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Releases from Failure of a Flexible Receiver Bag in High Winds

D. C. Slaughterbeck

Westinghouse Hanford Company, Richland, WA 99352

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Abstract: This document supports the development and presentation of the following accident scenario in the TWRS Final Safety Analysis Report:

Natural Phenomena - High Wind.

The calculations needed to quantify the risk associated with this accident scenario are included within.

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**RELEASES FROM
FAILURE OF A FLEXIBLE RECEIVER BAG IN HIGH WINDS
Revision 0**

**Tank Waste Remediation System
Final Safety Analysis Report Project**

by

Safety Analysis & Nuclear Engineering

and

**Don Slaughterbeck
Science Applications International Corporation
545 Shoup Avenue
Idaho Falls, Idaho
(208)-528-2101**

September 1996

NOTE: According to Section WP-6.7, Rev. 0 of WHC-CM-6-32, *Safety Analysis and Nuclear Engineering Work Procedures*, Calculation Notes are used to document the originator's analysis but are not to be used to authorize activities or justify facility modifications, or changes to an authorization basis, or design basis.

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Failure of a Flexible Receiver Bag in High Winds

1.0 Introduction and Purpose

This calculation note documents the radiological and toxicological consequence analyses of a Flexible Receiver Bag Failure in support of a TWRS FSAR high wind accident considered under Natural Phenomena. The specific wind accident in the FSAR is "Flexible Receiver Bag Failure".

Background

A flexible receiver is an engineered system of components used to wash, contain, transport, and dispose of contaminated equipment upon removal from underground waste storage tanks. The flexible receiver is bolted onto a 4-inch or 6-inch tank riser and is supported by four legs with hydraulic controls that rest on the surface above the tank dome. The first flexible receiver station above the riser contains a spray ring where high pressure water is used to wash contaminants from the equipment and drain them back to the tank. The equipment is then withdrawn through a pipe spool into a flexible receiver bag that provides containment of the contaminated equipment. The cylindrical receiver bag is initially folded (like an accordion) and then unfolds as the equipment is withdrawn from the tank riser by a crane. The bag is sealed at the top, and as the equipment is withdrawn above the tank riser, the bottom is sealed with a cable and cutters are used to separate the flexible bag from unused bag material. The flexible receiver bag inflates with air from the tank head space that is drawn through the riser and washing station. When used on a tank with an active ventilation system and the tank is under a slight vacuum, the bag tends to collapse around the instrument with a minimum of air inflation. Flexible receiver bags are made of an abrasion-resistant, tear-resistant fabric.

Accident Scenario Development and Description

This scenario assumes a wind-induced failure of a flexible receiver bag containing contaminated equipment removed from an underground waste storage tank. Failure of the flexible receiver bag is postulated when the equipment has been withdrawn above the riser and just prior to sealing the bottom. High winds cause the crane and supported equipment to swing and tear or puncture the bag in the area where the bottom seal would be placed. Because the equipment is fully withdrawn, it offers no resistance against the riser, and only moderate resistance by the bag guide rods. The maximum amount of contaminates is present when the equipment is fully withdrawn.

Accident Frequency Development Assuming No Controls.

During preoperational testing, crane operators report difficulty in precisely positioning a loaded flexible receiver in winds greater than about 32 km/h (20 mph). For winds up to 64 km/h (40 mph), it is assumed crane

operators could manage a loaded flexible receiver if necessary. For wind gusts at 97 km/hr (60 mph) it is assumed a loaded flexible receiver would be essentially out of control. Therefore, it is assumed that winds gusts of 97 km/h (60 mph) are sufficient to cause the flexible receiver to swing and puncture or tear the fabric. Wind gusts are assumed to be a more accurate indicator of accident risk than straight winds. As listed in Table 3.4.2.13-1 of the draft FSAR high wind section, such wind gusts occur once every two years. Operations estimate that flexible receivers withdraw equipment no more than 24 days per year. It is conservatively assumed the wind gusts occur at the time the flexible receiver is at risk. Without administrative controls, the joint probability of operating the flexible receiver and having wind velocities of 97 km/hr (60 mph) is then

$$\begin{aligned} \text{Probability} &= (1 \text{ high wind}/2 \text{ years}) (24 \text{ days operation}/365 \text{ days per year}) \\ &= 3 \times 10^{-2} \text{ occurrences per year (anticipated category)} \end{aligned}$$

Assuming administrative controls are in place to restrict crane operations in high winds, and assuming the controls work as intended, the flexible receiver bag failure in high winds is prevented.

