 1000.01p -0.0031 8000.01p -0.4407 11000.01p -0.0182 \$ concrete 2.258 g/cc
 12000.01p -0.0376 13000.01p -0.0607 14000.01p -0.2157
 15000.01p -0.0009 16000.01p -0.0009 36000.01p -0.0066
 20000.01p -0.1306 22000.01p -0.0049 26000.01p -0.0788

m5 8000.01p -0.511 14000.01p -0.2782 20000.01p -0.0717 \$ dirt 1.67 g/cc
 26000.01p -0.1091 13000.01p -0.08326 12000.01p -0.03142
 19000.01p -0.01155 11000.01p -0.02022 22000.01p -0.01655
 25000.01p -0.001781 15000.01p -0.0024

imp:p 0 9r 1 3r 0 0 1 1 0 1 4r 0 1 .25 .065 .25 .0625 .015625 .0625
 .015625 .00039063 0 0 0 1 8r \$ 1, 46

cut:p j j 0 0

c source

c source fraction of total sludge volume (76569 l total volume)

HNF-3361, Rev.0

c wgt = (2.926e+12 p/kg pu) x 30 kg pu x (4137/76569) = 4.743e+12

sdef wgt=4.743e+12 erg=d1 cel=d2 pos fcel d3 rad fcel d4 ext d5

axs 0 0 1

sc1 photo spectrum for 1 kg pu from HNF-SD-W460-ER-001

si1 sp1 sb1

	l	d	d
0.0150	1.409e+12	0.3	
0.0250	9.578e+10	5.0e-2	
0.0375	8.626e+09	8.6e-3	
0.0575	1.409e+12	1.409	
0.0850	1.306e+09	1.3e-2	
0.1250	1.492e+09	1.5e-1	
0.2250	3.656e+08	1.0e-1	
0.3750	1.839e+08	1.8e-1	
0.5750	3.078e+07	9.0e-2	
0.8500	9.134e+06	9.1e-2	
1.250	1.911e+05	6.0e-3	
1.750	8.269e+04	8.2e-3	
2.250	4.734e+04	1.4e-2	
2.750	2.718e+04	2.7e-2	
3.500	2.403e+04	7.0e-2	
5.000	1.012e+04	1.0e-1	
7.000	1.143e+03	5.0e-2	
11.00	1.300e+02	5.0e-2	

c 2.926e+12 p/s per kg pu

sc2 source cells

si2 1 28 29 30 31 32 33 34 35 36

sp2 86.18 86.18 86.18 258.54 258.54 258.54 1034.16 1034.16 1034.16

sb2 10 2.5 .625 7.5 1.875 .4688 7.5 1.875 .4688

ds3 1 59.436 0.0 228.60 59.436 0.0 198.12 59.436 0.0 167.64

59.436 0.0 228.60 59.436 0.0 198.12 59.436 0.0 167.64

59.436 0.0 228.60 59.436 0.0 198.12 59.436 0.0 167.64

ds4 s 41 41 41 42 42 42 43 43 43

si41 0. 30.

sp41 -21 1

si42 30. 60.

sp42 -21 1

si43 60. 120.

sp43 -21 1

si5 -15.24 15.24

sp5 -21 0

```

c
print 10 20 40 50 60 80 100 110 120 126 140 170
phys:p j 1 1
prmdp j -240 1
dxt:p 59.436 0 533.40 8.0 16.0
dxc:p 0 0r 1 0 0 12r 1 8r 0 4r 0 0 0 4r
ctme 30
c  ansi/ans-6.1.1-1991 AP fluence-to-dose,photons(mrem/hr)/(p/cm**2/s)
de0  log .01 .015 .02 .03 .04 .05
      .06 .08 .10 .15 .20 .30
      .40 .50 .60 .80 1.0 1.5
      2.0 3.0 4.0 5.0 6.0 8.0
      10. 12.
df0  log 2.232e-5 5.652e-5 8.568e-5 1.184e-4 1.314e-4 1.382e-4
      1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
      7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
      2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3
      8.892e-3 1.040e-2
fc2 surface tally 30 inches above top of riser
f2:p 24
fs2 -14 -23
sd2 222.397 22270 1
e2 0.1 0.3 0.6 1.3 2.3 3.0 4 5.1 7.1 12
fc12 surface tally 30 inches from side of riser
f12:p 23
fs12 -50 -51
sd12 13504 13504 13504
e12 0.1 0.3 0.6 1.3 2.3 3.0 4 5.1 7.1 12

```

File name: ilpc361 - Used to calculate the gamma ray dose rates above and around the closed riser.

Tank Z-361, settling tank, riser cap, ilpc361

c photon dose

```

1 1 -1.14 2 -5 4 -3 1 -28
2 4 -2.258 2 -5 -3 4 -1 7
3 4 -2.258 -2 8 -5 4 -6 7
4 4 -2.258 -9 3 -5 4 -6 7
5 4 -2.258 5 -10 8 -9 -6 7
6 4 -2.258 -4 11 8 -9 -6 7
7 4 -2.258 -2 8 -5 4 -12 6
8 4 -2.258 -9 3 -5 4 -12 6
9 4 -2.258 5 -10 8 -9 -12 6
10 4 -2.258 8 -9 11 -4 6 -12
11 2 -0.00129 -5 2 4 -3 6 -12
12 4 -2.258 8 -10 -9 11 14 34 -13
13 5 -1.67 -10 8 11 -9 39 -16 14
16 2 -0.00129 -15 12 -17
17 5 -1.67 20 -8 -10 11 22 -16
18 5 -1.67 -21 9 -10 11 22 -16
19 5 -1.67 20 10 -18 -21 -16 22
20 5 -1.67 20 -11 19 -21 -16 22
21 5 -1.67 -9 8 -10 11 -7 22
22 3 -7.86 15 -14 -17 12
23 2 -0.00129 14 -23 16 -17
24 2 -0.00129 -17 23 16 -18 20 19 -21
25 2 -0.00129 20 -18 -21 19 32 -24
26 2 -0.00129 20 -18 -21 19 24 -25
27 0 (((((18):-19)):(21-18 19)):(-18 19 -20 )):
    (20 -18 -21 19 25 )):(20 -18 -21 19 -22 )
28 1 -1.14 -6 26 -40
29 1 -1.14 -26 27 -40
30 1 -1.14 -27 28 -40
31 1 -1.14 -6 26 40 -41
32 1 -1.14 -26 27 40 -41
33 1 -1.14 -27 28 40 -41
34 1 -1.14 -6 26 41 -42
35 1 -1.14 -26 27 41 -42
36 1 -1.14 -27 28 41 -42
37 1 -1.14 2 -5 4 -3 -6 26 42

```

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```

38 1 -1.14 2 -5 4 -3 -26 27 42
39 1 -1.14 2 -5 4 -3 -27 28 42
40 2 -0.00129 20 -18 -21 19 17 -32 14
41 3 -7.86 17 -32 -14
42 4 -2.258 8 -10 -9 11 14 12 -33
43 4 -2.258 8 -10 -9 11 14 33 -34
44 5 -1.67 -10 8 11 -9 14 13 -35
45 5 -1.67 -10 8 11 -9 14 35 -36
46 5 -1.67 -10 8 11 -9 14 36 -37
47 5 -1.67 -10 8 11 -9 14 37 -38
48 5 -1.67 -10 8 11 -9 14 38 -39

```

1	p	-3.8460000e-02	0.0000000	0.9615400	0.0000000
2	px	-396.24000			
3	px	396.24000			
4	py	-198.12000			
5	py	198.12000			
6	pz	243.84000			
7	p	-3.8460000e-02	0.0000000	0.9615400	-30.480000
8	px	-426.72000			
9	px	426.74000			
10	py	228.60000			
11	py	-228.60000			
12	pz	533.40000			
13	pz	563.88000			
14	c/z	59.436000	0.0000000	8.4137500	
15	c/z	59.436000	0.0000000	7.7025500	
16	pz	624.84000			
17	pz	701.04000			
18	py	1752.6000			
19	py	-1752.6000			
20	px	-1950.7200			
21	px	1950.7200			
22	pz	-1600.0000			
23	c/z	59.436000	0.0000000	84.613750	
24	pz	777.24000			
25	pz	2301.2400			
26	pz	213.36000			
27	pz	182.88000			
28	pz	152.40000			
32	pz	703.550			

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33	pz	543.56		
34	pz	553.72		
35	pz	574.04		
36	pz	584.20		
37	pz	594.36		
38	pz	604.52		
39	pz	614.68		
40	c/z	59.436	0.000	30.00
41	c/z	59.436	0.000	60.00
42	c/z	59.436	0.000	120.00
50	pz	650.24		
51	pz	675.64		

mode p

m1 13000.01p -0.304 20000.01p -0.460 26000.01p -0.5622 \$source 1.14g/cc
 11000.01p -0.0405 14000.01p -0.0104 8000.01p -0.200
 1000.01p -0.060 6000.01p -0.0872 17000.01p -0.0342
 9000.01p -0.0039

m2 7000.01p 0.79000 8000.01p 0.21000 \$ air 0.00129 g/cc

m3 26000.01p -5.1009 24000.01p -1.566 28000.01p -0.9396 \$ steel 7.86 g/cc
 25000.01p -0.1566 14000.01p -0.0587 15000.01p -0.0035
 16000.01p -0.0023 6000.01p -0.0023

m4 1000.01p -0.0031 8000.01p -0.4407 11000.01p -0.0182 \$ concrete 2.258 g/cc
 12000.01p -0.0376 13000.01p -0.0607 14000.01p -0.2157
 15000.01p -0.0009 16000.01p -0.0009 36000.01p -0.0066
 20000.01p -0.1306 22000.01p -0.0049 26000.01p -0.0788

m5 8000.01p -0.511 14000.01p -0.2782 20000.01p -0.0717 \$ dirt 1.67 g/cc
 26000.01p -0.1091 13000.01p -0.08326 12000.01p -0.03142
 19000.01p -0.01155 11000.01p -0.02022 22000.01p -0.01655
 25000.01p -0.001781 15000.01p -0.0024

imp:p 0 9r 1 3r 0 0 1 1 0 1 4r 0 1 .25 .065 .25 .0625 .015625 .0625
 .015625 .00039063 0 0 0 1 8r \$ 1,46

cut:p j j 0 0

c source

c source fraction of total sludge volume (76569 l total volume)

c wgt = (2.926e+12 p/kg pu) x 30 kg pu x (4137/76569) = 4.743e+12

sdef wgt=4.743e+12 erg=d1 cel=d2 pos fcel d3 rad fcel d4 ext d5

axs 0 0 1

sc1 photo spectrum for 1 kg pu from HNF-SD-W460-ER-001

#	sil	sp1	sb1
	l	d	d

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```

0.0150 1.409e+12 0.3
0.0250 9.578e+10 5.0e-2
0.0375 8.626e+09 8.6e-3
0.0575 1.409e+12 1.409
0.0850 1.306e+09 1.3e-2
0.1250 1.492e+09 1.5e-1
0.2250 3.656e+08 1.0e-1
0.3750 1.839e+08 1.8e-1
0.5750 3.078e+07 9.0e-2
0.8500 9.134e+06 9.1e-2
1.250 1.911e+05 6.0e-3
1.750 8.269e+04 8.2e-3
2.250 4.734e+04 1.4e-2
2.750 2.718e+04 2.7e-2
3.500 2.403e+04 7.0e-2
5.000 1.012e+04 1.0e-1
7.000 1.143e+03 5.0e-2
11.00 1.300e+02 5.0e-2
c 2.926e+12 p/s per kg pu
sc2 source cells
si2 1 28 29 30 31 32 33 34 35 36
sp2 86.18 86.18 86.18 258.54 258.54 258.54 1034.16 1034.16 1034.16
sb2 10 2.5 .625 7.5 1.875 .4688 7.5 1.875 .4688
ds3 1 59.436 0.0 228.60 59.436 0.0 198.12 59.436 0.0 167.64
    59.436 0.0 228.60 59.436 0.0 198.12 59.436 0.0 167.64
    59.436 0.0 228.60 59.436 0.0 198.12 59.436 0.0 167.64
ds4 s 41 41 41 42 42 42 43 43 43
si41 0. 30.
sp41 -21 1
si42 30. 60.
sp42 -21 1
si43 60. 120.
sp43 -21 1
si5 -15.24 15.24
sp5 -21 0
c
print 10 20 40 50 60 80 100 110 120 126 140 170
phys:p j 1 1
prdm p j -240 1
dxt:p 59.436 0 533.40 8.0 16.0
dxc:p 0 9r 1 0 0 12r 1 8r 0 4r 0 0 0 4r

