308 --- Q199906170001
Scientific Notebook #345

LABORATORY NOTEBOOK

CNWRA/SwRI

NOTEBOOK NO. 345

ISSUED TO Dan Pomerening

ON June 9, **19** 99

DEPARTMENT

RETURNED June 10 **19** 99

NOTE: During an audit, it was determined that these data/info should be put into scientific notebooks. They were, promptly.

DP
6/10/99

CNWRA
CONTROLLED
COPY 345

—SCIENTIFIC NOTEBOOK CO.—
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INSTRUCTIONS

1. **The primary purpose of this notebook is to protect your and the Company's Patent-Rights by keeping records of all original work in a form acceptable as evidence if any legal conflict arises.**

2. • When starting a page, enter the title, project number, and book number.
   • Use ink for permanence -- avoid pencil.
   • Record your work as you progress, including any spur-of-the-moment ideas which may be developed later.
   • Avoid making notes on loose paper to be recopied.
   • Record your work in such a manner that a co-worker can continue from where you stop. You might be ill and to protect your priority it could be urgent that the work continue while you are absent.

3. • Give a complete account of your experiments and the results, both positive and negative, including your observations.
   • Record all diagrams, layouts, plans, procedures, new ideas, or anything pertinent to your work including the details of any discussions with suppliers, or other people outside the Company.
   • Do not try to erase any incorrect entries; draw lines deleting them, note the corrections, sign and date the changes. This extra care is worthwhile because of the necessity of original data to prove priority of new discoveries.

4. • After entering your data, sign and date the entries.
   • Explain your work to at least two witnesses who are not co-inventors, and have them sign and date the pages in the place provided.
   • Record the names of operators and witnesses present during any demonstration and have at least two witnesses sign the page. If no witnesses are present during an experiment of importance, repeat it in the presence of two witnesses.

5. Since computer programs can be patented these instructions apply to the development of computer software. In this case a description of the structure and operation of the program should be recorded in the notebook, together with a basic flow diagram which illustrates the essential features of the program. In the course of developing the code, the number of lines of code written each day should be recorded in the notebook, together with a statement of the portion of the flow diagram to which the section of code is directed.

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SUPPORTING CALCULATIONS FOR AP CHAPTERS 4 & 5	22-25

TITLE Review of the CISF TSAR	Project No. 20-1405-031 Book No. 345	1

From Page No. ____

Investigators: A. Ghosh
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The objective of this project is to review the Topical Safety Analysis Report (TSAR) for the Centralized Interim Storage Facility (CISF) submitted to the Nuclear Regulatory Commission (NRC) by the Department of Energy (DOE). The review consisted of ensuring that the proposed facility will meet all applicable NRC regulations including 10 CFR 20 and 10 CFR 72. This notebook documents calculations that were performed by CNWRA staff during their review of the TSAR to allow the reviewers to conclude that the proposed facility will meet NRC requirements.

The review has been conducted by a number of reviewers with a variety of technical disciplines. The review of the technical areas in the TSAR was conducted by reviewers with appropriate backgrounds in that technical area. The reviewers were familiar with NRC regulations and the NRC Standard Review Plan NUREG-1567

To Page No. ____

Witnessed & Understood by me,	Date	Invented by James Weldy	Date 6/9/99
		Recorded by James Weldy	

Project No. 20-1405-031
Book No. 345 TITLE Review of the CISF TSAR

From Page No.

JRW

James Welly
20-1405-031

1

Calculation of Dose Rate from an Array of CISF casks 9/14/98

The MCNP code will be used to confirm the dose rates calculated by the licensee in the CISF TSAR at the fence boundary. Since the cask SARs have been evaluated independently by NRC reviewers already, it is assumed that the dose rates on the side and top of the casks are correct and will be used in the calculation. Therefore, the geometry will be modeled as an array of 6000 casks and I will calculate the dose 700 m from the nearest cask in the centerline of the array.

Properties of air, Concrete, and soil - from "Principles of Radiation Shielding" by Chilton, Shultis, and Faw (1984)

Concrete - ordinary - Density = 2.35 g/cm³
- Oxygen = 49.6 %
- Silicon = 31.4 %
- Calcium = 8.26 %
- Aluminum = 4.55 %
- other = 6.19 %

Air - Density = 0.001209 g/cm³
- O = 21.2 %
- N = 77.8 %
- C = 0.01 %
- Ar = 0.9 %

Soil - U.S. Average - Density = 1.6 g/cm³
- O = 50.2 %
- Si = 26.5 %
- Al = 6.7 %
- Fe = 5.5 %
- Ca = 5.0 %
- Other = 6.1 %

Witnessed & Understood by me, | Date | Invented by James Welly | Date 6/9/99 | Recorded by James Welly

TITLE

From Page

James Welly
20-1405-031
Book No. 345
Review of the CISF TSAR
8/16/98
/home/jwelly/mcnp/cisfinal/cis2cf


```
Calculation of the dose around array of PWR MPCs for CISF
C Gamma source from radial sides
C
C Cell Cards
C
35 2 -2.406 -210 100 -187 imp:n,p=0.1 u=3 $ Concrete side shield
40 7 -0.001293 210:187:-100 imp:n,p=1 u=3 $ air around cask
C ____End of cask description - universe 3
82 0 -330 325 -340 335 -186 102 u=2 lat=1 imp:n,p=1 fill=0:74 0:3 &
     0:0 3 149R 5 149R $cask lattice
63 7 -0.001293 -300 #82 u=2 imp:n,p=1
C _____ Universe 2
76 0 -322 314 -310 302 -185 104 u=1 fill=2 imp:n,p=1  $pad-cask lattice
77 7 -0.001293 #76 -300 u=1 imp:n,p=1 $ other air - one pad only
C _______ Universe 4
73 0 -323 315 -313 305 -183 103 u=4 fill=2 lat=1 imp:n,p=1
C _______ Universe 1
70 0 -324 316 -405 307 -182 101 fill=4 (0 0 0) imp:n,p=1 $ lattice left
72 0 -435 420 -405 307 -182 101 fill=4 (47244 0 0) imp:n,p=1 $latt right
50 0 300 imp:n,p=0 $ rest of universe
60 8 -1.6 -101 -300 imp:n,p=1 $ ground under cask
80 7 -0.001293 -300 500 -600 700 -800 -900 #70 #72 #60 imp:n,p=1 $ air
81 7 -0.001293 -300 -500 505 700 -800 -900 #60 imp:n,p=10 $ air
93 7 -0.001293 -300 -505 510 700 -800 -900 #60 imp:n,p=10 $ air
83 7 -0.001293 -300 -510 515 700 -800 -900 #60 imp:n,p=100 $ air
84 7 -0.001293 -300 -515 520 700 -800 -900 #60 imp:n,p=100 $ air
85 7 -0.001293 -300 -520 525 700 -800 -900 #60 imp:n,p=1000 $ air
86 7 -0.001293 -300 -525 530 700 -800 -900 #60 imp:n,p=10000 $ air
87 7 -0.001293 -300 -530 535 700 -800 -900 #60 imp:n,p=10000 $ air
88 7 -0.001293 -300 -535 540 700 -800 -900 #60 imp:n,p=10 $ air
89 7 -0.001293 -300 -540 -900 #60 imp:n,p=0.0001 $ other air
90 7 -0.001293 -300 600 -900 #60 imp:n,p=0.0001
91 7 -0.001293 -300 -700 -900 -600 #60 imp:n,p=0.0001
92 7 -0.001293 -300 800 -900 #60 -600 imp:n,p=0.0001
94 7 -0.001293 -300 900 imp:n,p=0.0001
95 7 -0.001293 -300 imp:n,p=1 u=5

C
C Surface Cards
C
100 pz 0
101 pz 0.004
102 pz 0.001
103 pz 0.003
104 pz 0.002
182 pz 554.0596
183 pz 554.0597
185 pz 554.0598
186 pz 554.0599
187 pz 554.06
188 pz 75
189 pz 150
210 cz 190.5
300 so 720000
302 py -457.2
305 py -457.199
307 py -457.198
310 py 1371.6
313 py 2895.6
314 px -304.8
```

JRW

Witnessed & U | Recorded by | Page No.