2.0 Analysis Input

2.1 Amount of Material Released

Because of the high pressure washing jets in the lower portion of the flexible receiver, most concentrated tank wastes are removed from the equipment and drained to the tank before the equipment enters the flexible receiver bag. Some surface contaminates remain on the equipment, and the washing jets create aerosols that enter the flexible receiver bag as it inflates with air from the tank headspace. Field readings by operations show radiation levels near the flexible receiver bag are less than about 10 rem/hr. Using this external dose rate, a Microshield calculation (see Appendix A) determined that the equivalent of 11.6 L of tank waste (aging waste liquids) was present in a 9.1 m section of the flexible receiver bag.

Aging waste tank liquids were assumed because the flexible receiver has been used primarily on aging waste tanks. Note that the consequences are insensitive to the type of waste assumed because fewer liters of a more radioactive waste type would be required to produce 10 R/hr; fewer liters of the more radioactive waste type would result in essentially the same consequences because the release rate mechanisms are linear. Likewise, more liters of a less radioactive waste type would be required to produce 10 R/hr and again, the resulting consequences would be the same. As discussed below, the wastes are partitioned between the aerosols in the vapor space of the flexible receiver bag and on the internal surfaces of the instrument and bag.

The inside surfaces of the flexible receiver bag and instrument were assumed to have a water film carrying the 11.6 L of contaminants. These surfaces were assumed to drain to the ground when the flexible receiver bag was torn or punctured by high winds. High winds would cause aerodynamic entrainment and suspension of the waste from the ground. From DOE Handbook on *Airborne Release Fractions/Rates and Respirable Fractions for NonReactor Nuclear Facilities* (DOE-HDBK-3010-94, Section 3.2.4.5, page 3-42), the bounding airborne release rate (ARR) for suspension of contaminants deposited on soil was 9×10^{-5} per hour. The resulting time-dependent source term from the soil was 1.04×10^{-3} L per hour.

To bound the release from the vapor space inside the flexible receiver, it was assumed that the respirable aerosol content could be no greater than 100 mg/m^3 (quasi-stable maximum). Using a bounding mass density of 1 kg/L , the material at risk in the 2.7 m^3 vapor space of the bag was determined to be $2.7 \times 10^{-4} \text{ L}$. Therefore, the resulting source term (puff release) from the vapor space was $2.7 \times 10^{-4} \text{ L}$.

The total source term (both puff and time dependent) for 12 hours (used for onsite exposures) was $1.28 \times 10^{-2} \text{ L}$, and the source term for 24 hours (used for offsite exposures) was $2.52 \times 10^{-2} \text{ L}$.

2.2 Unit Liter Doses (ULDs) and Sum-of-Fractions

The ULDs for this analysis are taken from WHC-SD-WM-SARR-037, Rev 0, *Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations*. For Aging Waste Liquids, the Inhalation ULD is $1.4\text{E}3 \text{ Sv/L}$, and the Ingestion ULD is $0.092 \text{ Sv-m}^3/\text{s-L}$ (see table in Appendix B). Toxicological exposures were calculated consistent with WHC-SD-WM-SARR-011, Rev. 2, *Toxic Chemical Considerations for Tank Farm Releases* (see table in Appendix B).