```

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```

ctme 1200
c  ansi/ans-6.1.1-1991 AP fluence-to-dose,photons(mrem/hr)/(p/cm**2/s)
de0  log .01 .015 .02 .03 .04 .05
      .06 .08 .10 .15 .20 .30
      .40 .50 .60 .80 1.0 1.5
      2.0 3.0 4.0 5.0 6.0 8.0
      10. 12.
df0  log 2.232e-5 5.652e-5 8.568e-5 1.184e-4 1.314e-4 1.382e-4
      1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
      7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
      2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3
      8.892e-3 1.040e-2
fc2  surface tally 30 inches above top of riser
f2:p 24
fs2 -14 -23
sd2 222.397 22270 1
e2 0.1 0.3 0.6 1.3 2.3 3.0 4 5.1 7.1 12
fc12 surface tally 30 inches from side of riser
f12:p 23
fs12 -50 -51
sd12 13504 13504 13504
e12 0.1 0.3 0.6 1.3 2.3 3.0 4 5.1 7.1 12

```

File name: no361b - Used to calculate the neutron dose rate above and around the open riser.

Tank Z-361, settling tank, riser uncovered, no361b

c include extra cells for importances and dxtran

c neutron dose

```

1 1 -1.14 2 -5 4 -3 1 -31
2 4 -2.258 2 -5 -3 4 -1 7
3 4 -2.258 -2 8 -5 4 -6 7
4 4 -2.258 -9 3 -5 4 -6 7
5 4 -2.258 5 -10 8 -9 -6 7
6 4 -2.258 -4 11 8 -9 -6 7
7 4 -2.258 -2 8 -5 4 -12 6
8 4 -2.258 -9 3 -5 4 -12 6
9 4 -2.258 5 -10 8 -9 -12 6
10 4 -2.258 8 -9 11 -4 6 -12
11 2 -0.00129 -5 2 4 -3 6 -12
12 4 -2.258 8 -10 -9 11 12 -13 110 $ roof beyond r=120
13 5 -1.67 -10 8 11 -9 13 -16 110 $ roof beyond r=120
16 2 -0.00129 -15 12 -17
17 5 -1.67 20 -8 -10 11 22 -16
18 5 -1.67 -21 9 -10 11 22 -16
19 5 -1.67 20 10 -18 -21 -16 22
20 5 -1.67 20 -11 19 -21 -16 22
21 5 -1.67 -9 8 -10 11 -7 22
22 3 -7.86 15 -14 -17 12
23 2 -0.00129 14 -23 16 -17
24 2 -0.00129 -17 23 16 -18 20 19 -21
25 2 -0.00129 20 -18 -21 19 17 -24
26 2 -0.00129 20 -18 -21 19 24 -25
27 0 (((((18):(-19));(21 -18 19));(-18 19 -20));
(20 -18 -21 19 25));(20 -18 -21 19 -22 ))
28 1 -1.14 -6 26 -5 2 -3 4 121
29 1 -1.14 -26 27 -5 2 -3 4 121
30 1 -1.14 -27 28 -5 2 -3 4 121
31 1 -1.14 -28 29 -5 2 -3 4
32 1 -1.14 -29 30 -5 2 -3 4
33 1 -1.14 -30 31 -5 2 -3 4
c additional cells in roof for radius out to 120 cm around riser
101 4 -2.258 8 -10 -9 11 12 -111 14 -110
102 4 -2.258 8 -10 -9 11 111 -13 14 -110
103 5 -1.67 8 -10 -9 11 13 -112 14 -110

```

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104	5	-1.67	8	-10	-9	11	112	-16	14	-110
c	additional cells in top part of source below riser									
111	1	-1.14	-121	26	-6					
112	1	-1.14	-121	27	-26					
113	1	-1.14	-121	28	-27					
1	p	-3.8460000e-02		0.0000000		0.9615400		0.0000000		
2	px	-396.24000								
3	px	396.24000								
4	py	-198.12000								
5	py	198.12000								
6	pz	243.84000								
7	p	-3.8460000e-02		0.0000000		0.9615400		-30.480000		
8	px	-426.72000								
9	px	426.74000								
10	py	228.60000								
11	py	-228.60000								
12	pz	533.40000								
13	pz	563.88000								
14	c/z	59.436000		0.0000000		8.4137500				
15	c/z	59.436000		0.0000000		7.7025500				
16	pz	624.84000								
17	pz	701.04000								
18	py	1752.6000								
19	py	-1752.6000								
20	px	-1950.7200								
21	px	1950.7200								
22	pz	-1600.0000								
23	c/z	59.436000		0.0000000		84.613750				
24	pz	777.24000								
25	pz	2301.2400								
26	pz	213.36000								
27	pz	182.88000								
28	pz	152.40000								
29	pz	121.92000								
30	pz	91.440000								
31	pz	60.960000								
50	pz	650.24								
51	pz	675.64								
110	c/z	59.436		0.000		120.0	\$ beyond riser			
111	pz	548.64	\$ to divide concrete in top							

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112 pz 594.36 \$ to divide soil in top
121 c/z 59.436 0.000 56.0 \$ inner source

mode n

m1 13027.50c -0.304 20000.50c -0.460 26000.55c -0.5622 \$source 1.14g/cc
11023.50c -0.0405 14000.50c -0.0104 8016.50c -0.200
1001.50c -0.060 6000.50c -0.0872 17000.50c -0.0342
9019.50c -0.0039

m2 7014.50c 0.79000 8016.50c 0.21000 \$ air 0.00129 g/cc
m3 26000.55c -5.1009 24000.50c -1.566 28000.50c -0.9396 \$ steel 7.86 g/cc
25055.50c -0.1566 14000.50c -0.0587 15031.50c -0.0035
16032.50c -0.0023 6000.50c -0.0023

m4 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0182 \$ concrete 2.258 g/cc
12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157
15031.50c -0.0009 16032.50c -0.0009 36084.50c -0.0066
20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788
m5 8016.50c -0.511 14000.50c -0.2782 20000.50c -0.0717 \$ dirt 1.67 g/cc
26000.55c -0.1091 13027.50c -0.08326 12000.50c -0.03142
19000.50c -0.01155 11023.50c -0.02022 22000.50c -0.01655
25055.50c -0.001781 15031.50c -0.0024

imp:n .01 0 4r 10 3r 160 80 640 \$ to 13
5120 0 4r 10240 20480 5120 2560 0 \$ to 27
10 2.5 .625 .15625 .0391 .0391 \$ to 33
320 1280 5120 20480 160 20 2.5

c source

c wgt = (3.747e+05 n/kg pu) x 30 kg pu x (57427/76569)= 8.431e+06
sdef wgt=8.431e+06 erg=d1 cel=d2 pos=0 0 0 x fcel d3 y fcel d4 z fcel d5
sc1 spontaneous fission source spectrum (pu240)
sp1 -3 0.799 4.903
sc2 source cells
si2 1 28 29 30 31 32 33 111 112 113
sp2 0.968625 2r 1 1 1 0.031375 2r
sb2 10 2.5 .625 .15625 .0391 .0391 5.02 0.6275 0.0784375
ds3 s 31 31 31 31 31 31 31 32 32 32
si31 -396.24 396.24
sp31 0 1
si32 3.436 115.436
sp32 0 1
ds4 s 41 41 41 41 41 41 42 42 42
si41 -198.12 198.12
sp41 0 1

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```

si42 -56.0 56.0
sp42 0 1
ds5 s 51 52 53 54 55 56 51 52 53
si51 213.36 243.84
sp51 0 1
si52 182.88 213.36
sp52 0 1
si53 152.40 182.88
sp53 0 1
si54 121.92 152.40
sp54 0 1
si55 91.44 121.92
sp55 0 1
si56 60.96 91.44
sp56 0 1
c
print 10 40 60 80 100 110 126
cut:n j j 0 0 $ analog capture
prdm p j -240 1
dxt:n 59.436 0 533.40 7.70 10.0
dxcl:n 0 0 4r .03 3r .125 0 0 $ 13
      0 0 4r 0 5r $ 27
      .125 .06 .03 .015 2r $ 33
      0 3r .5 .125 .06
ctme 1080
c ansi/ans-6.1.1-1991 AP fluence-to-dose,neutrons(mrem/hr/(n/cm**2/s)
de0 log 2.5e-08 1.0e-07 1.0e-06 1.0e-05 1.0e-04
      .001 .01 .02 .05 .10
      .20 .50 1.0 1.5 2.0
      3.0 4.0 5.0 6.0 7.0
      8.0 10.0 14.0
df0 log 1.440-3 1.584-3 1.735-3 1.606-3 1.490-3
      1.379-3 1.631-3 2.113-3 3.924-3 7.128-3
      .01390 .03132 .05148 .06588 .07704
      .09504 .1080 .1177 .1249 .1314
      .1368 .1476 .1728
fc2 surface tally 30 inches above top of riser
f2:n 24
fs2 -14 -23
sd2 222.397 22270 1
fc12 surface tally 30 inches from side of riser

```

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f12:n 23

fs12 -50 -51

sd12 13504 13504 13504

File name: ilps36a - Used to calculate the gamma ray dose rate off of the tank side.

