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Dose Rate Calculations for Strontium Fluoride Capsules and Cesium Chloride Capsules and for such Capsules as Overpacked for Disposal

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Abstract: This documents the dose rate calculations for the Strontium Fluoride and Cesium Chloride capsules and Overpacked Capsules

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DOSE RATE CALCULATIONS FOR STRONTIUM FLUORIDE CAPSULES AND CESIUM CHLORIDE CAPSULES AND FOR SUCH CAPSULES AS OVERPACKED FOR DISPOSAL

1.0 INTRODUCTION

Dose Rates were estimated for both single and multiple capsule grouping of strontium fluoride capsules and also for cesium chloride capsules. This work was done to support TWRS program evaluations of planning options for capsule disposal, if they are eventually declared waste.

Dose rates were calculated at 1 cm and 1 m away from the outer surface of a single strontium fluoride (SrF_2) capsule unit, which is composed of two encapsulation barriers, each fully weld-sealed, on inside the other. Dose rates were also similarly calculated related to the outside surface of a thin-walled tube-in-tube overpack configuration with a set of 8 strontium fluoride capsules positioned end-to-end within a holder tube concentrically located along the axial centerline. This work is an extension of the cesium chloride dose rate calculations identified in Reference 1. Because the outer dimension of the overpack has changed since the reference (cesium chloride) calculations, an additional table is included in this report updating the dose rate values for 8 cesium chloride capsules in an overpack.

2.0 SUMMARY

Table 1 lists the dose rates calculated for a single strontium fluoride capsule with a salt (SrF_2) density of 2.9 g/cc. Table 2 lists the corresponding single capsule dose rates for a salt density of 3.8 g/cc. For overpacked capsules, Table 3 lists the dose rates calculated for 8 strontium fluoride capsules placed inside the proposed overpack with a salt (SrF_2) density of 2.9 g/cc. Table 4 lists the corresponding overpacked capsule dose rates for a salt density of 3.8 g/cc. Because the decay chain for ^{90}Sr is dominated by beta radiation emissions, the dose rates are more than a factor of ten lower than the dose rates reported in Reference 1 for the decay of ^{137}Cs, which is dominated by gamma radiation emissions.

Table 5 lists the updated dose rates for 8 cesium chloride capsules inside an overpack with a salt (CsCl) density of 2.6 g/cc, and Table 6 lists the calculated dose rates for this same configuration for a salt density of 3.8 g/cc. These updated cesium chloride dose rates are similar to those reported in Reference 1, but reflect the modified overpack diameter.

Table 1. Dose Rates for a single SrF_2 capsule with a density of 2.9 g/cc.

Dose Location	Inner Capsule Thick (in.)	Outer Capsule thick (in.)	Density (g/cc)	Capsule Dose Rates (rem/hr)					
				12/31/2000		12/31/2010		12/31/2030	
				Avg/capsule (33.39 KCi)	Max/capsule (80.81 KCi)	Avg/capsule (26.29 KCi)	Max/capsule (63.63 KCi)	Avg/capsule (16.3 KCi)	Max/capsule (39.45 KCi)
1cm	0.12	0.109	2.90	1.7e+04	4.1e+04	1.3e+04	3.2e+04	8.3e+03	2.0e+04
1 m	0.12	0.109	2.90	1.6e+02	3.9e+02	1.3e+02	3.0e+02	7.8e+01	1.9e+02
1cm	0.136	0.136	2.90	1.6e+04	3.9e+04	1.3e+04	3.0e+04	7.8e+03	1.9e+04
1 m	0.136	0.136	2.90	1.5e+02	3.6e+02	1.2e+02	2.9e+02	7.3e+01	1.8e+02

Table 2. Dose Rates for a single SrF_2 capsule with a density of 3.8 g/cc.

Dose Location	Inner Capsule Thick (in.)	Outer Capsule thick (in.)	Density (g/cc)	Capsule Dose Rates (rem/hr)					
				12/31/2000		12/31/2010		12/31/2030	
				Avg/capsule (33.39 KCi)	Max/capsule (80.81 KCi)	Avg/capsule (26.29 KCi)	Max/capsule (63.63 KCi)	Avg/capsule (16.3 KCi)	Max/capsule (39.45 KCi)
1cm	0.136	0.136	3.80	1.4e+04	3.4e+04	1.1e+04	2.7e+04	6.8e+03	1.7e+04
1 m	0.136	0.136	3.80	1.3e+02	3.1e+02	1.0e+02	2.5e+02	6.3e+01	1.5e+02
1cm	0.12	0.109	3.80	1.5e+04	3.6e+04	1.2e+04	2.9e+04	7.3e+03	1.8e+04
1 m	0.12	0.109	3.80	1.4e+02	3.4e+02	1.1e+02	2.7e+02	6.8e+01	1.7e+02

Table 3. Dose Rates for 8 SrF_2 Capsules in an Overpack with a density of 2.9 g/cc.