2.3 Dispersion Coefficients (x/Q)

Dispersion coefficients for puff releases:

Onsite-	$3.41\text{E}-2 \text{ s/m}^3$
Offsite-	$2.83\text{E}-5 \text{ s/m}^3$

Dispersion coefficients for continuous releases:

Onsite-	$1.13\text{E}-2 \text{ s/m}^3$
Offsite-	$2.12\text{E}-5 \text{ s/m}^3$

All dispersion coefficients were based on WHC-SD-WM-SARR-016 (see tables in Appendix B).

2.4 Breathing Rate (R)

Based on WHC-SD-WM-SARR-016, a breathing rate of $3.3\text{E}-4 \text{ m}^3/\text{s}$, corresponding to light physical activity, was used to calculate consequences for all receptors.

3.0 Assumptions

Radiological doses are based on a combined puff release of aerosols from the vapor space of the flexible receiver and a time-dependent release of aerosols from liquids dispersed in soil. The ULDs corresponded to aging waste liquids. Likewise, the sum-of-fractions were based on a combined DST liquid puff (acute) release and a DST liquid time-dependent release. For toxicological calculations, the DST liquids includes constituents of aging waste liquids. The dispersion coefficients X/Q corresponded to the 99.5 percentile with plume meander correction. This is initially very conservative because the accident occurs due to the high wind where dispersion would be much higher. However, high winds would not be expected to persist for the 12 and 24 hour exposure durations for onsite and offsite individuals, respectively.

4.0 Analytical Methods

The overall strategy used was to calculate the source term from bounding field radiation readings taken from the flexible receiver bag on contact (non-accident) using Microshield.¹ The resulting source term was partitioned into a vapor space term, and a liquid term that was assumed to drain to the soil after the flexible receiver bag was torn or punctured due to high winds. Radiological doses were then calculated for receptors consistent with WHC-SD-WM-SARR-016, Rev 2, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for use in ASA Consequence Assessments*, and WHC-SD-WM-SARR-037, Rev 0, *Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations*. Toxicological exposures were calculated consistent with WHC-SD-WM-SARR-011, Rev. 2, *Toxic Chemical Considerations for Tank Farm Releases*.

5.0 Radiological Dose Consequence Analysis

Calculations of Rad Doses consist of 5 parts:

- A. Inhalation of puff,
- B. Ingestion of puff,
- C. Inhalation of entrained spill,
- D. Ingestion of entrained spill, and
- E. Direct, skyshine and Bremsstrahlung.

There is an onsite and offsite calculation for these except ingestion does not apply to the onsite receptor.

PART A- Inhalation Dose From Puff

$$\begin{aligned} \text{Dose (Sv)} &= (\text{Source Term}) (x/Q) (\text{Breathing Rate}) (\text{ULD}) \\ &= (L) (s/m^3) (m^3/s) (Sv/L) \end{aligned}$$

$$\begin{aligned} \text{ONSITE:} \\ &= (2.7E-4) (3.41E-2) (3.3E-4) (1.4E+3) \end{aligned}$$

¹Microshield is a registered trademark of Grove Engineering, Inc.

$$= 4.3\text{E-}6 \text{ Sv}$$

OFFSITE:

$$= (2.7\text{E-}4) (2.83\text{E-}5) (3.3\text{E-}4) (1.4\text{E+}3) \\ = 3.5\text{E-}9 \text{ Sv}$$

PART B- Ingestion Dose From Puff

$$\text{Dose (Sv)} = (\text{Source Term}) (x/Q) (\text{ULD}) \\ = (L) (s/m^3) (Sv\text{-}m^3/s\text{-}L)$$

OFFSITE:

$$= (2.7\text{E-}4) (2.83\text{E-}5) (9.2\text{E-}2) \\ = 7.0\text{E-}10 \text{ Sv}$$

PART C- Inhalation Dose From Entrainment

$$\text{Dose} = (\text{Source Term})(\text{Breathing Rate}) (x/Q')(\text{Duration})(\text{ULD}) \\ = (L/s) (m^3/s) (s/m^3) (s) (Sv/L) = \text{Sv}$$

