

CALCULATION TITLE PAGE

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CLIENT & PROJECT <i>Private Fuel Storage Limited Liability Corp. / Private Fuel Storage Facility</i>					PAGE 1 OF 8	
CALCULATION TITLE (Indicative of the Objective): <i>Postulated Release of Removable Contamination from Canister Outer Surfaces - Dose Consequences</i>					QA CATEGORY (✓) ☒ I - NUCLEAR SAFETY RELATED ☐ II ☐ III ☐ OTHER	
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J. O. OR W. O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE			
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<i>J.R. Johns</i> <i>JR Johns</i> <i>6/5/97</i>	<i>W.P. Hennessy</i> <i>W.P. Hennessy</i> <i>6/15/97</i>	<i>W.P. Hennessy</i> <i>W.P. Hennessy</i> <i>6/15/97</i>	<i>0</i>	<i>N.A.</i>		<i>✓</i>
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SUBJECT/TITLE Postulated Release of Removable Contamination from Computer Control Surfaces - Dose Consequences	QA CATEGORY/CODE CLASS I
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Postulated Release of Removable Contamination
from Outer Surfaces - Dose Consequences

OA CATEGORY/CODE CLASS

I

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(Revisions, Additions, Deletions, Etc.)

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CALCULATION OBJECTIVE

The objective of this calculation is to determine conservative doses at the Private Fuel Storage Facility (PFSF) Owner Controlled Area (OCA) boundary and at 150 meters from the postulated release of contamination from the outer surfaces of a canister. In addition, concentrations inside the Canister Transfer Building resulting from this postulated accident are calculated for comparison with 10 CFR 20 derived air concentration occupational values.

CALCULATION METHOD / ASSUMPTIONS

It is conservatively assumed that the entire outer surface of a canister is covered with removable contamination at a concentration of 22,200 dpm/100 cm², slightly above the maximum allowable limit of PFSF Proposed Technical Specification 3/4.1, "Canister External Surface Contamination", 22,000 dpm/100 cm². It is assumed that all of the surface contamination is Co-60, consistent with the approach used by Sierra Nuclear Corporation in their evaluation of this postulated accident in the TranStor SAR (Reference 1). This particular event is not analyzed in the HI-STORM SAR (Reference 2). It is conservatively assumed that 100% of this external surface contamination is released from the vendor's canister having the greatest external surface area. Doses are calculated to individuals assumed to be 150 meters and 500 meters away, using the dispersion coefficients (χ/Q_s) calculated for these distances in Reference 3. Dose conversion factors are taken from Reference 4. It is also assumed that the 31.2 μ Ci of Co-60 postulated to be released from the outer surfaces of a canister into the high bay portion of the Canister Transfer Building remains in the building with uniform mixing. The concentration of Co-60 is calculated in the free volume of the high bay area and compared with 10 CFR 20 permissible derived air concentration values for occupational workers.

REFERENCES

1. Safety Analysis Report for the TranStor Storage Cask System, SNC-96-72SAR, Sierra Nuclear Corporation, Docket 72-1023, Revision B, March 1997.
2. Topical Safety Analysis Report for the Holtec International Storage and Transfer Operation Reinforced Module Cask System (HI-STORM 100 Cask System), Holtec Report HI-951312, Docket 72-1014, Revision 1, January 1997.
3. SWEC Calculation No. 0599601-UR-1, "Accident χ/Q_s for the PFSF", prepared by J.R. Johns, dated June 4, 1997.
4. Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, DE89-011065, U.S. Environmental Protection Agency, 1988.