Dose Location	Inner Capsule Thick (in.)	Outer Capsule thick (in.)	Density (g/cc)	Capsule Dose Rates (rem/hr)					
				12/31/2000		12/31/2010		12/31/2030	
				Avg/capsule (33.39 KCi)	Max/capsule (80.81 KCi)	Avg/capsule (26.29 KCi)	Max/capsule (63.63 KCi)	Avg/capsule (16.3 KCi)	Max/capsule (39.45 KCi)
1cm	0.12	0.109	2.90	6.9e+02	1.7e+03	5.4e+02	1.3e+03	3.4e+02	8.1e+02
1 m	0.12	0.109	2.90	1.6e+02	3.8e+02	1.3e+02	3.0e+02	7.8e+01	1.9e+02
1cm	0.136	0.136	2.90	6.5e+02	1.6e+03	5.1e+02	1.2e+03	3.1e+02	7.6e+02
1 m	0.136	0.136	2.90	1.5e+02	3.6e+02	1.2e+02	2.8e+02	7.3e+01	1.8e+02

Table 4. Dose Rates for 8 SrF_2 Capsules in an Overpack with a density of 3.8 g/cc.

Dose Location	Inner Capsule Thick (in.)	Outer Capsule thick (in.)	Density (g/cc)	Capsule Dose Rates (rem/hr)					
				12/31/2000		12/31/2010		12/31/2030	
				Avg/capsule (33.39 KCi)	Max/capsule (80.81 KCi)	Avg/capsule (26.29 KCi)	Max/capsule (63.63 KCi)	Avg/capsule (16.3 KCi)	Max/capsule (39.45 KCi)
1cm	0.136	0.136	3.80	5.7e+02	1.4e+03	4.5e+02	1.1e+03	2.8e+02	6.8e+02
1 m	0.136	0.136	3.80	1.3e+02	3.2e+02	1.0e+02	2.5e+02	6.5e+01	1.6e+02
1cm	0.12	0.109	3.80	6.1e+02	1.5e+03	4.8e+02	1.2e+03	3.0e+02	7.2e+02
1 m	0.12	0.109	3.80	1.4e+02	3.4e+02	1.1e+02	2.7e+02	6.9e+01	1.7e+02

Table 5. Dose Rates for 8 CsCl Capsules in an Overpack with a density of 2.6 g/cc.

Dose Location	Inner Capsule Thick (in.)	Outer Capsule thick (in.)	Density (g/cc)	Capsule Dose Rates (rem/hr)					
				12/31/2000		12/31/2010		12/31/2030	
				Avg/capsule (34.94 KCi)	Max/capsule (47.38 KCi)	Avg/capsule (27.77 KCi)	Max/capsule (37.66 KCi)	Avg/capsule (17.54 KCi)	Max/capsule (23.78 KCi)
1cm	0.095	0.109	2.60	5.2e+04	7.1e+04	4.2e+04	5.6e+04	2.6e+04	3.6e+04
1 m	0.095	0.109	2.60	1.2e+04	1.6e+04	9.5e+03	1.3e+04	6.0e+03	8.1e+03
1cm	0.103	0.119	2.60	5.1e+04	7.0e+04	4.1e+04	5.5e+04	2.6e+04	3.5e+04
1 m	0.103	0.119	2.60	1.2e+04	1.6e+04	9.3e+03	1.3e+04	5.9e+03	8.0e+03
1cm	0.136	0.136	2.60	4.9e+04	6.6e+04	3.9e+04	5.2e+04	2.4e+04	3.3e+04
1 m	0.136	0.136	2.60	1.1e+04	1.5e+04	8.9e+03	1.2e+04	5.6e+03	7.6e+03

Table 6. Dose Rates for 8 CsCl Capsules in an Overpack with a density of 3.8 g/cc.