ONSITE:

$$= (1.04\text{E-}3/3600) (3.3\text{E-}4) (1.13\text{E-}2) (4.3\text{E}4) (1.4\text{E+}3) \\ = 6.5\text{E-}5 \text{ Sv}$$

OFFSITE:

$$= (1.04\text{E-}3/3600) (3.3\text{E-}4) (2.12\text{E-}5) (8.6\text{E}4) (1.4\text{E+}3) \\ = 2.4\text{E-}7 \text{ Sv}$$

PART D- Ingestion Dose From Entrainment

$$\text{Dose} = (\text{Source Term}) (x/Q') (\text{ULD}) (\text{Duration}) \\ = (L/s) (s/m^3) (Sv\text{-}m^3/s\text{-}L) (s) = \text{Sv}$$

OFFSITE:

$$= (1.04\text{E-}3/3600) (2.12\text{E-}5) (9.2\text{E-}2) (8.6\text{E}4) \\ = 4.8\text{E-}8 \text{ Sv}$$

PART E- Direct, Skyshine and Bremsstrahlung

Direct radiation was calculated with Microshield by modeling the spill as a vertical cylinder 1 cm high and a diameter of 1.22 meters (attached). The resulting 12 hour dose for onsite exposure was 3.4 mR. Offsite exposure is negligible. Microskyshine² was used to calculate the skyshine (attached). The resulting 12 hour dose for onsite exposure was 3.2 mR. The offsite exposure is negligible. Bremsstrahlung doses were considered negligible based on similar calculations where they are a factor of 10 smaller than the direct and skyshine doses (e.g. see WHC-SD-WM-CN-004 Rev 0).

ONSITE SUM = 1.4E-4 Sv

OFFSITE SUM = 2.9E-7 Sv

²Microskyshine is a registered trademark of Grove Engineering, Inc.

6.0 Toxicological Exposure Consequence Analysis

Calculations of toxic exposures consist of 2 parts:

- A. Exposure to puff,
- B. Exposure to entrained spill.

There is an onsite and offsite calc for each of these.

PART A- Exposure to puff release

$$\begin{aligned}\text{EXPOSURE} &= (\text{ULD-anticipated}) (\text{Source term}) \\ &= (1/L) (L) = \text{sum-of-fractions}\end{aligned}$$

$$\begin{aligned}\text{ONSITE:} \\ &= (2.9\text{E}3) (2.7\text{E}-4) \\ &= 0.78\end{aligned}$$

$$\begin{aligned}\text{OFFSITE:} \\ &= (3.4\text{E}-2) (2.7\text{E}-4) \\ &= 9\text{E}-6\end{aligned}$$

PART B- Exposure to entrainment releases

$$\begin{aligned}\text{EXPOSURE} &= (\text{ULD-anticipated}) (\text{Source term rate}) \\ &= (s/L) (L/s) = \text{sum-of-fractions}\end{aligned}$$

$$\begin{aligned}\text{ONSITE:} \\ &= (1\text{E}4) (1.04\text{E}-3/3600) \\ &= 2.9\text{E}-3\end{aligned}$$

$$\begin{aligned}\text{OFFSITE:} \\ &= (8.4) (1.04\text{E}-3/3600) \\ &= 2.4\text{E}-6\end{aligned}$$

TOTAL ONSITE SUM = 0.78
TOTAL OFFSITE SUM = 1.1E-5

7.0 Analysis Results

Consequences of a wind-induced failure of the flexible receiver bag are summarized in Table 7-1.

Table 7-1. Consequences of Flexible Receiver Bag Failure.

Receptor/hazard	Calculated dose/exposure		Evaluation guideline		
	Unmitigated	Mitigated	Anticipated	Unlikely	Extremely unlikely
Offsite/radiological	2.9E-4 mSv	a	5 mSv	50 mSv	250 mSv
Onsite/radiological	1.4E-1 mSv	a	50 mSv	250 mSv	1 Sv
Offsite/toxicological sum-of-fractions	2.4E-6	a	1	1	1
Onsite/toxicological sum-of-fractions	0.78	a	1	1	1

a. The accident is prevented when controls are imposed.

