SEP 30 1998 (21) Station 15

ENGINEERING DATA TRANSMITTAL

1. EDT 623014

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 HAN91100 / ~~K6218~~ 10/383/A000 KN 10/5/98	7. Purchase Order No.: N/A
8. Originator Remarks: Transmittal of Tank Z-361 Dose Rate Calculations Report		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 241-Z-361 Tank
11. Receiver Remarks: 11A. Design Baseline Document? [ ] Yes [X] No		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
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15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-3361		0	Tank Z-361 Dose Rate Calculation	N/A			

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

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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	1	Peer Reviewer J. S. Lan [signature] B4-44 9/28/98
		Design Agent N/A			
1	1	Cog.Eng. R. F. Richard [signature] 9/25/98 B4-44			
1	1	Cog. Mgr. J. P. Estrellado [signature] B4-44 9/29/98			
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18. R. F. Richard [signature] 9/29/98 Signature of EDT Originator Date	19. Authorized Representative Date for Receiving Organization	20. [signature] J. P. Estrellado 9/29/98 Design Authority/ Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

S

TANK Z-361 DOSE RATE CALCULATIONS

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Key Words: Dose rates, gamma ray, photon, neutron, Z-361 settling tank

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

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HNF-3361, Rev.0

TANK Z-361 DOSE RATE CALCULATIONS

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 1and 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

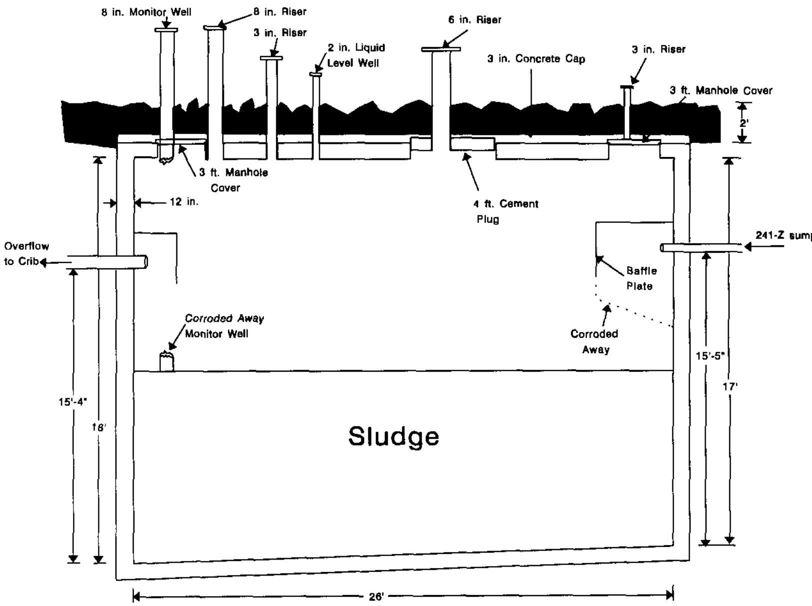
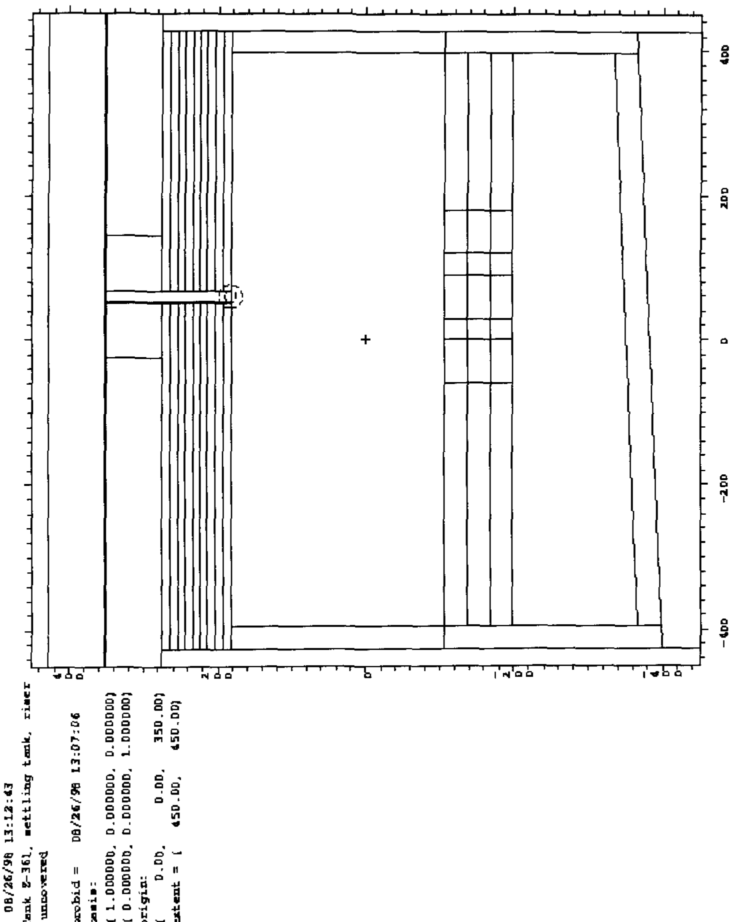


