STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

CLIENT & PROJECT	PAGE 1 OF 8
Private Fuel Storage Limited Liability Corporation / Private Fuel Storage Facility	
CALCULATION TITLE **Ingestion Dose Rate Estimates to Nearest Resident from Off-normal Contamination Release of Surface Contamination from the Exterior of a Canister**	QA CATEGORY 1

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
05996.02	**Rad. Protection**	**UR-7**	**NA**	**NA**

APPROVALS - SIGNATURE & DATE						
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J. L. Cooper J L Cooper 5-5-98	J. R. Johns J R Johns 5-8-98	J. Baron J Baron 5-11-98	0	NA		X

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TABLE OF CONTENTS AND HISTORICAL DATA
(Revisions, Additions, Deletions, Etc.)

CALCULATION IDENTIFICATION NUMBER				PAGE 3
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP Rad. Protection	CALCULATION NO. UR-7	OPTIONAL TASK CODE N.A.	

CALCULATION OBJECTIVE

The objective of this calculation is to determine the Ingestion Dose to the nearest resident resulting from the off-normal contamination release, evaluated in SAR Section 8.1.5 (Reference 1), of surface contamination from the exterior of a canister.

BACKGROUND / HISTORICAL INFORMATION

The ingestion pathway could apply where an individual could reasonably be expected to ingest water or food products contaminated with radioactivity released from the accident. While concentrations of radioactivity in the soil in unrestricted areas would be highest near the OCA boundary, it is not reasonable to consider ingestion occurring in this area due to land usage near the PFSF site. As discussed in Section 2.2.2 of the PFSF Environmental Report (Reference 2), some rangeland used for livestock grazing is located near the PFSF. However, there are no farm crops grown within 2 miles of the PFSF. Therefore, the closest location to the PFSF where ingestion could reasonably be expected to occur is the nearest residence located 2 miles southeast of the PFSF (Section 2.2.3.4 of the PFSF Environmental Report). Land use at this location is considered residential with the potential for back yard gardening activities and a dietary consumption as discussed in NUREG/CR-5512, Section 3.2.1 (Reference 3). In addition, Section 2.5.1 of the PFSF Environmental Report states:

> "There are no public or private surface drinking water supplies in the PFSF vicinity. Potable water supplies for the Skull Valley Indian Reservation, and the few scattered ranches or farms along the east side of the valley, are wells drilled into the unconsolidated or semi-consolidated sediments that form the alluvial fan along the base of the Stansbury Mountains. Consequently, there is no potable surface water supply that could be subject to normal or accidental effluents from the facility."

There are no bodies of water in the vicinity of the PFSF OCA boundary.

CALCULATION METHOD

Using the methodology provided in NRC Regulatory Guide 1.111 (Reference 4):

1. Determine the deposition rate and the plume width. Using this information calculate the radionuclide deposition on the surface of the soil.
2. Calculate the concentration of radionuclides per gram of soil.

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP Rad. Protection	CALCULATION NO. UR-7	OPTIONAL TASK CODE N.A.	PAGE 4

Based on the concentrations of radionuclides in the soil, use the results of the pathway dose calculations provided in NUREG/CR-5512, Table 3.3, to calculate the dose to the nearest resident due to the ingestion pathway.

ASSUMPTIONS

1. The removal mechanism (from Regulatory Guide 1.111) is taken to be dry deposition by sorption onto the ground surface.

2. The release (from Regulatory Guide 1.111) is considered a ground level release.

3. The plume depletion correction factor (from Regulatory Guide 1.111) is conservatively assumed to be 1.0.

4. To determine the concentration of Co-60 per gram of soil, assume it only mixes with the top 1 cm of the soil. This is conservative since NUREG/CR-5512 assumes the soil is uniformly contaminated to a depth of 15 cm.