Tank Z-361, settling tank, riser uncovered, ilps36a

c photon dose at side of tank, point detectors

```

1 1 -1.14 2 -5 4 -3 1 -28
2 4 -2.258 2 -5 -3 4 -1 7
3 4 -2.258 -2 62 -5 4 -6 7
4 4 -2.258 -9 3 -5 4 -6 7
5 4 -2.258 5 -10 8 -9 -6 7
6 4 -2.258 -4 11 8 -9 -6 7
7 4 -2.258 -2 60 -5 4 -12 6
8 4 -2.258 -9 3 -5 4 -12 6
9 4 -2.258 5 -10 8 -9 -12 6
10 4 -2.258 8 -9 11 -4 6 -12
11 2 -0.00129 -5 2 4 -3 6 -12
12 4 -2.258 8 -10 -9 11 14 34 -13
13 5 -1.67 -10 8 11 -9 39 -16 14
16 2 -0.00129 -15 12 -17
17 2 -0.00129 20 -57 -10 11 22 -16
18 5 -1.67 -21 9 -10 11 22 -16
19 5 -1.67 20 10 -18 -21 -16 22
20 5 -1.67 20 -11 19 -21 -16 22
21 5 -1.67 -9 8 -10 11 -7 22
22 3 -7.86 15 -14 -17 12
23 2 -0.00129 14 -23 16 -17
24 2 -0.00129 -17 23 16 -18 20 19 -21
25 2 -0.00129 20 -18 -21 19 32 -24
26 2 -0.00129 20 -18 -21 19 24 -25
27 0 (((((18):(-19)):(21 -18 19)):(-18 19 -20))):
    (20 -18 -21 19 25)):(20 -18 -21 19 -22 )
37 1 -1.14 47 -5 4 -3 -6 91 $ top 6" of source
38 1 -1.14 47 -5 4 -3 -91 92 $ next 12" of source
39 1 -1.14 47 -5 4 -3 -92 28
40 2 -0.00129 20 -18 -21 19 17 -32 14
41 2 -0.00129 17 -32 -14
42 4 -2.258 8 -10 -9 11 14 12 -33
43 4 -2.258 8 -10 -9 11 14 33 -34
44 5 -1.67 -10 8 11 -9 14 13 -35
45 5 -1.67 -10 8 11 -9 14 35 -36
46 5 -1.67 -10 8 11 -9 14 36 -37
47 5 -1.67 -10 8 11 -9 14 37 -38

```

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```

48 5 -1.67 -10 8 11 -9 14 38 -39
51 1 -1.14 2 -45 4 -5 -6 26
52 1 -1.14 2 -45 4 -5 -26 27
53 1 -1.14 2 -45 4 -5 -27 28
54 1 -1.14 45 -46 4 -5 -6 26
55 1 -1.14 45 -46 4 -5 -26 27
56 1 -1.14 45 -46 4 -5 -27 28
57 1 -1.14 46 -47 4 -5 -6 26
58 1 -1.14 46 -47 4 -5 -26 27
59 1 -1.14 46 -47 4 -5 -27 28
61 2 -0.00129 55 -8 -10 11 22 -16
62 2 -0.00129 56 -55 -10 11 22 -16
63 2 -0.00129 57 -56 -10 11 22 -16
65 4 -2.258 -60 63 -5 4 -6 7
66 4 -2.258 -61 64 -5 4 -6 7
67 4 -2.258 -60 61 -5 4 -12 6
68 4 -2.258 -61 8 -5 4 -12 6
70 4 -2.258 -62 60 -5 4 -6 7
71 4 -2.258 -63 61 -5 4 -6 7
72 4 -2.258 -64 8 -5 4 -6 7

```

```

1      p -3.8460000e-02   0.0000000   0.9615400   0.0000000
2      px  -396.24000
3      px   396.24000
4      py  -198.12000
5      py   198.12000
6      pz   243.84000
7      p -3.8460000e-02   0.0000000   0.9615400  -30.480000
8      px  -426.72000
9      px   426.74000
10     py   228.60000
11     py  -228.60000
12     pz   533.40000
13     pz   563.88000
14     c/z  59.436000   0.0000000   8.4137500
15     c/z  59.436000   0.0000000   7.7025500
16     pz   624.84000
17     pz   701.04000
18     py   1752.6000
19     py  -1752.6000
20     px  -1950.7200

```

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21	px	1950.7200		
22	pz	-1600.0000		
23	c/z	59.436000	0.0000000	84.613750
24	pz	777.24000		
25	pz	2301.2400		
26	pz	182.88000		
27	pz	121.92000		
28	pz	60.960000		
32	pz	703.550		
33	pz	543.56		
34	pz	553.72		
35	pz	574.04		
36	pz	584.20		
37	pz	594.36		
38	pz	604.52		
39	pz	614.68		
40	c/z	59.436	0.000	30.00
41	c/z	59.436	0.000	60.00
42	c/z	59.436	0.000	120.00
45	px	-365.76		
46	px	-335.28		
47	px	-304.80		
50	pz	650.24		
51	pz	675.64		
55	px	-526.72		
56	px	-626.72		
57	px	-726.72		
60	px	-406.40		
61	px	-416.56		
62	px	-401.32		
63	px	-411.48		
64	px	-421.64		
c tally segment surfaces				
70	py	30.48		
71	py	91.44		
72	py	152.40		
73	py	-30.48		
74	py	-91.44		
75	py	-152.40		
76	pz	304.80		
77	pz	365.76		

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```

78 pz 426.72
79 pz 487.68
80 pz 0.0
91 pz 228.60 $ 6" below top of source
92 pz 198.12 $ 18" below top of source

mode p
m1 13000.01p -0.304 20000.01p -0.460 26000.01p -0.5622 $source 1.14g/cc
    11000.01p -0.0405 14000.01p -0.0104 8000.01p -0.200
    1000.01p -0.060 6000.01p -0.0872 17000.01p -0.0342
    9000.01p -0.0039
m2 7000.01p 0.79000 8000.01p 0.21000 $ air 0.00129 g/cc
m3 26000.01p -5.1009 24000.01p -1.566 28000.01p -0.9396 $ steel 7.86 g/cc
    25000.01p -0.1566 14000.01p -0.0587 15000.01p -0.0035
    16000.01p -0.0023 6000.01p -0.0023
m4 1000.01p -0.0031 8000.01p -0.4407 11000.01p -0.0182 $ concrete 2.258 g/cc
    12000.01p -0.0376 13000.01p -0.0607 14000.01p -0.2157
    15000.01p -0.0009 16000.01p -0.0009 36000.01p -0.0066
    20000.01p -0.1306 22000.01p -0.0049 26000.01p -0.0788
m5 8000.01p -0.511 14000.01p -0.2782 20000.01p -0.0717 $ dirt 1.67 g/cc
    26000.01p -0.1091 13000.01p -0.08326 12000.01p -0.03142
    19000.01p -0.01155 11000.01p -0.02022 22000.01p -0.01655
    25000.01p -0.001781 15000.01p -0.0024
imp:p 1 0 16 0 2r 32 .5 2r 1 0 2r 512 0 9r 1 .125 0 2r .5 0 5r $ cell 1 to 48
    1 2r .5 .25 .25 .25 .0625 1r 512 2r 64 256 128 512 32 128 512
c imp:p 1 0 1 0 2r 2 0 2r 1 0 2r 32 0 30r 1 2r .25 2r .0625 2r 32 2r 4 16 8
c 32
c 2 8,32 $1, 65
c source
c source fraction of total sludge volume (76569 l total volume)
c wgt = (2.926e+12 p/kg pu) x 30 kg pu x (19326/76569) = 22.16e+12
sdef wgt=22.16e+12 erg=d1 cel=d2 pos 0 0 0 x fcel d3 y fcel d4 z fcel d5
sc1 photo spectrum for 1 kg pu from HNF-SD-W460-ER-001
# sil spl sbl
l d d
0.0150 1.409e+12 1.4e-3
0.0250 9.578e+10 2.0e-3
0.0375 8.626e+09 4.6e-4
0.0575 1.409e+12 1.4e-1
0.0850 1.306e+09 1.3e-2
0.1250 1.492e+09 1.5e-1