Figure 3.2 MCNP Plot of Settling Tank Z-361



3.2 Materials

The sludge material has a density of 1.14 g/cm^3 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/cm^3. Hanford dirt has a density of 1.67 g/cm^3. Material compositions as input into MCNP are given in Table 3.1. The table provides the material constituents in g/cm^3 which were normalized by MCNP to the material density.

Table 3.1 Material Composition (g/cm^3)

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

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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. Breismeister, 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
```

```
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
```

```
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)
```

```
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
     1        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 l 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 l 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
prdmp 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
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
```

```
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
```

```
  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
#   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 l 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 l 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
prdmp 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
```

```
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
```

```
 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
```

```
 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  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 l 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   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
```

```
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
prdmp j -240 1
dxt:n 59.436 0 533.40 7.70 10.0
dxc1: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
```

```
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
```

```
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
```

```
  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
```

```
  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
#    si1      sp1          sb1
     1       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
```

```
    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 l 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 32 32 32 33 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 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
prdmp 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
```

```
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
```

```
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
```

```
   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
```

```
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 l 51 52 53 54 55 56 57 58 59 37 38 39 1
sp2 1 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 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 41
si41 -198.12 198.12
```

```
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
prdmp 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
```

```
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
```

```
fs122   -73 70 -80 28
sd122  1 1 1 1 3716.12
fc132  3 m from tank side surface, centered on source cells
f132: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
f142: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
f152: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: Glcar39@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 $ supernantant 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
```

```
     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
```

```
 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
```

```
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
```

```
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
       j
tr2    -670.5600    0    0  j  j  j  j  j  j  j  j
       j
tr3    0 670.5600    0  j  j  j  j  j  j  j  j
       j
tr4    0 -670.5600    0  j  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" cnds 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
#      si1       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
```

```
      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
prdmp    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
```

```
f12: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
f14: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
```

```
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:
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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 sp1card 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 statical 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 j j 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 scatting 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 inportances with distance up though 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.

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

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 furture.

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

Thanks,

Bob

Author: Glcar39@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 probablility 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 squarred, 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 Glcar39@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

- (X) 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)

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

III. Comments:__________

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

DISTRIBUTION SHEET

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

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
<u>B & W Hanford</u>					
D. M. Bogen	T5-50	X			
D. L. Gardner	T5-57	X			
S. E. Huneycutt	T5-57	X			
R. S. Jansons	T5-03	X			
<u>Fluor Daniel Northwest</u>					
J. P. Estrellado, Jr.	B4-44	X			
D. P. Hughes	T5-57	X			
J. S. Lan	B4-44	X			
R. F. Richard	B4-44	X			
G. L. Rippy	T5-47	X			
Central Files (Orig. + 2)	B1-07	X			