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CONCLUSIONS

It was determined that the HI-STORM canister has the largest external surface area, of 312,000 cm². Assuming that the entire outer surface of a canister is covered with removable contamination at approximately the maximum allowable limit of PFSF Proposed Technical Specification 3/4.1 (22,000 dpm/100 cm²) and that 100% of this activity is released from the outer surface of the canister and becomes airborne results in a source term of 31.2 μ Ci. Based on a review of the dose conversion factors in Reference 4 for Co-60, it is determined that the dose conversion factor for lung is higher than that for any other organ. Therefore, the lung is the maximally exposed organ. Committed effective dose equivalents (CEDE) and committed dose equivalents (CDE) to the lung were calculated at 150 m and 500 m distances, with the following results:

CEDE (150 m) = 3.15 E-2 mrem

CDE (lung, 150 m) = 1.84 E-1 mrem

CEDE (500 m) = 4.37 E-3 mrem

CDE (lung, 500 m) = 2.55 E-2 mrem

These calculated dose equivalents, based on a conservative postulated accident scenario, are well within the 5 Rem to the whole body or any organ limit specified in 10 CFR 72.106(b) for design basis accidents, which applies to an individual located at or beyond the OCA boundary.

Assuming that the 31.2 μ Ci of Co-60 were released into the high bay of the Canister Transfer Building from a canister transfer cell, and assuming the activity remains in the building with uniform mixing in the high bay free volume, the calculated airborne concentration of 1.05 E-9 μ Ci/cm³ of Co-60 is within the 10 CFR 20 (Appendix B, Table 1) derived air concentration value for occupational workers.

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CALCULATIONDetermine External Surface Area of a CanisterHI-Storm

Dimensions of Holtec International's (Holtec's) HI-STORM canister are given in the following drawings in Section 1 of the HI-STORM SAR (Reference 2) as follows:

$$\text{O.D.} = 68.5 \text{ inches}, (68.5 \text{ inch})(2.540 \text{ cm/inch}) = 174.0 \text{ cm} = D$$

Based on Holtec Drawing No. 1395, sheet 1 of 5, "HI-STAR 100 MPC-24 Construction", Rev. 5 - gives the outer diameter of the canister as $68 \frac{3}{8} \text{ inches} \pm \frac{7}{32} \text{ inch}$. This is identical to the outer diameter of the MPC-68 canister, shown on Holtec Drawing No. 1401, sheet 1 of 4, "HI-STAR 100 MPC-68 Construction", Rev. 5.

$$\text{Height} = 190.5 \text{ inches}, (190.5 \text{ inch})(2.540 \text{ cm/inch}) = 483.9 \text{ cm} = H$$

Based on Holtec Drawing No. 1396, sheet 1 of 6, "HI-STAR 100 MPC-24 Construction", Rev. 5 - gives the outer height of the canister as $190 \frac{1}{2} \text{ inches} + \frac{1}{16} \text{ inch}, - \frac{1}{8} \text{ inch}$. This is identical to the outer height dimension of the MPC-68 canister, shown on Holtec Drawing No. 1402, sheet 1 of 6, "HI-STAR 100 MPC-68 Construction", Rev. 5.

$$\text{Surface Area} = \pi DH + 2(\pi D^2)/4$$

$$\text{Surface Area} = \pi(174.0 \text{ cm})(483.9 \text{ cm}) + 2(\pi)(174.0)^2/4 = 3.12 \text{ E5 cm}^2$$

TranStor

Dimensions of Sierra Nuclear Corporation's (SNC) TranStor canister (PWR and BWR canister dimensions are identical) are given in SNC Drawing No PPB-001, sheet 1 of 3, "TranStor System PWR Basket Assembly", Rev. 0, as follows:

$$\text{O.D.} = 66.0 \text{ inches}, (66.0 \text{ inch})(2.540 \text{ cm/inch}) = 167.6 \text{ cm} = D$$

$$\text{Height} = 181.3 \text{ inches}, (181.3 \text{ inch})(2.540 \text{ cm/inch}) = 460.5 \text{ cm} = H$$

$$\text{Surface Area} = \pi DH + 2(\pi D^2)/4$$

$$\text{Surface Area} = \pi(167.6 \text{ cm})(460.5 \text{ cm}) + 2(\pi)(167.6)^2/4 = 2.87 \text{ E5 cm}^2$$

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Removable Contamination on Outer Surfaces of a Canister

Since the HI-STORM canister has the largest surface area ($3.12 \text{ E}5 \text{ cm}^2$), this surface area is used to determine the total quantity of removable surface contamination on the outer surface of a canister. It is conservatively assumed that the entire outer surface of a canister is covered with removable contamination at $1.0 \text{ E-}4 \text{ cm}^2$, equal to $22,200 \text{ dpm}/100 \text{ cm}^2$, slightly above the maximum allowable limit of PFSF Proposed Technical Specification 3/4.1, "Canister External Surface Contamination", $22,000 \text{ dpm}/100 \text{ cm}^2$.