```

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0.2250	3.656e+08	1.0e-1
0.3750	1.839e+08	1.8e-1
0.5750	3.078e+07	9.0e-2
0.8500	9.134e+06	9.1e-2
1.250	1.911e+05	6.0e-3
1.750	8.269e+04	8.2e-3
2.250	4.734e+04	1.4e-2
2.750	2.718e+04	2.7e-2
3.500	2.403e+04	7.0e-2
5.000	1.012e+04	1.0e-1
7.000	1.143e+03	5.0e-2
11.00	1.300e+02	5.0e-2
c	2.926e+12 p/s per kg pu	
sc2	source cells	
si2	1 51 52 53 54 55 56 57 58 59 37 38	
sp2	1 1 1 1 1 1 1 1 1 5.75 11.50	
sb2	10 10 10 5.0 2.5 2.5 2.5 .625 .625 20 5	
ds3	s 31 31 31 31 32 32 32 33 33 34 34	
si31	-396.24 -365.76	
sp31	0 1	
si32	-365.76 -335.28	
sp32	0 1	
si33	-335.28 -304.80	
sp33	0 1	
si34	-304.80 396.24 \$ for top 6"	
sp34	0 1	
ds4	s 41 41 41 41 41 41 41 41 41 41	
si41	-198.12 198.12	
sp41	0 1	
ds5	s 51 52 53 51 52 53 51 52 53 54 55	
si51	182.88 243.84	
sp51	0 1	
si52	121.92 182.88	
sp52	0 1	
si53	60.96 121.92	
sp53	0 1	
si54	228.60 243.84 \$ for top 6"	
sp54	0 1	
si55	198.12 228.60 \$ for next 12"	
sp55	0 1	
c		

```

print 10 20 40 50 60 80 100 110 120 126 140 170
phys:p j 1 1
prtmp j -240 1
ctme 30
c ansi/ans-6.1.1-1991 AP fluence-to-dose,photons(mrem/hr/(p/cm**2/s)
de0 log .01 .015 .02 .03 .04 .05
      .06 .08 .10 .15 .20 .30
      .40 .50 .60 .80 1.0 1.5
      2.0 3.0 4.0 5.0 6.0 8.0
      10. 12.
df0 log 2.232e-5 5.652e-5 8.568e-5 1.184e-4 1.314e-4 1.382e-4
      1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
      7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
      2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3
      8.892e-3 1.040e-2
fc2 tank side surface, near bottom away from source cells
f2:p 8
fs2 -73 70 -80 28
sd2 1 1 1 1 3716.12
fc12 tank side surface, centered on source cells
f12:p 8
fs12 -73 70 -27 26
sd12 1 1 1 1 3716.12
fc22 tank side surface, at source top elevation
f22:p 8
fs22 -73 70 -6 76
sd22 1 1 1 1 3716.12
fc32 tank side surface, 7 ft above source top elevation
f32:p 8
fs32 -73 70 -78 79
sd32 1 1 1 1 3716.12
fc42 1 m from tank side surface, near bottom away from source cells
f42:p 55
fs42 -73 70 -80 28
sd42 1 1 1 1 3716.12
fc52 1 m from tank side surface, centered on source cells
f52:p 55
fs52 -73 70 -27 26
sd52 1 1 1 1 3716.12
fc62 1 m from tank side surface, at source top elevation
f62:p 55

```

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fs62 -73 70 -6 76
sd62 1 1 1 1 3716.12
fc72 1 m from tank side surface, 7 ft above source top elevation
f72:p 55
fs72 -73 70 -78 79
sd72 1 1 1 1 3716.12
fc82 2 m from tank side surface, near bottom away from source cells
f82:p 56
fs82 -73 70 -80 28
sd82 1 1 1 1 3716.12
fc92 2 m from tank side surface, centered on source cells
f92:p 56
fs92 -73 70 -27 26
sd92 1 1 1 1 3716.12
fc102 2 m from tank side surface, at source top elevation
f102:p 56
fs102 -73 70 -6 76
sd102 1 1 1 1 3716.12
fc112 2 m from tank side surface, 7 ft above source top elevation
f112:p 56
fs112 -73 70 -78 79
sd112 1 1 1 1 3716.12
fc122 3 m from tank side surface, near bottom away from source cells
f122:p 57
fs122 -73 70 -80 28
sd122 1 1 1 1 3716.12
fc132 3 m from tank side surface, centered on source cells
f132:p 57
fs132 -73 70 -27 26
sd132 1 1 1 1 3716.12
fc142 3 m from tank side surface, at source top elevation
f142:p 57
fs142 -73 70 -6 76
sd142 1 1 1 1 3716.12
fc152 3 m from tank side surface, 7 ft above source top elevation
f152:p 57
fs152 -73 70 -78 79
sd152 1 1 1 1 3716.12
e 0.1 0.3 0.6 1.3 2.3 3.0 4 5.1 7.1 12

File name: ns361a - Used to calculate the neutron dose rate off of the tank side.

Tank Z-361, settling tank, riser uncovered

c neutron dose at side of tank

```

1 1 -1.14 2 -5 4 -3 1 -28
2 4 -2.258 2 -5 -3 4 -1 7
3 4 -2.258 -2 60 -5 4 -6 7
4 4 -2.258 -9 3 -5 4 -6 7
5 4 -2.258 5 -10 8 -9 -6 7
6 4 -2.258 -4 11 8 -9 -6 7
7 4 -2.258 -2 60 -5 4 -12 6
8 4 -2.258 -9 3 -5 4 -12 6
9 4 -2.258 5 -10 8 -9 -12 6
10 4 -2.258 8 -9 11 -4 6 -12
11 2 -0.00129 -5 2 4 -3 6 -12
12 4 -2.258 8 -10 -9 11 14 34 -13
13 5 -1.67 -10 8 11 -9 39 -16 14
16 2 -0.00129 -15 12 -17
17 2 -0.00129 20 -57 -10 11 22 -16
18 5 -1.67 -21 9 -10 11 22 -16
19 5 -1.67 20 10 -18 -21 -16 22
20 5 -1.67 20 -11 19 -21 -16 22
21 5 -1.67 -9 8 -10 11 -7 22
22 3 -7.86 15 -14 -17 12
23 2 -0.00129 14 -23 16 -17
24 2 -0.00129 -17 23 16 -18 20 19 -21
25 2 -0.00129 20 -18 -21 19 32 -24
26 2 -0.00129 20 -18 -21 19 24 -25
27 0 (((((18):(-19)):(21 -18 19)):(-18 19 -20))):
    (20 -18 -21 19 25)):(20 -18 -21 19 -22 )
37 1 -1.14 47 -5 4 -3 -6 91 $ top 6" of source
38 1 -1.14 47 -5 4 -3 -91 92 $ next 12" of source
39 1 -1.14 47 -5 4 -3 -92 28
40 2 -0.00129 20 -18 -21 19 17 -32 14
41 2 -0.00129 17 -32 -14
42 4 -2.258 8 -10 -9 11 14 12 -33
43 4 -2.258 8 -10 -9 11 14 33 -34
44 5 -1.67 -10 8 11 -9 14 13 -35
45 5 -1.67 -10 8 11 -9 14 35 -36
46 5 -1.67 -10 8 11 -9 14 36 -37
47 5 -1.67 -10 8 11 -9 14 37 -38

```

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48 5 -1.67 -10 8 11 -9 14 38 -39
51 1 -1.14 2 -45 4 -5 -6 26
52 1 -1.14 2 -45 4 -5 -26 27
53 1 -1.14 2 -45 4 -5 -27 28
54 1 -1.14 45 -46 4 -5 -6 26
55 1 -1.14 45 -46 4 -5 -26 27
56 1 -1.14 45 -46 4 -5 -27 28
57 1 -1.14 46 -47 4 -5 -6 26
58 1 -1.14 46 -47 4 -5 -26 27
59 1 -1.14 46 -47 4 -5 -27 28
61 2 -0.00129 55 -8 -10 11 22 -16
62 2 -0.00129 56 -55 -10 11 22 -16
63 2 -0.00129 57 -56 -10 11 22 -16
65 4 -2.258 -60 61 -5 4 -6 7
66 4 -2.258 -61 8 -5 4 -6 7
67 4 -2.258 -60 61 -5 4 -12 6
68 4 -2.258 -61 8 -5 4 -12 6

1	p	-3.8460000e-02	0.0000000	0.9615400	0.0000000
2	px	-396.24000			
3	px	396.24000			
4	py	-198.12000			
5	py	198.12000			
6	pz	243.84000			
7	p	-3.8460000e-02	0.0000000	0.9615400	-30.480000
8	px	-426.72000			
9	px	426.74000			
10	py	228.60000			
11	py	-228.60000			
12	pz	533.40000			
13	pz	563.88000			
14	c/z	59.436000	0.0000000	8.4137500	
15	c/z	59.436000	0.0000000	7.7025500	
16	pz	624.84000			
17	pz	701.04000			
18	py	1752.6000			
19	py	-1752.6000			
20	px	-1950.7200			
21	px	1950.7200			
22	pz	-1600.0000			
23	c/z	59.436000	0.0000000	84.613750	

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24	pz	777.24000		
25	pz	2301.2400		
26	pz	182.88000		
27	pz	121.92000		
28	pz	60.960000		
32	pz	703.550		
33	pz	543.56		
34	pz	553.72		
35	pz	574.04		
36	pz	584.20		
37	pz	594.36		
38	pz	604.52		
39	pz	614.68		
40	c/z	59.436	0.000	30.00
41	c/z	59.436	0.000	60.00
42	c/z	59.436	0.000	120.00
45	px	-365.76		
46	px	-335.28		
47	px	-304.80		
50	pz	650.24		
51	pz	675.64		
55	px	-526.72		
56	px	-626.72		
57	px	-726.72		
60	px	-406.40		
61	px	-416.56		
c tally segment surfaces				
70	py	30.48		
71	py	91.44		
72	py	152.40		
73	py	-30.48		
74	py	-91.44		
75	py	-152.40		
76	pz	304.80		
77	pz	365.76		
78	pz	426.72		
79	pz	487.68		
80	pz	0.0		
91	pz	228.60	\$ 6" below top of source	
92	pz	198.12	\$ 18" below top of source	