Dose Location	Inner Capsule Thick (in.)	Outer Capsule thick (in.)	Density (g/cc)	Capsule Dose Rates (rem/hr)					
				12/31/2000		12/31/2010		12/31/2030	
				Avg/capsule (34.94 KCi)	Max/capsule (47.38 KCi)	Avg/capsule (27.77 KCi)	Max/capsule (37.66 KCi)	Avg/capsule (17.54 KCi)	Max/capsule (23.78 KCi)
1cm	0.095	0.109	3.80	4.5e+04	6.1e+04	3.6e+04	4.9e+04	2.3e+04	3.1e+04
1 m	0.095	0.109	3.80	1.0e+04	1.4e+04	8.3e+03	1.1e+04	5.2e+03	7.1e+03
1cm	0.103	0.119	3.80	4.4e+04	6.0e+04	3.5e+04	4.8e+04	2.2e+04	3.0e+04
1 m	0.103	0.119	3.80	1.0e+04	1.4e+04	8.1e+03	1.1e+04	5.1e+03	7.0e+03
1cm	0.136	0.136	3.80	4.2e+04	5.7e+04	3.4e+04	4.6e+04	2.1e+04	2.9e+04
1 m	0.136	0.136	3.80	9.7e+03	1.3e+04	7.7e+03	1.1e+04	4.9e+03	6.6e+03

3.0 MODEL FOR A SINGLE STRONTIUM FLUORIDE CAPSULE

Per discussions with E. H. Randklev, two different strontium fluoride densities were used in the calculations. A density of 2.9 g/cc (2.02 g/cc strontium, 0.88 g/cc fluoride) was used to represent a smeared density as referenced in the BUSS cask Safety Analysis Report for Packaging (SARP). The 2.9 g/cc is 70 % of theoretical density. A density of 3.8 g/cc (2.65 g/cc strontium, 1.15 g/cc fluoride) was used to represent the actual expected density as provided by reference information from E. H. Randklev. Dose rates were calculated at both 1 cm and 1 m away from the outer surface of the outer capsule envelope of the doubly encapsulated salt column. Appendix A includes the ISOSHIELD input files used for this case.

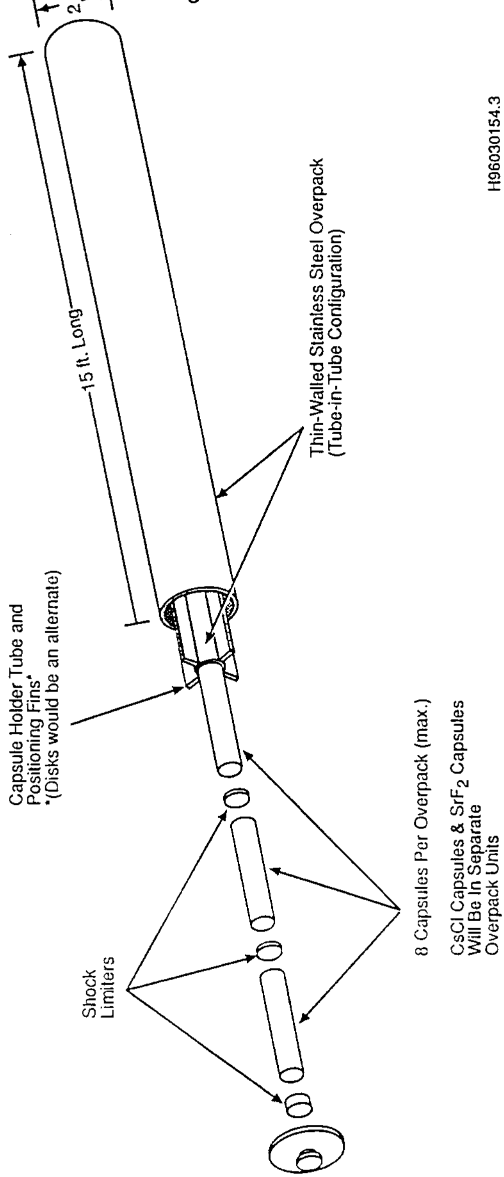
Tables 1 and 2 list the dose rates calculated for a single strontium fluoride capsule for two different salt density values. The Hanford strontium fluoride capsules consist of two metallic encapsulation envelopes, one inside the other and fully sealed by welding, both made of metal alloy tubing that is end capped. The single strontium fluoride salt column was modeled as a cylinder 18.92 in. (48.06 cm) long with a radius of 1.005 in. (2.5527 cm) or 0.989 in. (2.51206 cm) depending on the capsule wall thickness. Surrounding the salt column is an inner capsule of Hastelloy C-276 (nickel base alloy). Two cases of inner capsule wall thicknesses were modeled; namely a minimum thickness of 0.12 in. (0.3048 cm) and a maximum thickness of 0.136 in. (0.34544 cm) Surrounding the inner capsule is an outer capsule made of 316 stainless steel. The three generations of wall thickness for the outer capsule were modeled only as the minimum thickness of 0.109 in. (0.27686 cm) and a maximum thickness of 0.136 in. (0.34544 cm), for this analysis.