8.0 Conclusions

The unmitigated comparisons to risk evaluation guidelines are shown in Table 7-1. In all cases, the radiological and toxicological exposures are below the guidelines. Therefore, neither safety SSCs nor technical safety requirements are required for this accident.

9.0 References

- PNL-4622, 1983, *Climatological Summary for the Hanford Area*, Pacific Northwest Laboratory, Richland, Washington.
- DOE-HDBK-3010-94, 1994, *Airborne Release Fractions/rates and Respirable Fractions for NonReactor Nuclear Facilities*, U. S. Department of Energy, Washington, D. C.
- WHC-SD-WM-SARR-011, Rev 2, *Toxic Chemical Considerations for Tank Farm Releases*, 1996, Westinghouse Hanford Company, Richland, Washington.
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- MICROSHIELD Version 4, Grove Engineering, Inc. 15125 Shady Grove Road, Rockville, Maryland, 1992.
- MICROSKYSHINE, Grove Engineering, Inc. 15125 Shady Grove Road, Rockville, Maryland, 1987.
- WHC-SD-WM-CN-004, Rev 0, *Calculation Notes that Support Accident Scenario and Consequence Development for the Subsurface Leak Remaining Subsurface Accident*, 1996, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

Calculations of Source Term

Microshield was used to back calculate material at risk (MAR) inside flexible receiver bag when instrument is fully withdrawn from tank. Source is assumed liquid aging waste with radionuclide concentrations as in the table on the following page. Calculate unit radiation dose for 1 R/hour and adjust depending on bounding radiation readings from operations.

- Assume 30 feet of instrument exposed to liquid aging waste.
- Assume flexible receiver bag is 2 feet in diameter when inflated.
- Assume unit radiation dose of 1 R/hour at 13 inches from centerline.
- Using the dimensions above, the volume of a fully inflated receiver bag is:

$$\begin{aligned}
 V &= (\pi D^2/4) (\text{height}) \\
 &= (\text{m}^2) (\text{m}) = \text{m}^3 \\
 &= ((3.1416)(0.61)^2 / 4) (9.144) \\
 &= 2.67 \text{ m}^3
 \end{aligned}$$

(Note this value agrees with Microshield calculation of 2.6688E6 cubic centimeters.)

The radionuclide distribution of aging waste, the Microshield calculation, and interpretation follow.

Table Radionuclide Concentrations in Tank Waste.

Isotope	Concentration (Bq/L)					
	SST liquids	SST solids	DST liquids	DST solids	Aging waste liquids	Aging waste solids
⁶⁰ Co	9.53 E+06	4.2 E+08	6.97 E+06	1.5 E+07	7.71 E+05	4.9 E+08
⁹⁰ Sr	1.05 E+10	1.6 E+12	4.59 E+09	5.2 E+10	5.60 E+09	2.9 E+12
⁹⁰ Y	1.05 E+10	1.6 E+12	4.59 E+09	5.2 E+10	5.60 E+09	2.9 E+12
¹³⁷ Cs	2.21 E+10	1.0 E+11	5.86 E+10	5.9 E+10	8.84 E+10	9.8 E+10
¹⁵⁴ Eu	2.35 E+09	5.8 E+09	4.18 E+07	3.0 E+08	0.00	0.00
²³⁷ Np	0.00	0.00	2.3 E+05	8.1 E+05	9.20 E+04	9.9 E+08
²³⁸ Pu	9.21 E+04	1.9 E+08	1.78 E+06	7.2 E+07	2.75 E+03	6.7 E+07
²³⁹ Pu	3.62 E+07	4.4 E+08	7.65 E+06	1.6 E+09	1.20 E+06	4.4 E+08
²⁴¹ Pu	2.57 E+08	3.2 E+09	1.84 E+07	3.8 E+09	3.39 E+05	1.7 E+09
²⁴¹ Am	4.23 E+07	2.3 E+08	3.40 E+07	2.7 E+09	1.10 E+06	1.1 E+10
²⁴⁴ Cm	4.23 E+05	2.3 E+06	1.22 E+05	1.6 E+07	1.10 E+04	6.1 E+07

NOTE: The information in this table is from WHC-SD-WM-SARR-037, 1996, Development of Radiological Concentrations and Unit Liter Doses for TMS FSAR Radiological Consequence Calculations, Westinghouse Hanford Company, Richland, Washington.