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mode n

```
m1 13027.50c -0.304 20000.50c -0.460 26000.55c -0.5622 $source 1.14g/cc
    11023.50c -0.0405 14000.50c -0.0104 8016.50c -0.200
    1001.50c -0.060 6000.50c -0.0872 17000.50c -0.0342
    9019.50c -0.0039
m2 7014.50c 0.79000 8016.50c 0.21000 $ air 0.00129 g/cc
m3 26000.55c -5.1009 24000.50c -1.566 28000.50c -0.9396 $ steel 7.86 g/cc
    25055.50c -0.1566 14000.50c -0.0587 15031.50c -0.0035
    16032.50c -0.0023 6000.50c -0.0023
m4 1001.50c -0.0031 8016.50c -0.4407 11023.50c -0.0182 $ concrete 2.258 g/cc
    12000.50c -0.0376 13027.50c -0.0607 14000.50c -0.2157
    15031.50c -0.0009 16032.50c -0.0009 36084.50c -0.0066
    20000.50c -0.1306 22000.50c -0.0049 26000.55c -0.0788
m5 8016.50c -0.511 14000.50c -0.2782 20000.50c -0.0717 $ dirt 1.67 g/cc
    26000.55c -0.1091 13027.50c -0.08326 12000.50c -0.03142
    19000.50c -0.01155 11023.50c -0.02022 22000.50c -0.01655
    25055.50c -0.001781 15031.50c -0.0024
imp:n 1 0 1 0 2r 1 0 2r 1 0 2r 4 0 9r 1 2r 0 8r 1 8r 4 2r 2 4 2 4 $1, 53
c source
c source fraction of total sludge volume (76569 l total volume)
c wgt = (3.747e+05 p/kg pu) x 30 kg pu = 1.124e+07
sdef wgt=1.124e+07 erg=d1 cel=d2 pos 0 0 0 x fcel d3 y fcel d4 z fcel d5
sc1 spontaneous fission source spectrum (pu240)
sp1 -3 0.799 4.903
sc2 source cells
si2 1 51 52 53 54 55 56 57 58 59 37 38 39 1
sp2 1 1 1 1 1 1 1 1 5.75 11.5 51.75 26
sb2 10 10 10 5.0 2.5 2.5 2.5 .625 .625 20 5 .3125 .15625
ds3 s 31 31 31 32 32 32 33 33 33 34 34 35
si31 -396.24 -365.76
sp31 0 1
si32 -365.76 -335.28
sp32 0 1
si33 -335.28 -304.80
sp33 0 1
si34 -304.8 396.24
sp34 0 1
si35 -396.24 396.24
sp35 0 1
ds4 s 41 41 41 41 41 41 41 41 41 41 41 41
si41 -198.12 198.12
```

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```

sp41 0 1
ds5 s 51 52 53 51 52 53 51 52 53 54 55 56 57
si51 182.88 243.84
sp51 0 1
si52 121.92 182.88
sp52 0 1
si53 60.96 121.92
sp53 0 1
si54 228.60 243.84
sp54 0 1
si55 198.12 228.60
sp55 0 1
si56 60.96 198.12
sp56 0 1
si57 0 60.96
sp57 0 1
c
print 10 20 40 50 60 80 100 110 120 126 140 170
phys:n j 1 1
prtmp j -240 1
ctme 1020
c ansi/ans-6.1.1-1991 AP fluence-to-dose,neutrons(mrem/hr/(n/cm**2/s)
de0 log 2.5e-08 1.0e-07 1.0e-06 1.0e-05 1.0e-04
      .001 .01 .02 .05 .10
      .20 .50 1.0 1.5 2.0
      3.0 4.0 5.0 6.0 7.0
      8.0 10.0 14.0
df0 log 1.440-3 1.584-3 1.735-3 1.606-3 1.490-3
      1.379-3 1.631-3 2.113-3 3.924-3 7.128-3
      .01390 .03132 .05148 .06588 .07704
      .09504 .1080 .1177 .1249 .1314
      .1368 .1476 .1728
fc2 tank side surface, near bottom away from source cells
f2:n 8
fs2 -73 70 -80 28
sd2 1 1 1 1 3716.12
fc12 tank side surface, centered on source cells
f12:n 8
fs12 -73 70 -27 26
sd12 1 1 1 1 3716.12
fc22 tank side surface, at source top elevation

```

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f22:n 8
fs22 -73 70 -6 76
sd22 1 1 1 1 3716.12
fc32 tank side surface, 7 ft above source top elevation
f32:n 8
fs32 -73 70 -78 79
sd32 1 1 1 1 3716.12
fc42 1 m from tank side surface, near bottom away from source cells
f42:n 55
fs42 -73 70 -80 28
sd42 1 1 1 1 3716.12
fc52 1 m from tank side surface, centered on source cells
f52:n 55
fs52 -73 70 -27 26
sd52 1 1 1 1 3716.12
fc62 1 m from tank side surface, at source top elevation
f62:n 55
fs62 -73 70 -6 76
sd62 1 1 1 1 3716.12
fc72 1 m from tank side surface, 7 ft above source top elevation
f72:n 55
fs72 -73 70 -78 79
sd72 1 1 1 1 3716.12
fc82 2 m from tank side surface, near bottom away from source cells
f82:n 56
fs82 -73 70 -80 28
sd82 1 1 1 1 3716.12
fc92 2 m from tank side surface, centered on source cells
f92:n 56
fs92 -73 70 -27 26
sd92 1 1 1 1 3716.12
fc102 2 m from tank side surface, at source top elevation
f102:n 56
fs102 -73 70 -6 76
sd102 1 1 1 1 3716.12
fc112 2 m from tank side surface, 7 ft above source top elevation
f112:n 56
fs112 -73 70 -78 79
sd112 1 1 1 1 3716.12
fc122 3 m from tank side surface, near bottom away from source cells
f122:n 57

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fs122 -73 70 -80 28
 sd122 1 1 1 1 3716.12
 fc132 3 m from tank side surface, centered on source cells
 fl132:n 57
 fs132 -73 70 -27 26
 sd132 1 1 1 1 3716.12
 fc142 3 m from tank side surface, at source top elevation
 fl142:n 57
 fs142 -73 70 -6 76
 sd142 1 1 1 1 3716.12
 fc152 3 m from tank side surface, 7 ft above source top elevation
 fl152:n 57
 fs152 -73 70 -78 79
 sd152 1 1 1 1 3716.12
 e 0.1 0.3 0.6 1.3 2.3 3.0 4 5.1 7.1 12

APPENDIX B
Correspondence with Lee Carter

The following MCNP input file was provided as an example by Lee Carter to help improve the statistical uncertainties of the calculated dose rates.

Author: Glear39@aol.com at ~EXCHANGE

Date: 8/17/98 7:10 PM

Priority: Normal

BCC: Jay S Lan at ~HANFORD07A

TO: Jay_s_lan@rl.gov at ~EXCHANGE

Subject: TANK MCNP FILE ATTACHED

----- Message Contents -----

```
task W-151, tank AZ-101, file i21
c   bottom of tank
1  52 0.0652 -105 1 -2
c   radial side of tank
2  3 -7.8000 101 -102 2 -112
3  53 -0.0012 ((-111 102 -103 2 );(111 102 -22 -112 ));(112 21 -22
)
4  3 -7.8000 103 -104 2 -111
5  52 0.0652 2 -105 104 -111
c   top of tank
6  3 -7.8000 112 20 -21 -22
7  3 -7.8000 22 -23 52 54 56 58 60 62 111
8  52 0.0652 23 -105 ((-25 107 );(-24 -107 ))52 54 56 58 60 62 111
c   dummy concrete cells within dome for risers
11 52 0.0652 111 22 -24 -52
12 52 0.0652 111 -54 22 -24
13 52 0.0652 111 -56 22 -24
14 52 0.0652 111 -58 22 -24
16 52 0.0652 111 -62 22 -24
c   soil beyond tank
31 1 -1.67 111 -113 -106 60 (152:-115)(25:-107)(24:107)
32 1 -1.67 1 105 -106 ((111 -25):-111)
c   inside of tank
41 61 -1.70 2 -121 -101 $ sludge
42 62 -1.21 121 -122 -101 $ supernatant beyond source region used
(-177:854) (133:-141)
c   source region used
43 62 -1.21 -131 143 -122
```