The Hastelloy C-276 was modeled as 6.6639 g/cc nickel, 0.4443 g/cc iron, 1.4216 g/cc chrome and 0.3554 g/cc tungsten for a total density of 8.885 g/cc (0.321 lbs/cc) The 316 stainless steel alloy for the outer barrier of the Hanford SrF_2 capsules was modeled as having a composition of 1.106 g/cc nickel, 5.372 g/cc iron and 1.422 g/cc chrome and a density of 7.90 g/cc.

4.0 MODEL FOR 8 STRONTIUM FLUORIDE CAPSULES IN AN OVERPACK

Figure 1 provides a general illustration (Randklev) of the capsule loaded overpack design concept that was used in these analyses. Tables 3 and 4 list the dose rates calculated for 8 strontium fluoride capsules placed end-to-end in a thin-walled stainless steel tube-type overpack design. For this configuration, the salt column of strontium fluoride is modeled as a cylinder with a radius of 1.005 in. (2.5527 cm) or 0.989 in. (2.51206 cm) depending on the capsule wall thickness. Surrounding the salt column is an inner capsule of Hastelloy C-276 (Nickel base alloy) with a minimum thickness of 0.12 in. (0.3048 cm) and a maximum thickness of 0.136 in. (0.34544 cm) Surrounding the inner capsule is an outer stainless steel capsule, which was modeled as a minimum thickness of 0.109 in. (0.27686 cm) and a maximum thickness of 0.136 in. (0.34544 cm), from the set of three generations of tubing design.

Figure 1.
Configuration for tube-in-tube overpack concept.



Surrounding the string of eight capsules, positioned end-to-end, is a 3.0 in. OD, 0.25 in. thick stainless steel tube that is positioned down the axial centerline of this overpack. This tube is then surrounded by the outer shell of the overpack, which consists of a 24 in. OD, 3/8 in. thick stainless steel tube, which is closed with weld-sealed caps at both ends (Randklev 1996b) .

Because the ISOSHIELD code can only model at most 5 "shields" (i.e. radiation shielding barriers), the above geometry was modeled with the following 5 choices for the "shields". Shield 1 is the source region (i.e. salt column) with a minimum radius of 0.989 in. (2.51206 cm) and a maximum radius of 1.005 in. (2.5527 cm). Shield 2 is the Hastelloy C-276 (inner capsule barrier) with a minimum wall-thickness of 0.12 in. (0.3048 cm) and a maximum wall-thickness of 0.136 in. (0.34554 cm) (i.e., per the two generations of capsule tubing design). The dimensions for the capsule wall thickness options were taken from the Washburn (1989) reference, and were also used in performing the dose rate calculations reported in the Schwarz (1995) reference. Shield 3 is modeled as as the dimensional combination of the respective wall thicknesses of two 316 stainless steel components of the overpacked capsule configuration. Shield 3 combines the outer capsule wall and the 0.25 in. thick (capsule) holder tube of the thin-walled overpack design concept (Figure 1). Shield 3 has a minimum thickness of 0.359 in.(0.109 in. + 0.25 in.) (0.91186 cm) and a maximum thickness of 0.386 in. (0.136 in. + 0.25 in.) (0.98044 cm), where the 0.109in. and 0.136 in. values represent the first and third generations of outer capsule tubing design, respectively, for the three generations used in such Hanford capsule production. Shield 4 is an air gap with a minimum thickness of 10.114 in. (25.68956 cm) and a maximum thickness of 10.141 in. (25.75814 cm). Shield 5 is a 316 stainless steel shield (i.e. outer wall of the overpack) with a thickness of 0.375 in. (0.9525 cm).