By definition, $1 \text{ Ci} = 3.7 \text{ E}10 \text{ decays per second} = 2.22 \text{ E}12 \text{ decays per minute (dpm)}$

$$1 \mu\text{Ci} = 1 \text{ E-}6 \text{ Ci} = 2.22 \text{ E}6 \text{ dpm}$$

$$\frac{(22,000 \text{ dpm})}{100 \text{ cm}^2} \frac{(1 \mu\text{Ci})}{2.22 \text{ E}6 \text{ dpm}} = 9.91 \text{ E-}5 \frac{\mu\text{Ci}}{\text{cm}^2}$$

Assume the canister is coated with removable contamination at a concentration of $1.0 \text{ E-}4 \mu\text{Ci}/\text{cm}^2$, equal to $22,200 \text{ dpm}/100 \text{ cm}^2$ (0.9% above the Technical Specification limit):

$$(312,000 \text{ cm}^2) (1.0 \text{ E-}4 \mu\text{Ci}/\text{cm}^2) = 31.2 \mu\text{Ci}.$$

Thus, it is assumed that $31.2 \mu\text{Ci}$ of Co-60 is released from the surfaces of the canister and becomes airborne. It is also conservatively assumed that 100% of the Co-60 particles that become airborne are sufficiently small as to be respirable.

Dose Calculation

Doses are calculated assuming that an offsite individual is located at the OCA boundary at its closest point of approach to the Canister Transfer Building, 500 meters east of the Canister Transfer Building. This represents the nearest distance to the OCA boundary from a point where a loaded canister would be staged, stored, or handled at the PFSF. Doses are also calculated to an onsite individual assumed to be located 150 meters from the release point, which is an arbitrarily selected distance inside the OCA boundary.

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Doses are calculated in accordance with the following equation:

$$\text{Dose} = (\text{activity released, } \mu\text{Ci})(\chi/Q, \text{ sec/m}^3)(\text{breathing rate, m}^3/\text{sec})(\text{dose conversion factor, mrem}/\mu\text{Ci})$$

where:

Activity released is 31.2 μCi , as calculated above.

Adult breathing rate is assumed to be $3.3 \text{ E-4 m}^3/\text{sec}$, in accordance with Reference 4.

Dispersion factors of 1.40 E-2 sec/m^3 for 150 meters and 1.94 E-3 sec/m^3 for 500 meters were calculated in Reference 3, conservatively assuming an instantaneous release, a 1 meter/sec horizontal wind speed, and Pasquill Stability Class F meteorological conditions.

Dose conversion factors for Co-60 are stated in Reference 4 to be 5.91 E-8 Sv/Bq for Committed Effective Dose Equivalent, and 3.45 E-7 Sv/Bq for Committed Dose Equivalent to the lungs, which is the highest dose conversion factor for any organ. A factor of 3.7 E9 is used to convert from Sv/Bq to mrem/ μCi , in accordance with Reference 4, resulting in 218.7 mrem/ μCi for CEDE and 1,277 mrem/ μCi for CDE to the lungs.