```

      854
44  62 -1.21 -132 131 143 -122
45  62 -1.21 -133 132 143 -122
46  62 -1.21 -131 142 -143
      854
47  62 -1.21 -132 131 142 -143
48  62 -1.21 -133 132 142 -143
49  62 -1.21 -131 141 -142
      854
50  62 -1.21 -132 131 141 -142
51  62 -1.21 -133 132 141 -142
52  53 -.0012 122 -101 ((112 -20 -22):-112) $ above liquid
      854 (-173:60)
c    steam coil riser
101 53 -.0012   -59 -171 173 854 (158:-181)
      ((156:-189)(156:164:189:187)(164:-187:188)
      (164:166:-189:-188)(166:189:-190))
102 3  -7.8  59 -60 -171 173
c    steam coil flange above riser
106 3  -7.8 -159 -172 171 154 156 158
c    steam coil pipes
c    up to bottom of flange at top of riser
111 53 -.0012  -153 178 -171 $ #5 -x
112 3  -7.8 -854 177 -171 (153:-178)
113 53 -.0012   190 -171 $ 4" cnds
      ((-155 189):(-155 -163 -189 -187):(-163 187 -188):
      (-163 -165 189 188):(-165 -189))
114 3  -7.8 190 -171
      ((-156 189):(-156 -164 -189 -187):(-164 187 -188):
      (-164 -166 189 188):(-166 -189)) #113
115 53 -.0012  -157 181 -171 $ #5 -x
116 3  -7.8 -158 181 -171 157
c    1st imp zone above top of riser
117 53 -.0012  -153 171 -183 $ #5 -x
118 3  -7.8 -154 171 -183 153
119 53 -.0012  -155 171 -183 $ #5 +x
120 3  -7.8 -156 171 -183 155
121 53 -.0012  -157 171 -183 $ #5 -x
122 3  -7.8 -158 171 -183 157
c    2nd imp zone above top of riser
123 53 -.0012  -153 183 -184 $ #5 -x

```

124 3 -7.8 -154 183 -184 153
 125 53 -.0012 -161 183 -184 \$ #5 +x
 126 3 -7.8 (-156:186) 183 -184 161 (-162:-186)
 127 53 -.0012 -157 183 -184 \$ #5 -x
 128 3 -7.8 -158 183 -184 157

c 3rd imp zone above top of riser

129 53 -.0012 -153 184 -185 \$ #5 -x
 130 3 -7.8 -154 184 -185 153
 131 53 -.0012 -161 184 -185 \$ #5 +x
 132 3 -7.8 -162 184 -185 161
 133 53 -.0012 -157 184 -185 \$ #5 -x
 134 3 -7.8 -158 184 -185 157

c 4th imp zone above top of riser

135 53 -.0012 -153 185 -175 \$ #5 -x
 136 3 -7.8 -154 185 -176 (153:175)
 137 53 -.0012 -161 185 -175 \$ #5 +x
 138 3 -7.8 -162 185 -176 (161:175)
 139 53 -.0012 -157 185 -175 \$ #5 -x
 140 3 -7.8 -158 185 -176 (157:175)

c steam coil caisson

141 1 -1.67 -160 -183 115 (60:172) (159:172:-171)
 154 156 158
 142 1 -1.67 -184 115 -151 (160:183)
 154 (156:186) (162:-186) 158
 143 1 -1.67 -185 184 -151
 154 162 158
 144 1 -1.67 -174 185 -151
 154 162 158
 145 3 -7.80 151 -152 115 -184
 146 3 -7.80 151 -152 184 -185
 147 3 -7.80 151 -152 185 -174

c above soil and below upper z surface

691 0 -106 113 -114
 (152:174) ((154 162 158):176)

c outside world

799 0 (-1:106:114)

1 pz -60.96

2 pz 0.0000

c surface cards for tank dome area

20 sq 1.0000000 1.0000000 2.6408242 0.0000000 0.0000000

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```

0.0000000 -1306449.0000000 0.0000000 0.0000000 1072.6229500
21 sq 1.00000000 1.00000000 2.66667502 0.00000000 0.00000000
0.00000000 -1308627.32200000 0.00000000 0.00000000 1072.62295000
22 sq 1.00000000 1.00000000 7.14417474 0.00000000 0.00000000
0.00000000 -1486448.64000000 0.00000000 0.00000000 968.95920000
23 sq 1.0000000000 1.0000000000 7.1255520600 0.0000000000
0.0000000000 0.0000000000 -1488772.1229999999 0.0000000000
0.0000000000 968.9592000000
24 sq 1.00000000 1.00000000 6.47143574 0.00000000 0.00000000
0.00000000 -1580803.29000000 0.00000000 0.00000000 968.95920000
25 sq 1.00000000 1.00000000 2.20454312 0.00000000 0.00000000
0.00000000 -2316125.44000000 0.00000000 0.00000000 500.00000000
c riser surfaces
51 1 cz 53.34000000
52 1 cz 54.61000000
53 2 cz 53.34000000
54 2 cz 54.61000000
55 3 cz 53.34000000
56 3 cz 54.61000000
57 4 cz 53.34000000
58 4 cz 54.61000000
59 5 cz 53.34000000
60 5 cz 54.61000000
61 6 cz 53.34000000
62 6 cz 54.61000000
c radial surfaces for tank
101 cz 1143.00000000
102 cz 1143.95250000
103 cz 1219.20000000
104 cz 1220.15250000
105 cz 1264.92000000
106 cz 1325.00000000
107 cz 1095.85125000
c z-surfaces for outside of tank
111 pz 968.95900000
112 pz 1072.62300000
113 pz 1696.98 $ top of soil
114 pz 1820. $top of model
115 pz 1658.88 $ base of caisson
c z-surfaces for inside of tank
121 pz 50.8 $ top of sludge

```

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122	pz	914.4	\$ top of supernatant
c	radial surfaces for source in supernatant		
131	5	cz	91.44
132	5	cz	182.88
133	5	cz	365.76
c	axial surfaces for source in supernatant		
141	pz	822.96	
142	pz	853.44	
143	pz	883.92	
149	pz	1727.46	\$ for tally, radial edge of caisson
c	surfaces for steam coil		
151	5	cz	91.12 \$ inside of earth filled caisson
152	5	cz	91.44 \$ outside of earth filled caisson
153	5	c/z	45.72 0. 3.8964 \$ inside of pipe #5
154	5	c/z	45.72 0. 4.445 \$ outside of pipe #5
155	5	c/z	-45.72 0. 3.8964 \$ inside of pipe #5
156	5	c/z	-45.72 0. 4.445 \$ outside of pipe #5
157	5	c/z	16.51 -16.51 2.0447 \$ inside of pipe #15
158	5	c/z	16.51 -16.51 2.413 \$ outside of pipe #15
159	5	cz	63.50 \$ flange at top of riser
160	5	cz	72.0 \$ importance surface for caisson
161	5	c/z	-45.72 0. 2.62509 \$ inside of 2" cnds
162	5	c/z	-45.72 0. 3.01625 \$ outside of 2" cnds
163	9	cx	3.8964 \$ inside 4" cnds, jog below flange
164	9	cx	4.445 \$ outside 4" cnds, jog below flange
165	5	c/z	0. -45.72 3.8964 \$ inside 4" cnds, b jog b flange
166	5	c/z	0. -45.72 4.445 \$ outside 4" cnds, b jog b flange
171	pz	1712.22	\$ top of coil riser, bottom of flange
172	pz	1716.03	\$ top of flange
173	pz	1330.0	\$ bottom of riser ???
174	pz	1780.80	\$ top of caisson
175	pz	1804.93	\$ bottom edge of top of #5 pipe
176	pz	1805.48	\$ top of #5 pipe
177	pz	792.48	\$ bottom of #5 pipe
178	pz	793.0286	\$ bottom of \$5 pipe 153,154
179	pz	1681.74	\$ bottom of #5 pipe 155,156
180	pz	1682.2886	\$ bottom of #5 pipe 155,156
181	pz	1437.9	\$ bottom of #15 pipe 157,158
c	182	pz	152.7683 \$ bottom of #15 pipe 157,158
183	pz	1732.2	\$ importance surface for caisson
184	pz	1748.4	\$ importance surface for caisson

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185 pz 1764.6 \$ importance surface for caisson
 186 pz 1732.7486 \$ above reduction in 2"cnds
 187 9 px 0. \$ plane in cnds, 1st jog below flange
 188 9 px 64.65784407 \$ plane in cnds, 2nd jog below flange
 189 pz 1685.55 \$ jog of 4" cnds below flange
 190 pz 1655.07 \$ lower fake end of 4" cnds below flange
 354 5 c/z 45.72 0. 6.985 \$ 1" beyond 4" steam for tally
 454 5 c/z 45.72 0. 9.525 \$ 2" beyond 4" steam for tally
 362 5 c/z -45.72 0. 5.55625 \$ 1" beyond 2"cnds for tally
 462 5 c/z -45.72 0. 8.09625 \$ 1" beyond 2"cnds for tally
 358 5 c/z 16.51 -16.51 4.953 \$ 1" beyond 1.5" pipe for tally
 458 5 c/z 16.51 -16.51 7.493 \$ 2" beyond 1.5" pipe for tally
 374 pz 1785.8 \$ 2" above caisson for tally
 375 pz 1801.04 \$ 8" above caisson for tally
 854 5 c/z 45.72 0. 4.445001 \$ outside of pipe #5

mode p
 imp:p 0 0 3r .25 7r \$16
 1 0 0 0 1 .25 .0625 .25 .0625 .015625 .0625 .015625
 .000390625 1. \$ 52
 1 1 4 1 5r 8 5r 32 5r 128 5r 512 5r \$ 140
 8 32 128 512 8 32 128 512 0.

phys:p j 1
 m1 8000.01p -.511 14000.01p -.2782 20000.01p -.0717 \$ hwvp dirt
 26000.01p -.1091 13000.01p -.08326 12000.01p -.03142 \$ hwvp dirt
 19000.01p -.01155 11000.01p -.02022 22000.01p -.01655 \$ hwvp dirt
 25000.01p -.001781 15000.01p -.0024 \$ hwvp dirt

m3 26000.01p -1.
 m52 1000.01p 0.0642 8000.01p 0.5916 14000.01p 0.2405
 20000.01p 0.0738 26000.01p 0.0299 \$ ordinary H concrete

m53 7000.01p -0.765 8000.01p -0.235 \$ air
 c slude (with 60% supernate), EDT 155422, page 11, 1-initial

m61 1000.01p 25322 6000.01p 413.6 7000.01p 11284
 8000.01p 299001 9000.01p 298.5 11000.01p 37914
 13000.01p 2046 15000.01p 86.0 16000.01p 1449
 19000.01p 786.0 24000.01p 6266 26000.01p 69518
 40000.01p 23888 14000.01p 4955 48000.01p 7754
 38000.01p 55.1 44000.01p 0.19 55000.01p 3.24
 58000.01p 0.24 92000.01p 9009 94000.01p 38.2
 95000.01p 192.3