The "shield" material compositions are the same as those assumed for the single capsule case as discussed in Section 3.0. Dose rates were calculated at 1 cm and 1 m away from exterior surface of the outer barrier of the overpack. The ISOSHIELD input file for this case is listed in Appendix B.

5.0 MODEL FOR 8 CESIUM CHLORIDE CAPSULES IN AN OVERPACK

Tables 5 and 6 list the dose rates calculated for 8 cesium chloride capsules placed in the proposed overpack. Again, refer to Figure 1 (Randklev) for a general illustration of this design concept. For this configuration, the cesium chloride salt column is modeled as a cylinder with a nominal radius of 1.03 in. (2.6162 cm), 1.022 in. (2.59588 cm) or 0.9915 in. (2.51841 cm) depending on the respective wall thickness of the three generations of stainless steel tubing used during the production history (Washburn, 1989). Surrounding the salt column (radiation source) region is an inner and an outer set of 316 stainless steel tubes with each tube capped and fully sealed by welding. The capsules are encased in a 3.0 in. OD, 0.25 in. thick steel tube. This tube is then surrounded by the outer shell layer of the overpack which is stainless steel tubing that is 24 in. OD, and 3/8 in thick.

Because the ISOSHIELD code can only model up to 5 "shields" (i.e. radiation shielding barriers), the above geometry was modeled with the following 4 choices for the "shields". Shield 1 is the source region (i.e. salt column) with a radius of 1.03 in. (2.6162 cm), 1.022 in. (2.59588 cm) or 0.9915 in. (2.51841 cm). Shield 2 is composed of three stainless steel components of the overpacked capsules, as viewed in a radial cross-section; namely, the inner and outer capsule barrier tubing walls plus the thickness of the capsule holder tube component of the overpack design. . Hence Shield 2 is a steel multi-layered shield with a combined thickness of 0.454 in. (0.095 in. + 0.109 in. + 0.25 in.) (1.15316 cm), 0.472 in. (0.103 in. + 0.119 in. + 0.25 in.) (1.19888 cm) or 0.522 in. (0.136 in. + 0.136 in. + 0.25 in.) (1.32588 cm). Shield 3 is an air gap with a thickness of 10.141 in. (25.75814 cm), 10.131 in. (25.73274 cm), or 10.1115 in. (25.68321 cm), which correspond to such gap dimensioning when adjusted, respectively, for the three generations of capsule tubing wall design. Shield 4 is the wall thickness for the outer shell of the stainless steel overpack design, and is nominally 0.375 in. (0.9525 cm) thick.

The cesium chloride radiation source was also modeled for two density levels (i.e. 3.8 g/cc and 2.6 g/cc) to approximate the nominal smear density, including the range above and below a solid state CsCl phase transformation, which is also modified by selected impurities. Both of the encapsulation tubes of the cesium chloride capsule design are made of 316 stainless steel. Dose rates were calculated at 1 cm and 1 m away from the outside of the overpack. The ISOSHIELD input files (i.e. 1 file for each of the two density assumptions) for these cases are listed in Appendix C.

6.0 SOURCE DESCRIPTION

The capsule radioisotope inventory sources for the dose rate analyses results in Tables 1 through 3 were obtained from Randklev (1996b) for decay times of 12/31/2000, 12/31/2010 and 12/31/2030. Dose rates were calculated at each decay time for both the average and maximum estimates of capsule inventory (Kilocuries) and for the maximum and minimum capsule wall thicknesses.

7.0 CALCULATION

All calculations were done using the ISOSHIELD computer code (Reference 3), the "buildup factor" (i.e. factor to account for collisions within the shields) primary shielding material was specified for the last (steel) shield layer radially outward from the center of the capsule, across the radial cross section, for the two general analysis cases (i.e. both single capsule and overpacked capsule). The ANSI/ANS(1991) fluence to dose conversion factors were used in calculating the dose rates with the assumption that the radiation is entering the body assuming an anterior-posterior orientation (i.e. front to back).

8.0 REFERENCES

ANSI/ANS, 1991, ANSI/ANS-6.1.1-1991, "Neutron and Gamma-Ray Fluence-to-Dose Factors," American Nuclear Society.

Randklev, E. H., 1996, Informal Memorandum to Randy Schwarz, Eldon Cramer, , "Watts/Capsule and Kilocuries/Capsule for Cesium Chloride Capsules and Strontium Fluoride Capsules Estimated Per a Set of Decay Dates and Instructions on Which Dates to Use in Your Analysis", dated September 20, 1996. (See APPENDIX D for a copy.)