/home/jwelly/mcnp/cisfinal/cis20E

James Welly
20-1405-031
Book No. 315
Review of the CISF TSAR
8/16/99

```
315 px -304.799
316 px -304.798
322 px 4.54152e4
323 px 4.5415199e4
324 px 4.5415198e4
325 px -304.8
330 px 304.8
335 py -457.2
340 py 457.2
405 py 65074.799
420 px 46939.199
435 px 92659.198
500 py -10457.2
505 py -20457.2
510 py -30457.2
515 py -40457.2
520 py -50457.2
525 py -60457.2
530 py -70457.2
535 py -80457.2
540 py -90000
600 py 70000
700 px -20000
800 px 120000
850 px 46162
855 px 46192.4
900 pz 8000

c
C Material Cards
c
m2   1001 -2.389e-2 8016 -1.281
     11023 -6.986e-2 13027 -8.192e-2
     14028 -.809 20040 -0.1057
     26056 -0.0338
m7   6012 -1.18e-7
     7014 -9.409e-4
     8016 -2.567e-4
     18040 -1.126e-5
m8   8016   -50.2
     14000   -28.5
     13027   -6.7
     26056   -5.5
     20000   -5.0
mode p
nps 100000000
c dbcn 0 0 100 300
c sdef sur=300 nrm=-1 erg=d1
c void
sdef erg=d1 axs=0 0 1 rad=d2 ext=d3 par=2 pos=d5 $ cel= d8
si1 A 0.1 0.125 0.15 0.175 0.20 0.25 0.35 0.55 0.850 &
    1.250 1.75 2.25
sp1 0.2652 0.1663 0.0855 0.0567 0.0307 0.043 0.0575 0.0726 0.0895 &
    0.0920 0.0245 0.0166
si2 0 190.5
sp2 -21 1
si3 A 554.061 554.062
sp3 1 1
si5 L 0 0 0 609.6 0 0 1219.2 0 0 1828.8 0 0 2438.4 0 0 3048 0 0 3657.6 0 0 &
    4267.2 0 0 4876.8 0 0 5486.4 0 0 6096 0 0 6705.6 0 0 &
```

JRW

TITLE

From Page No

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/home/jwelly/mcnp/cisFinal/cis20E

Book No. 315

James Welly
20-1405-031
Review of the CISF TSAR
8/16/99

```
4267.2 64617.6 0 4876.8 64617.6 0 5486.4 64617.6 0 6096 64617.6 0 6705.6 &
64617.6 0 7315.2 64617.6 0 7924.8 64617.6 0 8534.4 64617.6 0 9144 64617.6 0&
9753.6 64617.6 0 10363.2 64617.6 0 &
10972.8 64617.6 0 11582.4 64617.6 0 12192 64617.6 0 12801.6 64617.6 0 &
13411.2 64617.6 0 14020.8 64617.6 0 14630.4 64617.6 0 15240 64617.6 0 &
15849.6 64617.6 0 16459.2 64617.6 0 &
17068.8 64617.6 0 17678.4 64617.6 0 18288 64617.6 0 18897.6 64617.6 0 &
19507.2 64617.6 0 20116.8 64617.6 0 20726.4 64617.6 0 21336 64617.6 0 &
21945.6 64617.6 0 22555.2 64617.6 0 &
23164.8 64617.6 0 23774.4 64617.6 0 24384 64617.6 0 24993.6 64617.6 0 &
25603.2 64617.6 0 26212.8 64617.6 0 26822.4 64617.6 0 27432 64617.6 0 &
28041.6 64617.6 0 28651.2 64617.6 0 &
29260.8 64617.6 0 29870.4 64617.6 0 30480 64617.6 0 31089.6 64617.6 0 &
31699.2 64617.6 0 32308.8 64617.6 0 32918.4 64617.6 0 33528 64617.6 0 &
34137.6 64617.6 0 34747.2 64617.6 0 &
35356.8 64617.6 0 35966.4 64617.6 0 36576 64617.6 0 37185.6 64617.6 0 &
37795.2 64617.6 0 38404.8 64617.6 0 39014.4 64617.6 0 39624 64617.6 0 &
40233.6 64617.6 0 40843.2 64617.6 0 &
41452.8 64617.6 0 42062.4 64617.6 0 42672 64617.6 0 43281.6 64617.6 0 &
43891.2 64617.6 0 44500.8 64617.6 0 45110.4 64617.6 0 47244 64617.6 0 &
47853.6 64617.6 0 48463.2 64617.6 0 &
49072.8 64617.6 0 49672.4 64617.6 0 50292 64617.6 0 &
50901.6 64617.6 0 51511.2 64617.6 0 52120.8 64617.6 0 52730.4 64617.6 0 &
53340 64617.6 0 53949.6 64617.6 0 &
54559.2 64617.6 0 55168.8 64617.6 0 55778.4 64617.6 0 56388 64617.6 0 &
56997.6 64617.6 0 57607.2 64617.6 0 58216.8 64617.6 0 58826.4 64617.6 0 &
59436 64617.6 0 60045.6 64617.6 0 &
60655.2 64617.6 0 61264.8 64617.6 0 61874.4 64617.6 0 62484 64617.6 0 &
63093.6 64617.6 0 63703.2 64617.6 0 64312.8 64617.6 0 64922.4 64617.6 0 &
65532 64617.6 0 66141.6 64617.6 0 &
66751.2 64617.6 0 67360.8 64617.6 0 67970.4 64617.6 0 68580 64617.6 0 &
69189.6 64617.6 0 69799.2 64617.6 0 70408.8 64617.6 0 71018.4 64617.6 0 &
71628 64617.6 0 72237.6 64617.6 0 &
72847.2 64617.6 0 73456.8 64617.6 0 74066.4 64617.6 0 74676 64617.6 0 &
75285.6 64617.6 0 75895.2 64617.6 0 76504.8 64617.6 0 77114.4 64617.6 0 &
77724 64617.6 0 78333.6 64617.6 0 &
78943.2 64617.6 0 79552.8 64617.6 0 80162.4 64617.6 0 80772 64617.6 0 &
81381.6 64617.6 0 81991.2 64617.6 0 82600.8 64617.6 0 83210.4 64617.6 0 &
83820 64617.6 0 84429.6 64617.6 0 &
85039.2 64617.6 0 85648.8 64617.6 0 86258.4 64617.6 0 86868 64617.6 0 &
87477.6 64617.6 0 88087.2 64617.6 0 88696.8 64617.6 0 89306.4 64617.6 0 &
89916 64617.6 0 90525.6 64617.6 0 &
91135.2 64617.6 0 91744.8 64617.6 0 92354.4 64617.6 0
sp5 D 1 5999R
f45:p 46177.2  -70457.2  100 15 &
      46177.2  -80457.2  100 15 $ south end between rows 700 m
f2:p 500 505 510 520 525 530 535
fs2 -188 -850 189 855
sd2 1 1 1 1 2280 1 1 1 1 2280 1 1 1 1 2280 1 1 1 1 2280 1 1 1 1 2280 &
    1 1 1 1 2280 1 1 1 1 2280
e0  0.1 0.125 0.15 0.175 0.2 0.25 0.35 0.55 0.85 1.25 1.75 2.25 &
     2.75 3.5 3.75 4.25 5.0 10.0
de0  0.05 0.07 0.1 0.15 0.2 0.25 0.35 0.55 1.0 &
     1.4 1.8 2.2 2.8 3.25 4.25 5 5.75 6.75 7.5 9 11
df0  log 2.9e-7 2.58e-7 2.83e-7 3.79e-7 5.01e-7 6.31e-7 8.78e-7 1.27e-6 &
     1.98e-6 2.51e-6 2.99e-6 3.42e-6 4.01e-6 4.41e-6 5.23e-6 5.8e-6 6.37e-6 &
     7.11e-6 7.66e-6 8.77e-6 1.03e-5
c mrem/hr = 2.0412e4 (gammas/sec/cm2)*1.14e5 cm2 * 6000 casks*1000 mrem/rem
fm45 1.396181e16 $ convert result into mrem/hr
fm2 1.396181e16 $ convert result into mrem/hr
```

ge No

Project No.
Book No. TITLE

From Page No.