c supernate, EDT 155422, page 11, 1-initial

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```

m62 1000.01p 647878 6000.01p 13127 7000.01p 364851
      8000.01p 6682008 9000.01p 9652 11000.01p 1197736
      13000.01p 66141 15000.01p 2779 16000.01p 46858
      19000.01p 25414 24000.01p 189 55000.01p 105
tr1 670.5600 0 0 j j j j j j j
      j
tr2 -670.5600 0 0 j j j j j j j
      j
tr3 0 670.5600 0 j j j j j j j
      j
tr4 0 -670.5600 0 j j j j j j j
      j
tr5 -431.0523 431.0523 0 j j j j j j j
      j j
tr6 431.0523 -431.0523 0 j j j j j j j
      j j
*tr9 -476.7723 431.0523 1685.55 $ 4" ends horizontal below flange
      45 135 90 45 45 90 90 90 90
c total weight in cells 43 to 51 = 1.002+8 * 46.51+6 = 4.660+15
sdef erg=d1 cel=d2 pos fcel d3 rad fcel d4 ext d8 wgt=4.660+15
      axs 0 0 1
c TOTAL PHOTON SPECTRUM, supernate
# sil sp1 sb1
      l d d
1.500E-02 9.844E+06 9.844
2.500E-02 2.298E+06 2.298
3.750E-02 6.188E+06 6.188
5.750E-02 1.508E+06 1.508
8.500E-02 8.045E+05 0.805
1.250E-01 5.830E+05 0.583
2.250E-01 5.463E+05 0.546
3.750E-01 5.572E+05 0.800
6.662E-01 7.759E+07 160.0
8.500E-01 1.323E+05 0.30
1.250E+00 1.496E+05 0.60
1.750E+00 1.086E+04 0.11
2.250E+00 5.201E+03 0.11
2.750E+00 3.295E+02 0.05
3.500E+00 4.271E+01 0.02
5.000E+00 2.487E-06 0.01
7.000E+00 2.854E-07 0.01

```

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```

1.100E+01 3.270E-08 0.01
c      total 1.002+8 photons/gram/second
si2 1 43 44 45 46 47 48 49 50 51
sp2 8.9724 27 108 8.9724 27 108 8.9724 27 108
sb2 9 6.75 6.75 2.25 1.6875 1.6875 .5625 .42188 .42188
ds3 1 -431.0523 431.0523 899.16 -431.0523 431.0523 899.16
      -431.0523 431.0523 899.16
      -431.0523 431.0523 868.68 -431.0523 431.0523 868.68
      -431.0523 431.0523 868.68
      -431.0523 431.0523 838.20 -431.0523 431.0523 838.20
      -431.0523 431.0523 838.20
ds4 s 5 6 7
      5 6 7
      5 6 7
si5 0.91.44
sp5 -21 1
si6 91.44 182.88
sp6 -21 1
si7 182.88 365.76
sp7 -21 1
si8 -15.24 15.24
sp8 -21 0
print
prdm p j -480
c ansi/ans-6.1.1-1991 fluence-to-dose,photons(mrem/hr)/(p/cm**2/s)
de0 log .01 .015 .02 .03 .04 .05
      .06 .08 .10 .15 .20 .30
      .40 .50 .60 .80 1.0 1.5
      2.0 3.0 4.0 5.0 6.0 8.0
      10. 12.
df0 log 2.232e-5 5.652e-5 8.568e-5 1.184e-4 1.314e-4 1.382e-4
      1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
      7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
      2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3
      8.892e-3 1.040e-2
fc2 dose (mrem/hr) reaching top of riser
f2:p 171
e2 .5 .67 1. 1.5 2.5 20.
fs2 -59
sd2 8938.3 1
fc12 dose (mrem/hr) reaching top of caisson beyond streaming paths

```

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fl2:p 174
 e12 .5 .67 1. 1.5 2.5 20.
 fs12 -59
 sd12 8795.9 1
 fc22 dose (mrem/hr) reaching top of model, 4" steam, 2" cnds, 1.5"
 f22:p 114
 e22 .5 .67 1. 1.5 2.5 20.
 fs22 -153 -161 -157 -59
 sd22 47.70 47.70 13.13 8829.8 1
 c fc32 dose (mrem/hr) reaching bottom of riser
 c f32:p 173
 c e32 .5 .67 1. 1.5 2.5 20.
 c fs32 -59
 c sd32 8938.3 1
 fc42 dose (mrem/hr) reaching top of riser
 f42:p 171
 e42 .5 .67 1. 1.5 2.5 20.
 fs42 -59
 sd42 8938.3 1
 ft42 scx 2
 fc52 dose (mrem/hr) reaching outer radial edge of caisson
 f52:p 152
 e52 .5 .67 1. 1.5 2.5 20.
 fs52 -113 -149 -183 -184 -185
 fc62 dose along 3 pipes above caisson, 4"steam, 2"cnds, 1.5 steam
 f62:p 154 162 158
 e62 .5 .67 1. 1.5 2.5 20.
 fs62 -374 375
 sd62 1 1 425.6 1 1 288.8 1 1 231.1
 c sd62 1. j 1. 467.73 1. j
 fc4 dose (mrem/hr) up condensate -- short pipe
 f4:p 119 125 131 137
 e4 .5 .67 1. 1.5 2.5 20.
 fc14 dose (mrem/hr) up steam inlet
 fl4:p 117 123 129 135
 e14 .5 .67 1. 1.5 2.5 20.
 fc24 dose (mrem/hr) up small steam vent line
 f24:p 121 127 133 139
 e24 .5 .67 1. 1.5 2.5 20.
 fc34 dose (mrem/hr) in last section of pipes, short - inlet - small
 f34:p 137 135 139

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```

e34      .5 .67 1. 1.5 2.5 20.
fs34     -174 t
fc54     dose (mrem/hr) radially beyond pipes above caisson, 4", 2", 1.5"
f54:p    691
e54      .5 .67 1. 1.5 2.5 20.
fs54     -374 375 -354 -454 -362 -462 -358 -458 -59
sd54     1 1 1372.0 2007.8 1042.5 1660.3 895.8 1513.6 1 1
nps      25000
ctme     1700.
cut:p    j j 0. 0.
dxt:p    -431.0523 431.0523 1325. 50. 100. 1.+17 1.+10
dxc1:p   0. 4r 0.1 7r $ 16
          0.1 0 0 0 1. 9r $ 52
          0 0 0 0.1 0.1 0 36r
    