Randklev, E. H., 1994, per T. J. Coates to E. H. Randklev letter transmittal (April 8, 1994) of Haynes Corp. C-276 Alloy - Product Bulletin (H-2002B ; 111891), Haynes International, Inc., Kokomo, Indiana, 46904 .
Rittman, P. D.,1995, "ISO-PC Version 1.98 - User's Guide," WHC-SD-WM-UM-030, Rev. 0, 1995, Westinghouse Hanford Company, Richland, WA 99352.

Schwarz, R. A., 1995, Letter Report to E. H. Randklev, "Dose Rate Calculations for CsCl Capsules", 8M730-RAS-95-003, dated June 2, 1995, Westinghouse Hanford Company, Richland, WA 99352.

Washburn, D. F., 1989, "Interim Report: Resolution of Special Form Issues Associated with Cesium Chloride Capsules Manufactured at WESF," SD-WM-DIC-004, EDT 461236, Westinghouse Hanford Company, Richland, Washington, 99352.

Appendix A. ISOSHIELD Input File for 1 Strontium Fluoride Capsule.

```
0       2 Dose Rate SRF2 with a density of 2.9 g/cc
One capsule, MIN DEN, MIN STEEL, AVG SRC, 2000
 &Input  Next= 1,  Option= 1,  Dunit=1, Iconc=0,
  Igeom= 7,  Slth= 48.06, Y=24.03,
  Npsi=100, Ntheta= 100, Delr= 0.1, X(1)= 4.33375, 103.33375,
  Nshld= 4, Jbuf= 4, T(1)=2.5527, T(2)=0.3048, T(3)=0.19939,
  T(4)=0.27686,
  Weight(82) =33390,  Weight(84) =33390  &
 Sr   18  2.02
 F    24  0.88
 Ni   10        6.6639              1.106
 Fe    9        0.4443              5.372
 Cr   34         1.4216             1.422
 W    13         0.3554
1 Air   3                 0.00129
One Capsule MIN DEN, MAX STEEL, AVG SRC, 2000
 &Input  Next= 4,  T(1)=2.51206, T(2)=0.34544, T(3)=0.13081, T(4)=0.34544 &
One Capsule MAX DEN, MAX STEEL, AVG SRC, 2000
 &Input  Next= 1  &
 Sr   18  2.65
 F    24  1.15
 Ni   10        6.6639              1.106
 Fe    9        0.4443              5.372
 Cr   34         1.4216             1.422
 W    13         0.3554
1 Air   3                 0.00129
One Capsule MAX DEN, MIN STEEL, AVG SRC, 2000
 &Input  Next= 4,  T(1)=2.5527, T(2)=0.3048, T(3)=0.19939, T(4)=0.27686 &
END OF RUN
 &Input Next= 6  &
```

Appendix B. ISOSHIELD Input File for 8 Strontium Fluoride Capsules.

```
0       2 Dose Rate SRF2 with a density of 2.9 g/cc
Eight Capsules MAX DEN, MIN STEEL, AVG SRC, 2000
 &Input  Next= 1,  Option= 1,  Dunit=1, Iconc=0,
  Igeom= 7,  Slth= 457.2, Y=228.6,
  Npsi=100, Ntheta= 100, Delr= 0.1, X(1)= 31.48, 130.48,
  Nshld= 5, Jbuf= 5, T(1)=2.5527, T(2)=0.3048,
  T(3)=0.91186, T(4)=25.75814, T(5)=0.9525,
  Weight(82)=267120,  Weight(84)=267120  &
 Sr   18   2.65
 F    24   1.15
 Ni   10         6.6639     1.106          1.106
 Fe    9         0.4443     5.372          5.372
 Cr   34         1.4216     1.422          1.422
 W     13        0.3554
1 Air  3                       0.00129
Eight Capsules MAX DEN, MAX STEEL, AVG SRC, 2000
 &Input  Next= 4, T(1)=2.51206, T(2)=0.34544,T(3)=0.98044,
 T(4)=25.68956, T(5)=0.9525  &
Eight Capsules MIN DEN, MAX STEEL, AVG SRC, 2000
 &Input  Next= 1  &
 Sr   18   2.02
 F    24   0.88
 Ni   10         6.6639     1.106          1.106
 Fe    9         0.4443     5.372          5.372
 Cr   34         1.4216     1.422          1.422
 W     13        0.3554
1 Air  3                       0.00129
Eight Capsules MIN DEN, MIN STEEL, AVG SRC, 2000
 &Input  Next=4, T(1)=2.5527, T(2)=0.3048, T(3)=0.91186,
 T(4)=25.75814, T(5)=0.9525  &
END OF RUN
 &Input Next= 6  &
```