$$\begin{aligned}\text{CEDE (150 m)} &= (31.2 \mu\text{Ci})(1.40 \text{ E-2 sec/m}^3)(3.3 \text{ E-4 m}^3/\text{sec})(218.7 \text{ mrem}/\mu\text{Ci}) \\ &= 3.15 \text{ E-2 mrem}\end{aligned}$$

$$\begin{aligned}\text{CDE (lung, 150 m)} &= (31.2 \mu\text{Ci})(1.40 \text{ E-2 sec/m}^3)(3.3 \text{ E-4 m}^3/\text{sec})(1,277 \text{ mrem}/\mu\text{Ci}) \\ &= 1.84 \text{ E-1 mrem}\end{aligned}$$

$$\begin{aligned}\text{CEDE (500 m)} &= (31.2 \mu\text{Ci})(1.94 \text{ E-3 sec/m}^3)(3.3 \text{ E-4 m}^3/\text{sec})(218.7 \text{ mrem}/\mu\text{Ci}) \\ &= 4.37 \text{ E-3 mrem}\end{aligned}$$

$$\begin{aligned}\text{CDE (lung, 500 m)} &= (31.2 \mu\text{Ci})(1.94 \text{ E-3 sec/m}^3)(3.3 \text{ E-4 m}^3/\text{sec})(1,277 \text{ mrem}/\mu\text{Ci}) \\ &= 2.55 \text{ E-2 mrem}\end{aligned}$$

These calculated dose equivalents, based on a conservative postulated accident scenario, are well within the 5 Rem to the whole body or any organ limit specified in 10 CFR 72.106(b) for design basis accidents, which applies to an individual located at or beyond the OCA boundary.

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Activity Concentration in the Canister Transfer Building, Assuming Uniform Mixing of Co-60 in the Canister Transfer Building Atmosphere

It is assumed that the 31.2 μCi of Co-60 is released from the outer surfaces of a canister into the high bay portion of the Canister Transfer Building, and there is uniform mixing. The walls of a canister transfer cell are approximately 30 ft. high (based on discussions with Steve Smith - SWEC). The ceiling of the high bay area is approximately 75 ft above the building floor, at grade level, per SWEC Drawing No. 0599601-EA-9-B, "Canister Transfer Building Elevations -Sh1". Therefore, contamination released from a canister would not be trapped in the canister transfer cell in which the release occurred, but would tend to mix with air in the entire high bay portion of the Canister Transfer Building. The high bay area is approximately 63 ft wide by 260 ft long and includes canister transfer cells No. 1, 2, and 3, the transfer equipment laydown area, the LLW storage room (east of canister transfer cell No. 1), the crane aisle east of the transfer cells, the shipping cask load/unload bays No. 1 and 2, and the impact limiter laydown area (SWEC Drawing No. 0599601-EA-8-B, "Canister Transfer Building Floor Plan"). Based on these dimensions, the inside volume of the high bay area is:

$$\text{Total Volume} = (63 \text{ ft}) (260 \text{ ft}) (75 \text{ ft}) = 1.23 \text{ E}6 \text{ ft}^3$$

Assume 15 % of this volume is occupied by equipment and walls, then the free volume inside the high bay area is approximately:

$$\text{Free Volume} = (0.85) (1.23 \text{ E}6 \text{ ft}^3) (2.832 \text{ E}4 \text{ cm}^3 / \text{ft}^3) = 2.96 \text{ E}10 \text{ cm}^3$$

Assuming uniform mixing throughout the high bay free volume, the concentration of Co-60 would be:

$$\frac{31.2 \mu\text{Ci}}{2.96 \text{ E}10 \text{ cm}^3} = 1.05 \text{ E-}9 \mu\text{Ci/cm}^3$$

10 CFR 20 Appendix B, Table 1, specifies derived air concentration values for occupational workers. For Co-60, the limits are 1 E-8 $\mu\text{Ci/ml}$ for cobalt oxides, hydroxides, halides, and nitrates and 7 E-8 $\mu\text{Ci/ml}$ for all other cobalt compounds. Since a cm^3 is the same volume as a ml, the calculated airborne concentration of 1.05 E-9 $\mu\text{Ci/cm}^3$ of Co-60 is less than the 10 CFR 20 derived air concentration values for occupational workers, and represents an acceptable concentration for occupational workers for this nuclide.