/home/jweldy/mcnp/cisfinal/cis20E

James Welty
20-1405-031
Book No. 315
Review of the CISF TSAR
8/16/98

```
prdmp -5000 -120 0
cut:p 9e99 0.001 -1e-6 -0.0000001
```

JRW

To Page No.

Witnessed & Understood by me.	Date	Invented by	Date
		Recorded by	

Output file - note only the relevant pages are included. The entire file is located in /home/jweldy/mcnp/cisfinal/cis20Eo

James Welty
20-1405-031
Book No. 315
Review of the CISF TSAR

```
mcnp     version 4a     ld=10/01/93                    08/20/98 16:41:32
************************************************************************
c i=contjw o=cis20Eo r=cis20Er

starting from dump no.   11 from file cis20Er     nps =  16990132     ctm = 1205.07     probid =   08/19/98 13:42:39

Calculation of the dose around array of PWR MPCs for CISF

  1-        continue
  2-        nps 150000000

      13 warning messages so far.

************************************************************************************************************************
dump no.   12 on file cis20Er     nps =  18947454     coll =     151060982     ctm = 1325.08     nrn =     2314730741

************************************************************************************************************************
dump no.   13 on file cis20Er     nps =  19603411     coll =     175573421     ctm = 1499.37     nrn =     2877710845

************************************************************************************************************************
dump no.   14 on file cis20Er     nps =  21677257     coll =     188265793     ctm = 1619.37     nrn =     2875429085

************************************************************************************************************************
dump no.   15 on file cis20Er     nps =  23628766     coll =     201191948     ctm = 1739.37     nrn =     3077359226

************************************************************************************************************************
dump no.   16 on file cis20Er     nps =  24275277     coll =     218172778     ctm = 1859.37     nrn =     3319524103

problem summary

    run terminated by tty interrupt.                                                          08/21/98 08:22:52

    Calculation of the dose around array of PWR MPCs for CISF                                probid =   08/19/98 13:42:39
    continue
```

photon creation	tracks	weight (per source particle)	energy (per source particle)
source	25944785	1.0000E+00	9.6967E-01
weight window	0	0.	0.
cell importance	75962187	1.1768E+00	7.4951E-01
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
from neutrons	0	0.	0.
bremsstrahlung	2216235	1.2982E-01	3.4943E-03
annihilation	54904	2.9290E-03	1.4968E-03
electron x-rays	0	0.	0.
1st fluorescence	1263004	9.0768E-02	4.2231E-04
2nd fluorescence	0	0.	0.
total	105441115	2.4004E+00	1.7246E+00

photon loss	tracks	weight (per source particle)	energy (per source particle)
escape	0	0.	0.
energy cutoff	0	0.	0.
time cutoff	0	0.	0.
weight window	0	0.	0.
cell importance	87228508	1.1594E+00	7.3162E-01
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
compton scatter	0	0.	9.2290E-01
capture	18185155	1.2395E+00	6.7314E-02
pair production	27452	1.4645E-03	2.7710E-03
total	105441115	2.4004E+00	1.7246E+00

/home/jwelly/mcnp/cisfinal/cis20F0 James Welly 20-1405-031 Book No. 345 Review of the CISF TSAR 8/20/98

From Pa

```
          tally for  photons

          this tally is modified by a dose function.

          this tally is all multiplied by  1.39618E+16

detector located at x,y,z = 4.61772E+04-7.04572E+04 1.00000E+02
    energy
  1.0000E-01   4.35172E-05 0.4036
  1.2500E-01   1.69343E-05 0.3089
  1.5000E-01   1.42925E-05 0.3115
  1.7500E-01   1.56307E-05 0.3290
  2.0000E-01   1.29846E-05 0.3024
  2.5000E-01   4.02465E-05 0.3166
  3.5000E-01   4.64994E-05 0.1966
  5.5000E-01   8.15005E-05 0.1459
  8.5000E-01   1.21138E-04 0.0789
  1.2500E+00   1.56847E-04 0.0383
  1.7500E+00   1.13592E-04 0.0232
  2.2500E+00   3.23123E-05 0.0478
  2.7500E+00   0.00000E+00 0.0000
  3.5000E+00   0.00000E+00 0.0000
  3.7500E+00   0.00000E+00 0.0000
  4.2500E+00   0.00000E+00 0.0000
  5.0000E+00   0.00000E+00 0.0000
  1.0000E+01   0.00000E+00 0.0000
    total      6.95496E-04 0.0873

detector located at x,y,z = 4.61772E+04-7.04572E+04 1.00000E+02
 collided photon flux
    energy
  1.0000E-01   1.82285E-07 0.0964
  1.2500E-01   2.59326E-08 0.0855
  1.5000E-01   2.40636E-08 0.1293
  1.7500E-01   2.96116E-08 0.3952
  2.0000E-01   2.84583E-08 0.1537
  2.5000E-01   4.98243E-08 0.1269
  3.5000E-01   8.37288E-08 0.1821
  5.5000E-01   8.70442E-08 0.0854
  8.5000E-01   1.05811E-07 0.0781
  1.2500E+00   3.11113E-07 0.0349
  1.7500E+00   7.56409E-07 0.0106
  2.2500E+00   8.22437E-07 0.0156
  2.7500E+00   0.00000E+00 0.0000
  3.5000E+00   0.00000E+00 0.0000
  3.7500E+00   0.00000E+00 0.0000
  4.2500E+00   0.00000E+00 0.0000
  5.0000E+00   0.00000E+00 0.0000
  1.0000E+01   0.00000E+00 0.0000
    total      2.50872E-06 0.0172

detector score diagnostics                  cumulative      tally       cumulative
                                            fraction of     per         fraction of
  times average score   transmissions       transmissions   history     total tally
      1.00000E-01       51364381            0.72819         1.78733E-15 0.03352
      1.00000E+00       15480724            0.94766         1.03623E-14 0.22783
      2.00000E+00        1809392            0.97331         5.26738E-15 0.32660
      5.00000E+00        1200438            0.99033         7.72381E-15 0.47144
      1.00000E+01         393588            0.99601         5.83703E-15 0.57715
      1.00000E+02         253637            0.99950         1.10518E-14 0.79564
```

Witne

Input file

/home/jwelly/mcnp/cisfinal/cis20F James Welly 20-1405-031 Book No. 345 Review of the CISF TSAR 8/20/98