Appendix C. ISOSHIELD Input Files for 8 Cesium Chloride Capsules.

```
0        2 Dose Rate CsCl with a density of 3.8 g/cc
Eight Capsules, 0.518 thick, AVG SRC, 2000
 &Input  Next= 1,  Option= 1,  Dunit=1, Iconc=0,
   Igeom= 7,  Slth= 457.2, Y=228.6,
   Npsi=100, Ntheta= 100, Delr= 0.1, X(1)= 31.48, 130.48,
   Nshld= 4, Jbuf= 4, T(1)=2.6162, T(2)=1.15316,
   T(3)=25.75814, T(4)=0.9525,
   Weight(335)=279520,  Weight(336)=279520  &
  Cs   39   3.00
  Cl   30   0.80
  Ni   10           1.106             1.106
  Fe    9           5.372             5.372
  Cr   34           1.422             1.422
1 Air   3                 0.00129
Eight Capsules, 0.564 thick, AVG SRC, 2000
 &Input  Next= 4, T(1)=2.59588, T(2)=1.19888,T(3)=25.73274,
 T(4)=0.9525  &
Eight Capsules, 0.635 thick, AVG SRC, 2000
 &Input  Next= 4, T(1)=2.51841, T(2)=1.32588,T(3)=25.68321,
 T(4)=0.9525  &
END OF RUN
 &Input Next= 6  &
```

```
0        2 Dose Rate CsCl with a density of 2.6 g/cc
Eight Capsules, 0.518 thick, AVG SRC, 2000
 &Input  Next= 1,  Option= 1,  Dunit=1, Iconc=0,
   Igeom= 7,  Slth= 457.2, Y=228.6,
   Npsi=100, Ntheta= 100, Delr= 0.1, X(1)= 31.48, 130.48,
   Nshld= 4, Jbuf= 4, T(1)=2.6162, T(2)=1.15316,
   T(3)=25.75814, T(4)=0.9525,
   Weight(335)=279520,  Weight(336)=279520  &
  Cs   39   2.05
  Cl   30   0.55
  Ni   10           1.106             1.106
  Fe    9           5.372             5.372
  Cr   34           1.422             1.422
1 Air   3                 0.00129
Eight Capsules, 0.564 thick, AVG SRC, 2000
 &Input  Next= 4, T(1)=2.59588, T(2)=1.19888,T(3)=25.73274,
 T(4)=0.9525  &
Eight Capsules, 0.635 thick, AVG SRC, 2000
 &Input  Next= 4, T(1)=2.51841, T(2)=1.32588,T(3)=25.68321,
 T(4)=0.9525  &
END OF RUN
 &Input Next= 6  &
```

Appendix D.--Copy of Randklev (1996) reference--Informal Memorandum

DON'T SAY IT --- *Write It!*

DATE: Sept. 20, 1996

TO: Randy Schwarz/WHC H0-35
Eldon Cramer/WHC H0-34

FROM: Ed Randklev/WHC H5-27
Telephone: 376-1456

cc: Victor Roetman H0-35
EHR file

SUBJECT: Watts/Capsule and Kilocuries/Capsule for Cesium Chloride Capsules and Strontium Fluoride Capsules Estimated Per a Set of Decay Dates and Instructions on Which Dates to Use in Your Analyses

Randy Schwarz: Radiation Analysis Work — (Copy of just this portion of DSI)