DST = double-shell tank.

SST = single-shell tank.

Microshield 3.13

(SAIC - #212)

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File : FLEXBAG3.MSH
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Run time: 2:43 p.m.

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Date: ____/____/____
By: _____
Checked: _____

CASE: Radionuclide source term for 1 R/hr @ 1 inch from Flex Bag

GEOMETRY 7: Cylindrical source from side - cylindrical shields

Distance to detector.....	X	33.020	cm.
Source length.....	L	914.4	"
Dose point height from base.....	Y	91.440	"
Source cylinder radius.....	T1	30.480	"
Thickness of second shield.....	T2	2.540	"

Source Volume: 2.6688e+6 cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2
-----	-----	-----
Air	.001220	.001220
Aluminum		
Carbon		
Concrete		
Hydrogen		
Iron		
Lead		
Lithium		
Nickel		
Tin		
Titanium		
Tungsten		
Uranium		
Water		
Zirconium		

Page 2

File: FLEXBAG3.MSH

CASE: Radionuclide source term for 1 R/hr @ 1 inch from Flex Bag

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies	Nuclide	Curies
Am-241	3.4500e-05	Ba-137m	2.5600e+00	Cm-244	3.4500e-07
Co-60	2.4100e-05	Cs-137	2.7700e+00	Eu-154	0.0000e+00
Np-237	2.8800e-06	Pu-238	8.6100e-08	Pu-239	3.7600e-05
Pu-241	1.0600e-05	Sr-90	1.7500e-01	Y-90	1.7500e-01

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
1	1.3359	8.917e+05	1.013e+01	1.827e-02
2	1.1797	8.917e+05	8.944e+00	1.662e-02
3	.6953	1.455e+02	8.626e-04	1.776e-06
4	.6641	8.523e+10	4.830e+05	1.001e+03
5	.2109	1.705e+02	3.094e-04	5.784e-07
6	.1953	2.242e+02	3.769e-04	6.908e-07
7	.1641	1.116e+03	1.576e-03	2.775e-06
8	.1484	7.089e+02	9.066e-04	1.560e-06
9	.1172	8.432e+02	8.524e-04	1.345e-06
10	.1016	1.273e+03	1.116e-03	1.682e-06
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		8.523e+10	4.830e+05	1.002e+03

Source Term Results

The table below illustrates that there is the equivalent of approximately 1.157 L of aging waste in the 30 feet of exposed flexible receiver bag for each measured R/hour. From operations, actual radiation readings are less than 10 R per hour, or a source term equivalent of about 11.6 L of aging waste. Using 9.0E-5 per hour for the airborne release rate (from Mishima, bounding high wind value), and assuming the damage ratio, respirable fraction and leak path factors are all unity, the source rate from the leaked material on the ground is 1.04E-3 L/hr.

Key to Table:

Note: Table based on 1 R/hr

Column 1-Isotopes

Column 2-Radioactive content of liquid aging waste in tank, Bq/L

Column 3-Conversion of tank contents to Curies

Column 4-A back-calculated conversion factor used to check Microshield input values (used only as check)

Column 5-Number of Curies in flexible receiver calculated by Microshield in 30 foot section to yield 1 R/hr.

Column 6-Curies per liter of bag volume (not used)

Column 7-Liters of liquid aging waste distributed in flexible receiver bag to yield 1 R/hr.