TITLE

From I

```
Calculation of the dose around array of PWR MPCs for CISF
C Gamma source from radial sides
C
C Cell Cards

35 2 -2.406 -210 100 -187 imp:n,p=0.1 u=3 $ Concrete side shield
40 7 -0.001293 210:187:-100 imp:n,p=1 u=3 $ air around cask
C ____End of cask description - universe 3
82 0 -330 325 -340 335 -186 102 u=2 lat=1 imp:n,p=1 fill=0:74 0:3 &
     0:0 3 149R 5 149R $cask lattice
63 7 -0.001293 -300 #82 u=2 imp:n,p=1
C _____ Universe 2
76 0 -322 314 -310 302 -185 104 u=1 fill=2 imp:n,p=1  $pad-cask lattice
77 7 -0.001293 #76 -300 u=1 imp:n,p=1 $ other air - one pad only
C _______ Universe 4
73 0 -323 315 -313 305 -183 103 u=4 fill=2 lat=1 imp:n,p=1
C ______ Universe 1
70 0 -324 316 -405 307 -182 101 fill=4 (0 0 0) imp:n,p=1 $ lattice left
72 0 -435 420 -405 307 -182 101 fill=4 (47244 0 0) imp:n,p=1 $latt right
50 0 300 imp:n,p=0 $ rest of universe
60 8 -1.6 -101 -300 imp:n,p=1 $ ground under cask
80 7 -0.001293 -300 500 -600 700 -800 -900 #70 #72 #60 imp:n,p=1 $ air
81 7 -0.001293 -300 -500 505 700 -800 -900 #60 imp:n,p=10 $ air
93 7 -0.001293 -300 -505 510 700 -800 -900 #60 imp:n,p=10 $ air
83 7 -0.001293 -300 -510 515 700 -800 -900 #60 imp:n,p=100 $ air
84 7 -0.001293 -300 -515 520 700 -800 -900 #60 imp:n,p=100 $ air
85 7 -0.001293 -300 -520 525 700 -800 -900 #60 imp:n,p=1000 $ air
86 7 -0.001293 -300 -525 530 700 -800 -900 #60 imp:n,p=10000 $ air
87 7 -0.001293 -300 -530 535 700 -800 -900 #60 imp:n,p=10000 $ air
[illegible] -0.001293 -300 -535 540 700 -800 -900 #60 imp:n,p=10 $ air
[illegible] -0.001293 -300 -540 -900 #60 imp:n,p=0.0001 $ other air
90 7 -0.001293 -300 600 -900 #60 imp:n,p=0.0001
91 7 -0.001293 -300 -700 -900 -600 #60 imp:n,p=0.0001
92 7 -0.001293 -300 800 -900 -600 #60 imp:n,p=0.0001
94 7 -0.001293 -300 900 imp:n,p=0.0001
95 7 -0.001293 -300 imp:n,p=1 u=5

C
C Surface Cards
C
100 pz 0
101 pz 0.004
102 pz 0.001
103 pz 0.003
104 pz 0.002
182 pz 554.0596
183 pz 554.0597
185 pz 554.0598
186 pz 554.0599
187 pz 554.06
188 pz 75
189 pz 150
210 cz 190.5
300 so 720000
30[illegible] py -457.2
[illegible] py -457.199
307 py -457.198
310 py 1371.6
313 py 2895.6
314 px -304.8
```

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/home/jwelly/mcnp/cisfinal/cis20f

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```
315 px -304.799
316 px -304.798
322 px 4.54152e4
323 px 4.5415199e4
    px 4.5415198e4
325 px -304.8
330 px 304.8
335 py -457.2
340 py 457.2
405 py 65074.799
420 px 46939.199
435 px 92659.198
500 py -10457.2
505 py -20457.2
510 py -30457.2
515 py -40457.2
520 py -50457.2
525 py -60457.2
530 py -70457.2
535 py -80457.2
540 py -90000
600 py 70000
700 px -20000
800 px 120000
850 px 46162
855 px 46192.4
900 pz 8000

c
    terial Cards
c
m2    1001 -2.389e-2 8016 -1.281
      11023 -6.986e-2 13027 -8.192e-2
      14028 -.809 20040 -0.1057
      26056 -0.0338
m7    6012 -1.18e-7
      7014 -9.409e-4
      8016 -2.567e-4
      18040 -1.126e-5
m8    8016    -50.2
      14000   -26.5
      13027   -6.7
      26056   -5.5
      20000   -5.0
mode p
nps 100000000
c dbcn 0 0 100 300
c sdef sur=300 nrm=-1 erg=d1
c void
sdef erg=d1 axs=0 0 1 rad=d2 ext=d3 par=2 pos=d5 $ cel= d8
si1 A 0.1 0.125 0.15 0.175 0.20 0.25 0.35 0.55 0.850 &
    1.250 1.75 2.25
sp1 0.2652 0.1663 0.0855 0.0567 0.0307 0.043 0.0575 0.0726 0.0895 &
    0.0920 0.0245 0.0166
d[illegible] 290.5 290.51
    -21 1
si3 A 0 554.06
sp3 1 1
si5 L 0 0 0 609.6 0 0 1219.2 0 0 1828.8 0 0 2438.4 0 0 3048 0 0 3657.6 0 0 &
    4267.2 0 0 4876.8 0 0 5486.4 0 0 6096 0 0 6705.6 0 0 &
```

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```
4267.2 64617.6 0 4876.8 64617.6 0 5486.4 64617.6 0 6096 64617.6 0 6705.6 &
64617.6 0 7315.2 64617.6 0 7924.8 64617.6 0 8534.4 64617.6 0 9144 64617.6 0&
9753.6 64617.6 0 10363.2 64617.6 0 &
10972.8 64617.6 0 11582.4 64617.6 0 12192 64617.6 0 12801.6 64617.6 0 &
13411.2 64617.6 0 14020.8 64617.6 0 14630.4 64617.6 0 15240 64617.6 0 &
15849.6 64617.6 0 16459.2 64617.6 0 &
17068.8 64617.6 0 17678.4 64617.6 0 18288 64617.6 0 18897.6 64617.6 0 &
19507.2 64617.6 0 20116.8 64617.6 0 20726.4 64617.6 0 21336 64617.6 0 &
21945.6 64617.6 0 22555.2 64617.6 0 &
23164.8 64617.6 0 23774.4 64617.6 0 24384 64617.6 0 24993.6 64617.6 0 &
25603.2 64617.6 0 26212.8 64617.6 0 26822.4 64617.6 0 27432 64617.6 0 &
28041.6 64617.6 0 28651.2 64617.6 0 &
29260.8 64617.6 0 29870.4 64617.6 0 30480 64617.6 0 31089.6 64617.6 0 &
31699.2 64617.6 0 32308.8 64617.6 0 32918.4 64617.6 0 33528 64617.6 0 &
34137.6 64617.6 0 34747.2 64617.6 0 &
35356.8 64617.6 0 35966.4 64617.6 0 36576 64617.6 0 37185.6 64617.6 0 &
37795.2 64617.6 0 38404.8 64617.6 0 39014.4 64617.6 0 39624 64617.6 0 &
40233.6 64617.6 0 40843.2 64617.6 0 &
41452.8 64617.6 0 42062.4 64617.6 0 42672 64617.6 0 43281.6 64617.6 0 &
43891.2 64617.6 0 44500.8 64617.6 0 45110.4 64617.6 0 47244 64617.6 0 &
47853.6 64617.6 0 48463.2 64617.6 0 &
49072.8 64617.6 0 49672.4 64617.6 0 50292 64617.6 0 &
50901.6 64617.6 0 51511.2 64617.6 0 52120.8 64617.6 0 52730.4 64617.6 0 &
53340 64617.6 0 53949.6 64617.6 0 &
54559.2 64617.6 0 55168.8 64617.6 0 55778.4 64617.6 0 56388 64617.6 0 &
56997.6 64617.6 0 57607.2 64617.6 0 58216.8 64617.6 0 58826.4 64617.6 0 &
59436 64617.6 0 60045.6 64617.6 0 &
60655.2 64617.6 0 61264.8 64617.6 0 61874.4 64617.6 0 62484 64617.6 0 &
63093.6 64617.6 0 63703.2 64617.6 0 64312.8 64617.6 0 64922.4 64617.6 0 &
65532 64617.6 0 66141.6 64617.6 0 &
66751.2 64617.6 0 67360.8 64617.6 0 67970.4 64617.6 0 68580 64617.6 0 &
69189.6 64617.6 0 69799.2 64617.6 0 70408.8 64617.6 0 71018.4 64617.6 0 &
71628 64617.6 0 72237.6 64617.6 0 &
72847.2 64617.6 0 73456.8 64617.6 0 74066.4 64617.6 0 74676 64617.6 0 &
75285.6 64617.6 0 75895.2 64617.6 0 76504.8 64617.6 0 77114.4 64617.6 0 &
77724 64617.6 0 78333.6 64617.6 0 &
78943.2 64617.6 0 79552.8 64617.6 0 80162.4 64617.6 0 80772 64617.6 0 &
81381.6 64617.6 0 81991.2 64617.6 0 82600.8 64617.6 0 83210.4 64617.6 0 &
83820 64617.6 0 84429.6 64617.6 0 &
85039.2 64617.6 0 85648.8 64617.6 0 86258.4 64617.6 0 86868 64617.6 0 &
87477.6 64617.6 0 88087.2 64617.6 0 88696.8 64617.6 0 89306.4 64617.6 0 &
89916 64617.6 0 90525.6 64617.6 0 &
91135.2 64617.6 0 91744.8 64617.6 0 92354.4 64617.6 0
sp5 0 1 5999R
f45:p 46177.2  -70457.2  100 15 &
      46177.2  -80457.2  100 15 $ south end between rows 700 m
f2:p 500 505 510 520 525 530 535
fs2 -188 -850 189 855
sd2 1 1 1 1 2280 1 1 1 1 2280 1 1 1 1 2280 1 1 1 1 2280 1 1 1 1 2280 &
    1 1 1 1 2280 1 1 1 1 2280
e0  0.1 0.125 0.15 0.175 0.2 0.25 0.35 0.55 0.85 1.25 1.75 2.25 &
    2.75 3.5 3.75 4.25 5.0 10.0
de0  0.05 0.07 0.1 0.15 0.2 0.25 0.35 0.55 1.0 &
     1.4 1.8 2.2 2.8 3.25 4.25 5 5.75 6.75 7.5 9 11
df[illegible] log 2.9e-7 2.58e-7 2.83e-7 3.79e-7 5.01e-7 6.31e-7 8.78e-7 1.27e-6 &
     1.98e-6 2.51e-6 2.99e-6 3.42e-6 4.01e-6 4.41e-6 5.23e-6 5.8e-6 6.37e-6 &
     7.11e-6 7.88e-6 8.77e-6 1.03e-5
c mrem/hr = 1.7740e4 (gammas/sec/cm2)*2*pi*290.5*554.06 * 6000 casks*1000 mrem/rem
fm45 1.0764e17 $ convert result into mrem/hr
fm2 1.0764e17 $ convert result into mrem/hr
```