1. Cesium Chloride Capsule Analyses:
   a. Please note that I am now interested in an earlier start date (per new info. on disposal processing scenarios) than the 2010 date I noted in my letter of 8/30/96. Namely, 2000 is now the earliest start date of interest for moving and processing such capsules per some of the scenario options. Please let me know if I am wrong, but I do NOT think this matters for the MCNP decay energy deposition profile problem you are analyzing (i.e., what you get for an answer per a 2010 decay date will be the same). See Attachment I for the CsCl capsule values for several decay dates.
   b. I am now interested in knowing what the estimated dose rates will be for a single capsule and an overpack filled with 8 capsules (i.e., like what was done in FY-95 for me for the decay years of 2010 and 2035). Again, correct me if I am wrong, but I am assuming that I can suitably estimate the dose rate values I need for the 2000 decay date, and 2030, by just proportionally adjusting the FY-95 values relative to the kCi/capsule values (i.e., we do not need to formally run this case in the code). Please let me know your recommendation.
   c. At present I do not think you have need for the decay values for 2035 that I put in my letter of 8/30/96. This situation will only be relevant to the thermal analysis work that Eldon Cramer will be doing.
   d. I am still somewhat concerned about the salt density value that you use in your analyses. I can see where the "smeared" density value used in the past shielding calculations (per ref. to SARP work on BUSS cask) will yield conservative dose rate values. However, for MCNP and the energy deposition profile, given our primary concern about salt:metal interface temperatures, I am concerned about any use of such a "smeared" density value in MCNP. To what extent is MCNP even sensitive to the density value used for the salt?
   ACTION/Randy: Get back to me on this one.

2. Strontium Fluoride Capsule Analyses:
   a. Please do the dose rate determinations for the decay years of 2000, 2010 and 2030 for a single capsule (max. and ave. inventories) and an overpacked set of 8 capsules (max. and ave. inventories).

9/20/96
EHR

Attachment I

CESIUM CAPSULES (1328)

Activity	12/31/2000	12/31/2003	12/31/2005	12/31/2010	12/31/2030	12/31/2040	12/31/2080
Maximum Wattage	227.54	212.39	202.85	180.84	114.22	90.77	36.21
Average Wattage	167.80	156.63	149.59	133.36	84.23	66.94	26.70
Minimum Wattage	109.64	102.34	97.74	87.14	55.04	43.74	17.45
Median Value - Wattage	167.09	155.92	148.96	132.80	83.88	66.66	26.59
Maximum kCi	47.38	44.23	42.24	37.66	23.78	18.90	7.54
Average kCi	34.94	32.61	31.15	27.77	17.54	13.94	5.56
Minimum kCi	22.87	21.35	20.39	18.17	11.48	9.12	3.64
Median Value - kCi	34.79	32.48	31.02	27.65	17.47	13.88	5.54

9/20/96
EHR

Attachment II

STRONTIUM CAPSULES (600*)

Activity	12/31/2000	12/31/2003	12/31/2005	12/31/2010	12/31/2030	12/31/2040	12/31/2080
Maximum Wattage	545.63	507.90	484.18	429.64	266.38	209.74	80.63
Average Wattage	225.71	210.10	200.28	177.73	110.19	86.76	33.35
Minimum Wattage	25.60	23.83	22.72	20.16	12.50	9.84	3.78
Median Value - Wattage	220.62	205.36	195.77	173.72	107.71	84.81	32.60
Maximum kCi	80.81	75.23	71.71	63.63	39.45	31.06	11.94
Average kCi	33.39	31.08	29.63	26.29	16.30	12.83	4.93
Minimum kCi	3.75	3.49	3.33	2.96	1.83	1.44	0.55
Median Value - kCi	32.55	30.30	28.89	25.63	15.89	12.51	4.81

*Does not include tracer capsule S-2. Actual number of capsules could be as high as 636.

CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW
NUMBER: WHC-SD-TI-790 Rev 0
DOCUMENT REVIEWED
Dose Rate Calculations for Strontium Fluoride Capsules and Cesium Chloride Capsules and for such Capsules as Overpacked for Disposal
AUTHOR(s) Randolph Schwarz

I. Method(s) of Review

(X) Input data checked for accuracy
(X) Independent calculation performed
    (   ) Hand calculation
    (X) Alternate computer code: MCNP
(   ) 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
(NA) Uncertainty assesment appropriate and reasonable
(   ) Other (define)

III. Comments:

IV. REVIEWER: Victor Roetman *Victor Roetman* DATE: 11/18/96

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Criticality and Shielding	Date November 13, 1996
Project Title/Work Order		EDT No. 619209
Dose Rate Calculations for Strontium Fluoride Capsules and Cesium Chloride Capsules and for such Capsules as Overpacked for Disposal		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
R. D. Claghorn	H5-49	X			
E. R. Cramer	H0-34	X			
J. Greenborg	H0-35	X			
E. H. Randklev	H5-27	X			
V. E. Roetman	H0-35	X			
R. A. Schwarz	K8-34	X			
Central Files (1 + Original)	A3-88	X			