REFERENCES

1. Private Fuel Storage Facility Safety Analysis Report, Revision 0, Docket No. 72-22

2. Private Fuel Storage Facility Environmental Report, Revision 0, Docket No. 72-22

3. NUREG/CR-5512, Residual Radioactive Contamination From Decommissioning - Technical Basis for Translating Contamination Levels to Annual Dose (draft report for comment, January, 1990)".

4. NRC Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases From Light-Water-Cooled Reactors.

5. Calculation 05996.01-UR-3, Revision 1, "Postulated Release of Removable Contamination from Canister Outer Surfaces-Dose Consequences".

6. Private Fuel Storage Facility, Design Criteria Manual, Revision 2, dated 6-20-97, Section 4.4.1.

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP Rad. Protection	CALCULATION NO. UR-7	OPTIONAL TASK CODE N.A.	PAGE 5

CONCLUSION

This analysis indicates that conservatively estimated doses to the nearest resident from the ingestion pathway are negligible (less than I microrem).

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP Rad. Protection	CALCULATION NO. UR-7	OPTIONAL TASK CODE N.A.	PAGE 6

CALCULATION

DETERMINE CONCENTRATIONS OF CO-60 IN SOIL

In order to calculate doses from the ingestion pathway at the nearest residence, it is first necessary to determine concentrations of Co-60 in the soil at this location that could potentially result from the postulated activity release. NRC Regulatory Guide 1.111 contains methodology for calculating deposition of radionuclides on the ground surface due to passage of a plume containing radioactivity across an area.

Deposition for ground level release

The relative deposition for ground level releases is calculated by extracting values off the graph in Figure 6 of this Reg. Guide. It is noted that for ground level releases, the dry deposition rate is independent of wind speed. Page 1.111-7 of this Reg. Guide states the following:

"All effluents can undergo dry deposition by sorption onto the ground surface; however, the dry deposition rate for noble gases, tritium, carbon-14, and nonelemental radioiodines is so slow that depletion is negligible within 50 miles of the release point. Elemental radioiodines and other particulates are much more readily deposited. The transfer of elemental radioiodines and particulates to a surface can be quantified as a transfer velocity (where concentration X transfer velocity = deposition rate). There is evidence that the transfer velocity is directly proportional to windspeed and, as a consequence, the rate of deposition is independent of windspeed since concentration in air is inversely proportional to windspeed."

Deposition rate and plume width

Based on Figure 6 of the Reg. Guide, at 3,219 meters (2.0 miles), a relative deposition rate of 2.3 E-5 $meter^{-1}$ is determined. While Figure 6 identifies the relative deposition rate in units of $meter^{-1}$ (Ci/sec per meter divided by Ci/sec), it is necessary to divide this by the plume width to determine the deposition rate in units of $meter^{-2}$. Page 1.111-12 of the Reg. Guide states the following:

"Figures 6 through 9 are based on the assumption that the effluent concentration in a given sector is uniform across the sector at a given distance. Therefore, for the straight-line trajectory model, or for any model that assumes uniform concentration across the sector at a given distance, the relative deposition rate should be divided by the arc length of the sector at the point being considered..."

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP Rad. Protection	CALCULATION NO. UR-7	OPTIONAL TASK CODE N.A.	PAGE 7

Based on Regulatory Position C.4 of Regulatory Guide 1.111, for routine releases taking place over the course of a year a sector is typically assumed to be 1/16 of a circle, an arc of 22.5 degrees, and annual average dispersion/deposition factors calculated. For a one-time release, it is reasonable to assume the plume is confined to a narrower sector so 1/32 of a circle, an arc of 11.25 degrees, was considered for this special case (smaller sector results in greater ground concentrations). The arc length at 2.0 miles for an 11.25 degree angle is 632 meters. Dividing the relative deposition rate of 2.3 E-5 m^{-1} at a distance of 3,219 m by the plume sector width at 2.0 miles results in a deposition rate of:

$$\frac{2.3\text{ E-5 m}^{-1}}{632\text{ m}} = 3.64\text{ E-8 m}^{-2}$$

<u>Radionuclide deposition on soil surface</u>

This deposition rate assumes a uniform activity concentration across the width of the plume. Radionuclide deposition is then calculated by multiplying the deposition rate by the source term for the Co-60 in the plume. The source term is given in Calculation 05996.01-UR-3 (Reference 5) as 31.2 μCi released to atmosphere from the external surfaces of a canister. The concentration of Co-60 on the surface of soil at a distance of 2.0 miles from the PFSF is thus:

$$(31.2\ \mu\text{Ci})\ (3.64\text{ E-8 meter}^{-2}) = 1.14\text{ E-6 }\mu\text{Ci/meter}^2$$

<u>Determine concentration per gram of soil</u>

If it is conservatively assumed that this concentration of Co-60 mixes uniformly with soil <u>only in the top 1 cm from the surface</u> due to leaching, the concentration of Co-60 per gram of soil can be calculated. The density of moist in situ topsoil is taken as 1.3 g/cc (Reference 6).

$$\text{Activity Concentration} = \frac{(1.14\text{ E-6 }\mu\text{Ci/m}^2)}{(1.0\text{ E4 cm}^2/\text{m}^2)\ (1\text{ cm depth})} = 1.14\text{ E-10 }\mu\text{Ci/cm}^3$$

$$\frac{(1.14\text{ E-10 }\mu\text{Ci/cm}^3)}{1.3\text{ g/cm}^3} = 8.77\text{ E-11 }\mu\text{Ci/g} = 8.77\text{ E-5 pCi/g}$$

CALCULATION IDENTIFICATION NUMBER				PAGE 8
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP Rad. Protection	CALCULATION NO. UR-7	OPTIONAL TASK CODE N.A.	

DOSE TO NEAREST RESIDENT

This is an extremely low concentration of Co-60 in soil. For comparison purposes, NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning - Technical Basis for Translating Contamination Levels to Annual Dose (draft report for comment)", (reference 3), was consulted since it includes pathway dose calculations based on concentrations of radionuclides in soil. Specifically, Section 3.2.1 of this NUREG, "Residential Use (Surface Soil) Scenario", contains dose conversion factors assuming a resident has a backyard garden from which the person grows a substantial fraction of their vegetable diet in contaminated soil, and ingests these vegetables. This section considers three major radiation exposure pathways: inhalation of contaminated dust, ingestion of vegetables grown in the contaminated soil, and direct exposure to gamma radiation. This model assumes the soil is uniformly contaminated to a depth of 15 cm and the resident ingests 25% of their total diet from food grown in contaminated soil at the site. In addition to the soil-to-vegetable-to-person ingestion pathway, the analysis also considers ingestion of milk, meats and eggs from animals whose foodstuffs are contaminated by grazing on grass and crops grown in the contaminated soil. Table 3-3 of this NUREG lists resulting annual total effective dose equivalent (TEDE) factors in units of mrem per pCi/g in soil. For Co-60, the TEDE for the residential use scenario is 7.7 mrem per pCi/g concentration of Co-60 in the soil. This table indicates that nearly all of this total is from external dose due to ground shine, with 6.0 E-3 mrem per pCi/g due to the ingestion pathway.

Based on this model, which is conservative for the nearest residence to the PFSF, the soil concentration of 8.77 E-5 pCi/g Co-60 calculated to result from the postulated release of canister contamination event would potentially produce a TEDE of:

(8.77 E-5 pCi/g) (7.7 mrem per pCi/g) = 6.75 E-4 mrem per year to the nearest resident

with

(8.77 E-5 pCi/g) (6.0 E-3 mrem per pCi/g) = 5.26 E-7 mrem per year of this total from the ingestion pathway

This analysis indicates that conservatively estimated doses to the nearest resident from the ingestion pathway are negligible (less than I microrem).