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```
prdmp -5000 -120 0
cut:p 9e99 0.001 -1e-6 -0.0000001
```

JRW

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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	

Output file

/home/jwelly/mcnp/cisfinal/cis20fo James Welly
20-1405-031
Book No. 345
Review of the CISF TSAR

```
1mcnp     version 4a    ld=10/01/93                    08/11/98 16:44:03
*************************************************************************
c i=contjw o=cis20Fo r=cis20Fr

starting from dump no.  116 from file cis20Fr     nps = 191055524     ctm =18821.72     probid =   08/20/98 08:46:00

Calculation of the dose around array of PWR MPCs for CISF

   1-       continue
   2-       nps 1500000000

      119 warning messages so far.

*************************************************************************************************************
dump no.  117 on file cis20Fr     nps = 193151124     coll =     2318331441     ctm =18941.73     nrn =     32988737333

*************************************************************************************************************
dump no.  118 on file cis20Fr     nps = 194770259     coll =     2342274969     ctm =19123.67     nrn =     33337660669

*************************************************************************************************************
dump no.  119 on file cis20Fr     nps = 196927770     coll =     2355227469     ctm =19243.67     nrn =     33530561459

*************************************************************************************************************
dump no.  120 on file cis20Fr     nps = 199210509     coll =     2368024188     ctm =19363.67     nrn =     33722513090

*************************************************************************************************************
dump no.  121 on file cis20Fr     nps = 201331764     coll =     2380993843     ctm =19483.67     nrn =     33917162947

*************************************************************************************************************
dump no.  122 on file cis20Fr     nps = 203517285     coll =     2394014003     ctm =19603.68     nrn =     34111875930

*************************************************************************************************************
dump no.  123 on file cis20Fr     nps = 205749677     coll =     2406931735     ctm =19723.68     nrn =     34305289392

*************************************************************************************************************
dump no.  124 on file cis20Fr     nps = 207887192     coll =     2420027014     ctm =19843.68     nrn =     34501023586

*************************************************************************************************************
dump no.  125 on file cis20Fr     nps = 210096458     coll =     2432975003     ctm =19963.69     nrn =     34694547834

*************************************************************************************************************
dump no.  126 on file cis20Fr     nps = 212258865     coll =     2446050464     ctm =20083.70     nrn =     34889854895

*************************************************************************************************************
dump no.  127 on file cis20Fr     nps = 214415312     coll =     2459012785     ctm =20203.70     nrn =     35083612509

*************************************************************************************************************
dump no.  128 on file cis20Fr     nps = 216653395     coll =     2471857993     ctm =20323.70     nrn =     35276138411
```

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/home/jweldy/mcnp/cisfinal/cis20fo

```
5.01+10      1 3.87-19 -18.412 ***************************
6.31+10      0 0.00+00   0.000
 94+10       0 0.00+00   0.000
 0+11        0 0.00+00   0.000
1.26+11      0 0.00+00   0.000
1.58+11      1 1.22-19 -18.912 *
 total      10 3.99-08         d-----------------------------------------------d-----------------------------------------------d
```

cumulative tally number for tally 2 nonzero tally mean(m) = 2.769E+10 nps = 250730760 print table 162