```

Following are communications with Lee Carter

Author: Glcar39@aol.com at ~EXCHANGE
Date: 9/4/98 11:04 AM
Priority: Normal
BCC: Robert F Richard at ~HANFORD07A
TO: Jay_s_lan@rl.gov at ~EXCHANGE
TO: Robert_F_Richard@rl.gov at ~EXCHANGE
Subject: REVIEW OF PHOTON PORTION OF TANK Z-361

----- Message Contents -----

Jay and Bob,

I have reviewed the photon portion of the summary and the input files. The attached Word Perfect 6 file contains my comments. I thought I would give this to you now since there is some other work I must get to. Will try to look at the neutron portion in a few days.

Note that I have made some revised calculations, where some modifications were made in the input files to attempt to improve the efficiency and do some other fine tuning. Will send these two input files to you separately.

Best regards,

Lee Carter

TECHNICAL REVIEW OF DOSE RATE CALCULATIONS FOR TANK Z-361

September 14, 1998

Review by:

Dr. Lee L. Carter
Carter Monte Carlo Analysis
6636 Hogan Drive N.
Keizer, OR 97303
Phone (503) 304-2966
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E-mail Glcar39@aol.com

Following is a summary of the review, where there are separate discussions of the photon

calculations and of the neutron calculations. The discussion of the photon calculations was made available previously. No errors were identified in the neutron calculations, but a number of suggestions are given on how to make these types of Monte Carlo calculations more efficient.

PHOTON CALCULATIONS

The summary and MCNP input files po361 and ps361 have been reviewed. These Monte Carlo calculations are quite difficult and the input files represent a sophisticated treatment. However, there are some concerns/recommendations that, if addressed, may change the calculated dose rates.

The concerns/recommendations for the po361 MCNP input file, used to determine dose rates above and around the open riser, are:

1. The energy biasing probability on the sb1card is available to improve the efficiency of the calculation. This is accomplished by computing each entry on this card as the product of the corresponding source strength entry on the splcard and an estimate of the importance at that source energy. In shielding dose-rate problems the importance essentially always increases with photon energy. However, the sb1 entries for the po361 file must have been determined some other way, and some of the entries actually correspond to a decrease instead of an increase in the importance function with photon energy. This likely doesn't make much difference for the dose rate above the riser since the large low energy photon portion of the source tends to dominate at the top of the riser, but it may lead to poor statistical uncertainties and a tendency to underestimate the dose rates radially beyond the riser.

2. The three concrete cells, (42, 43, and 12), should probably have entries of zero rather than one on the dxc:p card because this tends to force scattering back down to the sphere and makes the problem less efficient.

3. Inclusion of the input card

cut:p jj 0 0

is recommended to eliminate the random walk weight check leaving dxtran sphere.

4. The po361 input file was modified to incorporate the above three comments, with the most important being the first comment, and a 30 minute calculation was made on a 200 MH Pentium. The resulting tallies appear to have reduced uncertainties from this short calculation and the results give improved contributions from the higher energies, and actually may change the answers significantly out the side. It is suggested that the changes in this input file be examined, any other appropriate changes incorporated, and a full length calculation be made with the modified input file.

The concerns/recommendations for the ps36a MCNP input file, used to determine dose rates beyond the side of the tank, are:

1. The same comment is pertinent here as comment #1 for the po361 input file regarding the energy bias sb1 card. In this problem, the energy biasing is more important because of attenuation through the concrete.
2. The top of the source is neglected for distances greater than three feet from the wall. However, this portion of the source likely makes a significant contribution for the dose rates above the elevation of the top of the source.
3. The importances were set to zero for the ceiling and walls (except for the tally wall) above source. This scattering contribution should either be included in the calculation or a justification for neglecting it should be given. It probably is small for photons.
4. The ps36a input file was modified to incorporate the above three comments, some additional fine tuning of the importances was made, and a 30 minute calculation was made on a 200 MH Pentium. The resulting dose rates give better statistics in general, especially for the higher energies. The dose rate at the 6 to 8 foot elevation on the outer wall surface still has large uncertainties in this short calculation, but the results indicate that the dose rate there may be two orders of magnitude higher than given in the summary. It is suggested that the changes in this input file be examined, any other appropriate changes incorporated, and a full length calculation be made with the modified input file.

The following are some additional questions and editing comments that you may want to consider:

1. Many of the results shown in the tables are with large statistical uncertainties, and sometimes dose rates increase (or decrease) when one would physically expect the opposite. It should be stated in the text, or tables, or both that dose rates with statistical uncertainties greater than 20% are order of magnitude estimates only, and the actual values may be off by factors of two or more.
2. In Table 2.1, rather than showing the dose rate as 0.0 above the riser with one inch of steel, perhaps it should either be quantified or a footnote included stating that it is "very small". Also consider including a clarifying footnote that the "dose rate outside radius of riser" is the average from $r=8.41$ cm to $r=84.61$ cm.
3. I assume you have looked at the source distribution with the Visual Editor? I have not done

that, but its certainly worthwhile to do.

4. The sludge material, m1, has an interesting composition. The number of oxygen atoms per hydrogen atom is only about 0.84, while I thought a factor of two or more was typical. Also, the dirt is completely dry with no hydrogen -- is this to be conservative for the neutrons?

5. I did not do any review of the source. Apparently, there isn't any radioactive materials in the tank except plutonium, no fission products?

NEUTRON CALCULATIONS

The summary and MCNP input files no361 and ns361 have been reviewed. No specific errors were found in the review. There are a few comments on each of the input files that you may want to consider, where some of these comments have to do with making the calculations more efficient; i.e., obtaining reliable answers with less computer time.

The comments on the no361 MCNP input file, used to determine dose rates above and around the open riser, are:

1. Its my recommendation to typically use the "cut:n j j 0 0" card and have analog capture for neutrons. The manual often recommends non-analog capture or occasional use of the "phys:n j 1 1" card, but I don't agree with those recommendations.
2. Its not clear that one is sampling the important part of the source sufficiently or that scattering from the source to the riser vicinity is frequent enough in the random walks in this brute force approach. However, the statistical uncertainties obtained in Table 2.3 do indicate that the problem was ran sufficiently long to obtain reliable information. The following could be done in this type of problem to improve the efficiency, but 2c of the following is not straightforward -- however, even the implementation of 2a and 2b could substantially improve the efficiency:
 - 2a. Create an additional radial zone in the concrete and soil of the roof, where this radial zone extends from the riser out a little beyond where the radial side tally is made. Split the concrete and soil in this radial zone into a number of cells to increase importances with distance up through these cells. The lowest concrete of the roof in this radial zone would probably have an importance a factor of perhaps 8 (or even 64) greater than the source. The intent is to focus the calculation on the riser vicinity and also with distance up through the concrete and soil.
 - 2b. Create an additional radial zone for each axial cell of the source (or at least for the top cell or two), where this radial zone is centered about the axial center of the riser and its radius is somewhat greater than the line-of-sight up the riser. Then include this in the si2,

sp2, and sb2 source description, where sb2 would be set to sample this radial zone more frequently [usually set each sb2 entry to the corresponding sp2 entry multiplied by a guess importance]. This is to increase sampling the source in the line-of-sight region of the source. For consistency, should also set cell importances within the source region proportional to the importance used to compute the corresponding sb2 entry.

- 2c. Consider using a DXTRAN sphere (like was done for the photon) with center at the bottom of the riser. Then put zero probabilities on the dxc:n card for all of the roof and above, and decreasing probabilities for distances down into the source -- these probabilities could be uniformly decreased if neutrons penetrating up through the concrete and soil are important relative to those up through the riser so one doesn't spend all the time on DXTRAN particles. Its my understanding that the default weight cutoffs of zero on the dxt card do not play roulette with the neutrons upon leaving the DXTRAN sphere, which is good. You don't want to kill these particles with roulette, and can usually tell if they are being terminated from the summary table.

Note: I set up a problem modifying file no361 as described in 2a, 2b, and 2c above, and ran it for five hours on my slower Pentium 150 MH. The resulting dose rates agreed well with those in Table 2.3 of the report. The uncertainties were considerably improved for the tallies at 76.20 cm from the side of the riser — varying from 8.9% to 12.8% for this shorter run. However, the uncertainty of 38% in the dose rate above the riser and within the riser radius is still poor. Another short 10 minute calculation was made with only the source out to a radius of 56 cm and for the top 3 feet of the source region to obtain the direct streaming dose rate 30 inches above the top of the riser using a point detector. The result was a dose rate of 5.57×10^{-5} (4.4% uncertainty) mrem/hr, where this provides a useful confirmation with a good statistical uncertainty that the direct streaming contribution is small. This result indicates that more than half of the dose rate above the riser is from bulk shield rather than streaming up the riser. These types of problems, where part of the contribution is from bulk shield and part from streaming, tend to be difficult. A further improvement might be obtained by creating more radial cells near the riser in the concrete and soil of the roof and increasing importances near the riser and with increasing elevation to emphasize that vicinity in the calculation.

The comments on the ns361 MCNP input file, used to determine dose rates out the side of the tank, are:

1. The source part of the geometry was apparently set up to improve the efficiency with an sb2 card, but an sb2 card wasn't included. Could use an sb2 emphasizing the source near the wall and near the top [high guess importance near the wall and near the top as multiplier to sp2], along with a cell importance distribution consistent with the sb2, and also increase importances

at entrance to the dose tally wall by at least a factor of 8 to focus more of the calculation on the wall.

2. Importances are zero in the walls (except for tally wall), even above the source elevation, so wall scattering is being neglected. Should probably either include the walls above the source or else quantify that scattering off them is negligible.

3. Importances are decreased by a factor of two at entrance to the air beyond the wall. That will increase the statistical uncertainties for the tally planes beyond the wall.

The following are some additional questions and editing comments that you may want to consider:

1. Apparently Table 2.3 of the report is mislabeled and should be neutron dose rates rather than gamma.

2. Shouldn't the location in Table 2.4 (Table 2.2 also for the gammas) be "0 to 2 ft above top" instead of "1 to 2 ft above top" since that's apparently where the tallies were made?

Subject: Photon Dose rates

Author: Robert F Richard at ~HANFORD07A

Date: 9/9/98 9:26 AM

Lee,

Thanks for the revised input files. I ran them overnight on the UNIX machines and got much improved uncertainties. For total dose rates over all energies most uncertainties are in the range of a few percent, some 1 to 2 percent or less, and one around 10 percent. Some specific energy groups had uncertainties a bit higher.

The dose rates didn't change much, but those off to the side now decrease with distance as would be expected.

My question is: How does one go about determining the correct biasing? Specifically the relative importance of each energy group.

In my attempt to determine the biasing I did a tally on the inside

surface of the tank top (only air between the source and top). That tally result gave essentially no photons from the higher energy groups. I was obviously off track and would like to know how approach it in the future.

Have you had a chance to look at the neutron calculations yet?

Thanks,

Bob

Author: G1car39@aol.com at ~EXCHANGE
Date: 9/9/98 2:37 PM
Priority: Normal
BCC: Robert F Richard at ~HANFORD07A
TO: Robert_F_Richard@RL.gov at ~EXCHANGE
Subject: Re: Photon Dose rates

----- Message Contents -----

Bob,

One can calculationally determine an energy dependent importance for a given dose rate location by replacing the energy dependence of the source with a monoenergetic, unit-strength source. The dose rate is then proportional to the importance. Then you repeat this with enough unit-strength source calculations at other energies until you can draw a curve through the dose rates (importances); i.e., obtain a curve giving importance as a function of source energy. The problem is that sometimes you are interested in some dose rate locations through a thick shield as well as at other locations with little or no shielding. Then you may need to run a problem for the dose rate locations beyond the thick shield and another problem for dose rate locations with little or no shielding -- calculating an importance function with monoenergetic calculations for each problem type. Sometimes you can use the importance function for the thick shield ok for the thin shield results also -- this may require adjusting the importance function a little at low energies so that you sample the lower energies with the biasing function occasionally. I usually try to adjust my bias probability distribution so that I'm sampling all energies that I think could possibly be important at least occasionally (at least once every 10,000 source particles, for example).

Its time consuming to calculationally determine an importance function. You can usually assume one, with appropriate modifications to make sure that all possibly important energy groups are sampled at least occasionally. The assumed importance function might be proportional to photon energy, energy squared, energy cubed, or even stronger with energy, depending upon the shield thickness and the general energy range of the photons. After multiplying the photon probability distribution by this importance function to obtain a bias function, then I do some more thinking about this bias function. If there is one or more very intense low energy groups that could possibly contribute to the dose and the bias probability is very low, I will increase these so they are sampled occasionally. Similarly, if the very high energy groups could possibly contribute to the dose and the bias probability is very

low, I will increase these groups so they are sampled occasionally; i.e., really modify the low and/or high energy part of the importance function so all possibly important groups are sampled occasionally in case my guess of the importance function is poor for some tallies.

There can be quite a bit of computation going on in creating the bias probability distribution so its usually a good idea to look at the right hand weight multiplier in the energy table of print table 10 in the outp file as a check on your final bias distribution. This column is inversely proportional to the importance function being used and for photons should typically decrease with increasing photon energy.

Often the neutron importance function is nearly constant as a function of energy so its not even necessary to use a bias distribution.

I'm really pressed for time right now and haven't looked any at the neutron calculations. My plans were to do that this Saturday and next Monday so would probably get any comments I might have to you by Monday afternoon. Will that work in your schedule? I assume that the neutrons are simpler in some aspects than the photons.

Best regards,

Lee Carter

Gicar39@aol.com
Phone (503) 304-2966
Fax (503) 304-2967

APPENDIX C: CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW
DOCUMENT REVIEWED

NUMBER: HNF-3361, Rev. 0

TITLE: Tank Z-361 Dose Rate Calculations

AUTHOR(s): J. S. Lan

I. Method(s) of Review

- ☒ Input data checked for accuracy
- ☐ Independent calculation performed
 - ☐ Hand calculation
 - ☐ Alternate computer code: _____
- ☐ Comparison to experiment or previous results
- ☐ Alternate method (define) _____

II. Checklist (either check or enter NA if not applied)

- ☒ Task completely defined
- ☒ Activity consistent with task specification
- ☒ Necessary assumptions explicitly stated and supported
- ☒ Resources properly identified and referenced
- ☒ Resource documentation appropriate for this application
- ☒ Input data explicitly stated
- ☒ Input data verified to be consistent with original source
- ☒ Geometric model adequate representation of actual geometry
- ☒ Material properties appropriate and reasonable
- ☒ Mathematical derivations checked including dimensional consistency
- ☒ Hand calculations checked for errors
- ☒ Assumptions explicitly stated and justified
- ☒ Computer software appropriate for task and used within range of validity
- ☒ Use of resource outside range of established validity is justified
- ☒ Software runstreams correct and consistent with results
- ☒ Software output consistent with input
- ☒ Results consistent with applicable previous experimental or analytical findings
- ☒ Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
- ☒ Conclusions consistent with analytical results and established limits
- ☒ Uncertainty assessment appropriate and reasonable
- ☐ Other (define) _____

III. Comments: _____

IV. REVIEWER: J. S. Lan DATE: 9-29-98

DISTRIBUTION SHEET

To DISTRIBUTION	From Criticality and Shielding	Page 1 of 1
		Date 9/29/98
Project Title/Work Order Tank Z-361 Dose Rate Calculations		EDT No. 623014
		ECN No. NA

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