```
 abscissa     cum   ordinate    plot of the cumulative number of tallies in the tally fluctuation chart bin from 0 to 100 percent
  tally      number  cum pct:--------10--------20--------30--------40--------50--------60--------70--------80--------90-------100
5.01188E+09      3   30.000|*********|*********|*********|         |         |         |         |         |         |         |
6.30956E+09      5   50.000|*********|*********|*********|*********|*********|         |         |         |         |         |
7.94331E+09      6   60.000|*********|*********|*********|*********|*********|*********|         |         |         |         |
1.00000E+10      6   60.000|*********|*********|*********|*********|*********|*********|         |         |         |         |
1.25893E+10      6   60.000|*********|*********|*********|*********|*********|*********|         |         |         |         |
1.58490E+10      6   60.000|*********|*********|*********|*********|*********|*********|         |         |         |         |
1.99526E+10      7   70.000|*********|*********|*********|*********|*********|*********|*********|         |         |         |
2.51190E+10      7   70.000|*********|*********|*********|*********|*********|*********|*********|         |         |         |
3.16228E+10      7   70.000|mmmmmmmmm|mmmmmmmmm|mmmmmmmmm|mmmmmmmmm|mmmmmmmmm|mmmmmmmmm|mmmmmmmmm|         |         |         |
3.98109E+10      8   80.000|*********|*********|*********|*********|*********|*********|*********|*********|         |         |
5.01188E+10      9   90.000|*********|*********|*********|*********|*********|*********|*********|*********|*********|         |
6.30956E+10      9   90.000|*********|*********|*********|*********|*********|*********|*********|*********|*********|         |
7.94331E+10      9   90.000|*********|*********|*********|*********|*********|*********|*********|*********|*********|         |
1.00000E+11      9   90.000|*********|*********|*********|*********|*********|*********|*********|*********|*********|         |
1.25893E+11      9   90.000|*********|*********|*********|*********|*********|*********|*********|*********|*********|         |
 58490E+11      10  100.000|*********|*********|*********|*********|*********|*********|*********|*********|*********|*********|
   total        10  100.000:--------10--------20--------30--------40--------50--------60--------70--------80--------90-------100
1tally  45        nps =250730760
```

tally type 5 particle flux at a point detector.

tally for photons

this tally is modified by a dose function.

this tally is all multiplied by 1.07640E+17

detector located at x,y,z = 4.61772E+04-7.04572E+04 1.00000E+02

energy		
1.0000E-01	3.44182E-04	0.4065
1.2500E-01	8.85313E-05	0.3050
1.5000E-01	5.82102E-05	0.2342
1.7500E-01	6.41200E-05	0.3720
2.0000E-01	6.38418E-05	0.2717
2.5000E-01	8.93254E-05	0.1977
3.5000E-01	1.59029E-04	0.1782
5.5000E-01	3.67605E-04	0.1535
8.5000E-01	4.44223E-04	0.1028
1.2500E+00	5.80569E-04	0.0425
1.7500E+00	5.52714E-04	0.1322
2.2500E+00	2.27160E-04	0.0117
2.7500E+00	0.00000E+00	0.0000
3.5000E+00	0.00000E+00	0.0000
3.7500E+00	0.00000E+00	0.0000
4.2500E+00	0.00000E+00	0.0000
5.0000E+00	0.00000E+00	0.0000
1.0000E+01	0.00000E+00	0.0000
total	3.01251E-03	0.0890

Recorded by James Welly | JRW 6/9/94

1 James Weldy
20-1405-031
9/18/98
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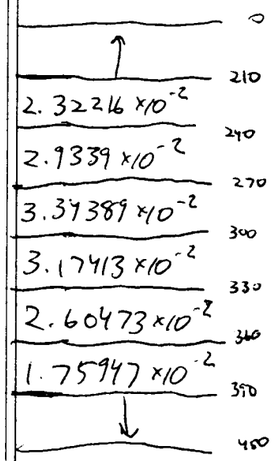
Review of the CISF TSAR

Calculation of Dose Rate from an Array of CISF casks.

Flux distribution on exterior of Cask from page II-163 of DOE Calcs.



Assume that the measured fluxes at the top + bottom extend all the way to the edge of the cask. (extremely conservative as the flux will drop considerably past the region outside the fuel.). Each 30 cm segment constitutes $\frac{30\text{ cm}}{450\text{ cm}} = 0.0667$ of the outside area. Therefore, areally averaged flux on outside of cask is equal to 2.39416×10^{-2}, or 71.6% of the maximum. This factor should be applied to the dose rate calculated from the sides of the cask.

Dose rate from max. flux around entire side of casks: 3.01×10^{-3} mrem/hr

Dose rate from top of casks: 6.95×10^{-4} mrem/hr - from MCNP calcs

Total dose rate from cask array $= 0.716 \times 3.01 \times 10^{-3} + 6.95 \times 10^{-4}$
$= 2.85 \times 10^{-3}$ mrem/hr

Total annual dose from cask array = 24.98 mrem/yr assuming 100% occupation by a member of the public.

This confirms that the dose calculation performed by the DOE is acceptable

Recorded by

11-13-97
James Weldy
20-1405-031
Book No. 345
Review of the CISF TSAR

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Independent Calculations for CIS TSAR:

Confirm that doses in unrestricted areas will be less than 2 mrem/hr.

Page 9.3-4: Calculation of dose rates in unrestricted areas of the transfer facility

1. Locker room: 18 in of concrete, 22 ft from source
from Hubbell, $\frac{\mu}{\rho}$ of concrete for 800 keV γ's (about 90% of source term is this or less) is 0.071 cm²/g

$$\dot{D} = \dot{D}_o \cdot B \cdot e^{-\mu/\rho \cdot \rho \cdot x} \cdot G$$

$\dot{D}$ = Dose rate in area (mrem/hr)

$\dot{D}_o$ = 10 mrem/hr at 2 m

$\frac{\mu}{\rho}$ = attenuation coefficient $\left(\frac{cm^2}{g}\right)$

ρ = density (g/cm³) = 2.35 for concrete

x = thickness of shielding (cm)

G = Geometry factor - use cask as line source and dose falls off as $\frac{1}{r}$ - conservative est.

B = Buildup factor (from RHH) - for 800 keV γ through 18 in concrete (mix of Al + Fe): 19.25

$$\dot{D} = 10\text{ mrem/hr} \cdot 19.25 \cdot e^{-0.071 \cdot 2.35 \cdot 18\text{ in} \cdot \frac{2.54\text{ cm}}{\text{in}}} \cdot \frac{2\text{ m} \cdot 100}{22\text{ ft} \cdot 12 \cdot 2.54}$$

$$\dot{D} = 10\text{ mrem/hr} \cdot \frac{1}{358}$$

$\dot{D}$ = 0.028 mrem/hr. Much less than allowable dose rate in unrestricted area of 2 mrem/hr

2. Remote operating room: 18 in of concrete, no distance given so G=1

$$\dot{D} = 10\text{ mrem/hr} \cdot 19.25 \cdot e^{-0.071 \cdot 2.35 \cdot 18 \cdot 2.54}$$

$$\dot{D} = 10\text{ mrem/hr} \cdot \frac{1}{106.8}$$

$\dot{D}$ = 0.094 mrem/hr. Much less than 2 mrem/hr.

3. Crane operating room: 10 in of concrete, 50 ft. from source

$$\dot{D} = 10\text{ mrem/hr} \cdot 8.5 \cdot e^{-0.071 \cdot 2.35 \cdot 10 \cdot 2.54} \cdot \left(\frac{2\text{ m} \cdot 100}{50\text{ ft} \cdot 12 \cdot 2.54}\right)^2$$ for enough to follow $\frac{1}{r^2}$

$$\dot{D} = 10\text{ mrem/hr} \cdot \frac{1}{473}$$

$\dot{D}$ = ~~0.16~~ 0.021 mrem/hr. Much less than 2 mrem/hr

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Book No. 345
Review of the CISF TSAR

Independent Calcs - pg. 9.3-4 - Dose rates in operational areas

11-14-97

4. denote operating cubicles 12 in concrete, 20 feet away

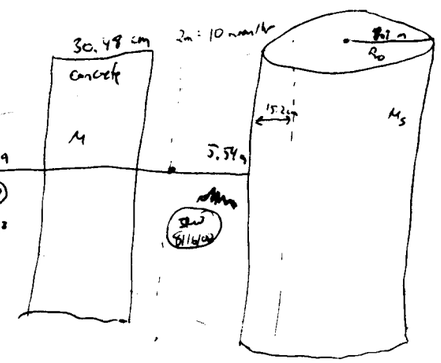
$\dot{D} = 10 \text{ mrem/hr} \cdot \frac{10.75}{1} \cdot e^{-0.071 \cdot 2.35 \cdot 12 \cdot 2.54} \cdot \frac{2^2/100^2}{20 \cdot 12 \cdot 2.54}$

$\dot{D} = 10 \text{ mrem/hr} \cdot \frac{1}{45.8}$

$\dot{D} = 0.22 \text{ mrem/hr}$

This one is kind of close. Lets model it more accurately.

- Ignore attenuation of air
- Assume activity is evenly distributed w/in cylinder
- Approximate as line source w/in cylinder
- Density $\approx [2.31 \text{ g/cm}^3 (\text{fuel}) + 2.41 (\text{concrete})]/2 = 2.36 \text{ g/cm}^3$
- Use μ for concrete and 800 keV for cask



First, calculate the 10 mrem/hr at 2 m back to a line source photon emission rate

$\frac{a}{R_0} = \frac{2}{1.9} = 1.05 < 10$

$\mu_s/\rho = \mu/\rho = 0.07103 \frac{\text{cm}^2}{\text{g}}$

$\mu_s (a + R_0) = 0.07103 \frac{\text{cm}^2}{\text{g}} \cdot 3.9 \text{ m} \cdot 100 \text{ cm/m} \cdot 2.36 = 27.7 \frac{\text{cm}^3}{\text{g}} \cdot 2.36 \text{ g/cm}^3$

$\mu_s (a + R_0) = 65.4$

$m = 1.7$

$b = \Sigma \mu t = 0.07103 \cdot 2.36 \cdot 0 = 0$

$\frac{1}{m} \mu_s z = 1.5$

$z = 15.2 \text{ cm}, \quad \theta_{c_1} = \theta_{c_2} = \tan^{-1}\left(\frac{277}{215.2}\right) = 0.91 \text{ radians} = 52°$

$\phi = \frac{S_v \cdot R_0^2}{4(a+z)} [F(\theta_2, b) + F(\theta_1, b)]$

$\dot{D} \cdot \phi' = \frac{S_v \cdot (190 \text{ cm})^2}{4(215.2 \text{ cm})} [.83 + .83] = S_v \cdot 139.2 \frac{\text{s}}{\text{sec} \cdot \text{cm}^2}$

$S_v = \frac{10 \text{ mrem/hr} \cdot \phi' \text{ s/sec/cm}^2/\text{mrem/hr}}{139.2} = 7.18 \times 10^{-2} \cdot \phi' \frac{\text{s/sec}}{\text{cm}^3}$

R_0 = radius of cask

a = distance between dose point and front of cask

S_v = emission rate from source $\left(\frac{\text{s/sec}}{\text{cm}^3}\right)$

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Independent Calcs - Dose rates in operational areas - page 9-3.4

11-14-97

4. (cont)

Now, calculate the dose at 20 feet behind 12 inches of concrete

$S_v = 7.18 \times 10^{-2} \cdot \phi' \frac{\text{s/sec}}{\text{cm}^3}$

$a = 6.1 \text{ m}$

$R_0 = 1.9 \text{ m}$

$\frac{\mu_s}{\rho_s} = \frac{\mu}{\rho} = 0.07103 \frac{\text{cm}^2}{\text{g}}$ (E = 800 keV)

$\rho_s = 2.36 \frac{\text{g}}{\text{cm}^3}$

$\rho = 2.41 \frac{\text{g}}{\text{cm}^3}$

$\frac{a}{R_0} = \frac{6.1}{1.9} = 3.21 < 10$

$\mu_s (a + R_0) = 0.07103 (610 + 190)^{2.36} = 56.8 \cdot 2.36 = 134$

$m = 2$

$b' = \Sigma \mu t = 12 \text{ in} \cdot 2.54 \text{ cm/in} \cdot 0.07103 \frac{\text{cm}^2}{\text{g}} \cdot 2.41 \frac{\text{g}}{\text{cm}^3}$

$b' = 5.2$

$\frac{1}{m} \mu_s z = 1.08$

$z = 12.9 \text{ cm}$

$b = 0.07103 \cdot 2.41 \cdot 12 \text{ in} \cdot 2.54 + 0.07103 \cdot 2.36 \cdot 12.9$

$b = 7.38$

$\theta_1 = \theta_2 = \tan^{-1}\left(\frac{277}{623}\right) = 0.4184 = 24°$

$\phi = \frac{S_v R_0^2}{4(a+z)} [F(\theta_2, b) + F(\theta_1, b)] \cdot B$

$\phi = \frac{7.18 \times 10^{-2} \cdot \phi' \cdot (190 \text{ cm})^2}{4(610 + 12.9)} \cancel{[1.05 \times 10^{-4} + 1.05 \times 10^{-4}]} [2.1 \times 10^{-4} + 2.1 \times 10^{-4}] \cdot B$

$\frac{\phi}{\phi'} = \dot{D} = 1.04 [2.1 \times 10^{-4}] \cdot 2 \cdot B$

$\dot{D} = \cancel{2.18 \times 10^{-4} \frac{\text{mrem}}{\text{hr}}} \; 4.37 \times 10^{-4} \frac{\text{mrem}}{\text{hr}} \cdot B$

B = Buildup factor for a plane, nondirectional source

$B = B_{Fe} \approx 6.2$ → from Hubbell (1982)

$\dot{D} = 2.71 \times 10^{-3}$ mrem/hr - we can see that the rough estimate is very conservative. The conclusion in the TSAR is accurate.

JRW

Reviewed by James Welty Date

Recorded by James Welty 6/9/99

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Review of the CISF TSAR
James Welly
20-1405-031
11/14/97
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Independent Calculation for the dose rate at the queuing area

From before, emission rate from the cask = $7.18\times10^{-2}\,\phi'\,\frac{\text{g/sec}}{\text{cm}^3}$

Total emission rate from cask = $7.18\times10^{-2}\,\phi'\,\frac{\text{g/sec}}{\text{cm}^3}\cdot\pi(190\text{ cm})^2\cdot 554\text{ cm}$

Total emission rate = $4.51\times10^{6}\cdot\phi'$ g/sec = S

Far enough to consider this a point source and consider air attenuation

$\frac{\mu}{\rho}_{air} = 0.0707\ (E = 800\text{ keV})\ \frac{\text{cm}^2}{\text{g}}$

$\rho_{air} = 0.001293\ \frac{\text{g}}{\text{cm}^3}$

$\phi = \frac{S}{4\pi r^2} B e^{-\mu K}$ — neglect buildup in air

$\phi = \frac{4.51\times10^{6}\cdot\phi'\ \text{g/sec}}{4\pi\cdot(5000\text{ cm})^2}\cdot 1\cdot e^{-.0707\cdot.001293\cdot5000}$

$\frac{1}{\phi'}\cdot\phi = 0.014\ \text{mrem/hr}\ e^{-.457}$

$\dot{D}_{cask} = 0.0089$ mrem/hr

$\dot{D}_{Total} = 0.044$ mrem/hr — 50 m setback is plenty to reduce dose to below 2 mrem/hr

JRW

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12-17-97

Calculation of dose to an off-site individual from the release of Cs-137 from external contamination of 6000 storage casks in CISF TSAR

Allowable Concentration on Storage cask = 300 dpm/cm²

$= 300\ \text{dpm/cm}^2\cdot\frac{1\text{ Bq}}{60\text{ dpm}}\cdot\frac{1\text{ Ci}}{3.7\times10^{10}\text{ Bq}}$

$= 1.35\times10^{-10}\ \text{Ci/cm}^2$

Surface area of storage cask = top + sides

$= \pi r^2 + 2\pi r h$

$= \pi\cdot(190.5\text{ cm})^2 + 2\cdot\pi\cdot190.5\text{ cm}\cdot554.06\text{ cm}$

$= 1.14\times10^{5}\text{ cm}^2 + 6.632\times10^{5}\text{ cm}^2$

$= 7.772\times10^{5}\ \text{cm}^2/\text{cask}$

Source term = Conc · Surface Area · # of casks

$= 1.35\times10^{-10}\ \text{Ci/cm}^2\cdot7.772\times10^{5}\ \text{cm}^2/\text{cask}\cdot6000\text{ casks}$

$= 0.63$ Ci

Assume that 0.63 Ci are released in 1 year. Since this is a generic site, use a Gaussian Plume model with stability class F, wind speed 1 m/sec, and assume the wind blows towards the receptor 50% of the year. Also assume a lid height of 1000 m. Receptor point is 700 m away

$\frac{\chi}{Q} = \frac{1}{\bar{u}\,\pi\,\sigma_y\sigma_z}\cdot0.5$

My results: Yill mrem/yr
~~CAP 88 results: 4.5 mrem/yr~~
Conclusions based on hand calculations JRW 11/25/98

$\bar{u} = 1$ m/sec

$\sigma_y = 27$ m

$\sigma_z = 10$ m

$\frac{\chi}{Q} = \frac{1}{1\text{ m/sec}\cdot\pi\cdot27\text{ m}\cdot10\text{ m}} = 1.18\times10^{-3}\ \frac{\text{sec}}{\text{m}^3}\cdot0.5$

$\chi_{receptor} = 1.18\times10^{-3}\ \frac{\text{sec}}{\text{m}^3}\cdot0.63\text{ Ci/yr}\cdot\frac{1\text{ yr}}{3.16\times10^{7}\text{ sec}}\cdot0.5$

$\chi_{receptor} = 1.18\times10^{-11}\ \frac{\text{Ci}}{\text{m}^3}$

Air breathed in 1 yr = 8.33×10^{6} L = 8330 m³

Cs-137 ingested = $1.18\times10^{-11}\ \frac{\text{Ci}}{\text{m}^3}\cdot8330\text{ m}^3 = 9.83\times10^{-8}$ Ci (Eckerman, 1988)

m is less than 5 mrem, so is acceptable

Dose$_{weak}$ = $9.83\times10^{-8}\text{ Ci}\cdot8.63\times10^{-9}\ \frac{\text{Sv}}{\text{Bq}}\cdot\frac{100\text{ rem}}{1\text{ Sv}}\cdot\frac{3.7\times10^{10}\text{ Bq}}{\text{Ci}} = 3.14$ mrem (LaPlante, 1997)

Dose ground = $9.18\times10^{-11}\text{ Ci/m}^3\cdot0.001\text{ m/sec}\cdot4.6\times10^{-6}\text{ rem/Ci/m}^2\cdot3.16\times10^{7}\text{ sec/yr} = 0.97$ mrem

JRW

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THIS GROUP OF CALCULATIONS COVERS A REVIEW OF CHAPTERS 3 "PRINCIPAL DESIGN CRITERIA", 7 "INSTALLATION DESIGN AND STRUCTURAL EVALUATION" OF THE TSAR
"CENTERALIZED INTERIM STORAGE FACILITY TOPICAL SAFETY ANALYSIS REPORT"

THE REVIEW WAS IN SUPPORT OF CHAPTERS 4 & 5 OF
"ASSESSMENT REPORT OF TOPICAL SAFETY ANALYSIS REPORT FOR THE CENTERALIZED INTERIM STORAGE FACILITY (DOCKET NO 72-21)"

THIS IS A TOPICAL REPORT AND THEREFORE THE INFORMATION PRESENTED IN THE TSAR IS LIMITED. ONLY LIMITED CHECKS OF THE PRELIMINARY ANALYSIS ARE GIVEN. COPIES OF CALCULATIONS PRODUCED AT DJP 6/1/99 DURING THE REVIEW ARE INCLUDED HERE.

				Analysis
LONG BEAMS	6x3 ②	3497 lbsec²/in		[3735]
	6x4 ①	6211 lbsec²/in		[6316]
		side and end walls		

DJP 8/16/2000

MODAL	freq	Effect mass	
X DIREC	3.505	17771	
	8.46	42419	Σ 71%
Y-DIREC	3.616	9484	
	23.66	2447	
	24.66	2728	
	31.83	2936	Σ 57%
Z-DIREC	3.761	68519	Σ 93%

DJP

Y - Vertical
X - Longitudinal Direction
Z - Cross direction

DJP

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THE MASS OF THE MAJOR BEAMS IN THE TRANSFER FACILITY WAS FOUND TO BE PROPERLY IMPLEMENTED IN THE ANALYSIS.
THE RESOLVED MODAL MASS IN THE ANALYSIS WAS CHECKED. THE Z-DIREC WAS 93%, THE X-DIRECTION WAS 71% AND THE Y-DIRECTION WAS 57%

THE GEOMETRY OF THE SLAB WAS THEN CHECKED, MASS & INERTIA

23 July 99

Slab Geometry Checks

720 960
60' x 80' x 3'

14,400 ft³ ⇒ 2,160,000 lbs ⇒ 5,596 lbsec²/in

DJP 8/16/2000

ANALYSIS 5745.3 lbsec²/in 2.6% high ~~[illegible]~~ added thickness) use 37" get 5745.3 lbsec²/in

$I = \frac{1}{12} bt^3$

AREA

$I_1 = \frac{1}{12}(720)(960)^3 = .531 \times 10^{14}$ in⁴
$I_2 = \frac{1}{12}(960)(720)^3 = .299 \times 10^{11}$ in⁴
$I_p = \frac{1}{12}(720)(960)(720^2 + 960^2) = .829 \times 10^{11}$ in⁴

MASS MOMENT OF INERTIA

$I_1 = \frac{1}{12}(\text{mass})(960)^2 = .441 \times 10^9$ lbsec²in
$I_2 = \frac{1}{12}(\text{mass})(720)^2 = .248 \times 10^9$ "
$I_p = \frac{1}{12}(\text{mass}(960^2 + 720^2) = 689 \times 10^9$ "

ADDITIONAL CHECKS OF THE BUILDING STRUCTURE WERE MADE. THE CALCULATED WALL & ROOF WEIGHT COMPARED TO THE ANALYSIS

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From P

Building Geometry
Checks 7/23/98
DJP

WALL HEIGHT 75' 18" Thick

BUILDING LENGTH 250'

BUILDING WIDTH 88'

VERTICAL COLUMNS 2×11 @ 4×8 (5) & (7)
2×2 @ 4×3 (6)

LONG BEAMS 1×2 @ 6'×3' @ 128'
1×2 @ 6'×4' @ 150'
1×2 @ 6'×4' @ 176'
2×1 @ 3'×4' ROOF

ROOF BEAMS 11 @ 5×4'
Corner @ 6×4

ROOF 14" THICK

WALLS 75' × 250' × 2' × 18" = 56,250 ft³ ⇒ 8.458×10⁶
END WALLS 75' × 88' × 2' × 18" = 19,800 ft³ ⇒ 2.970×10⁶
ROOF 88' × 250' × 14" = 25,666 ft³ = 3.850×10⁶

ANALYSIS (18) WALLS = 77683 ≈ (29554)
(19) ROOF = 10247 ≈ (9974)

15.258×10⁶ lb
39,530 lbsec²/in

VERTICAL COLUMNS 360,000 lbs each (932.6 lbsec²/in)
Analysis [22,897] 20,518 lbsec²/in total
135,000 lbs each (349.7 lbsec²/in)
Analysis [1546] ≈ 1,399 lbsec²/in

ROOF BEAMS

				Analysis
3×4	450,000 lbs each	1,166 lbsec²/in	⇒ 2332	(9) [2486]
5×4	264,000 lbs each	684 lbsec²/in	⇒ 6155	(8) [6250]
6×4			4663	(10) [4935]

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AS NOTED THIS WAS A TOPICAL REPORT. DETAILED RESULTS WERE NOT GIVEN. BASED ON CHECKS OF THE MODEL GEOMETRY THE SCOPING ANALYSIS IS CONSIDERED ADEQUATE

DJP

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I have reviewed this scientific notebook and find it in compliance with SAP-001. There is sufficient information regarding procedures used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

6/10/99

MGFE Manager

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