Assume 1 Rem/hr at one inch from flex bag

Based on Microshield

	Original Bq/L	Original Ci/L	Proportion	Ci in 30 ft	Ci/L in bag	L of orig
Co	7.710E+05	2.084E-05	3.126E-11	2.410E-05	9.030E-09	1.157E+00
Sr	5.600E+09	1.514E-01	3.126E-11	1.751E-01	6.559E-05	1.157E+00
Y	5.600E+09	1.514E-01	3.126E-11	1.751E-01	6.559E-05	1.157E+00
Cs	8.840E+10	2.389E+00	3.126E-11	2.763E+00	1.035E-03	1.157E+00
Np	9.200E+04	2.486E-06	3.126E-11	2.876E-06	1.078E-09	1.157E+00
Pu*	2.750E+03	7.432E-08	3.126E-11	8.597E-08	3.221E-11	1.157E+00
Pu*	1.200E+06	3.243E-05	3.126E-11	3.751E-05	1.405E-08	1.157E+00
Pu*	3.390E+05	9.162E-06	3.126E-11	1.060E-05	3.970E-09	1.157E+00
Am	1.100E+06	2.973E-05	3.126E-11	3.439E-05	1.288E-08	1.157E+00
Cm	1.100E+04	2.973E-07	3.126E-11	3.439E-07	1.288E-10	1.157E+00

* Pu isotopes (top to bottom) are 238,239, and 241.

APPENDIX B

Calculations of Direct and Skyshine Radiation Doses

This appendix lists the following:

Table of Unit Liter Doses for Radiological Doses
 Tables of Atmospheric Diffusion Coefficients
 Table of Sum-of-Fraction Guidelines for Toxicological Exposures
 MICROSHIELD input and output for direct radiation.
 MICROSKYSHINE input and output for skyshine radiation.

Unit Liter Doses for Inhalation and Ingestion.

Composite	Inhalation ULD (Sv/L)	Ingestion ULD (Sv-m ³ /s-L)
Single-shell tank liquids	1.1 E+04	0.052
Single-shell tank solids	2.2 E+05	4.1
Double-shell tank liquids	6.1 E+03	0.068
Double-shell tank solids	5.3 E+05	0.48
× Aging waste facility liquids	1.4 E+03	0.092
Aging waste facility solids	1.7 E+06	8.1

NOTE: The information in this table is from WHC-SD-WM-SARR-037, 1996, Development of Radiological Concentrations and Unit Liter Doses for TMS FSAR Radiological Consequence Calculations, Westinghouse Hanford Company, Richland, Washington.
 ULD = unit liter dose.

Centerline Atmospheric Dispersion Coefficients for 200-Area Tank Farm Acute Release to 100-m Onsite Receptor Located in Worst Sector.

Meteorological condition	Integrated x/Q' (s/m ³)	Integrated x/Q' (s/m ³) with PM ^a	Maximum puff x/Q (1/m ³)
99.5 percentile (bounding)	8.41 E-02 E 100 m	1.13 E-02 ESE 100 m	9.85 E-03 E 100 m
Annual Average	1.20 E-02 N 100 m	3.80 E-03 N 100 m	NA
50 percentile	5.33 E-03 N 100 m	2.27 E-03 N 100 m	9.48 E-04 E 100 m

^aNRC Regulatory Guide 1.145 (NRC 1982) plume meander correction applied.

Centerline Atmospheric Dispersion Coefficients for 200-Area Tank Farm Acute Release to Site Boundary Receptor Located in Worst Sector.

Meteorological condition	Integrated x/Q' (s/m ³)	Integrated x/Q' (s/m ³) with PM ^a	Maximum puff x/Q (1/m ³)
99.5 Percentile (bounding)	2.83 E-05 N 8,760 m	2.12 E-05 N 8,760 m	1.14 E-07 NNW 8,690 m
Annual average	1.05 E-05 N 8,760 m	7.92 E-06 N 8,760 m	NA
50 percentile	4.43 E-06 N 8,760 m	3.79 E-06 N 8,760 m	1.02 E-08 N 8,760 m

^aNRC Regulatory Guide 1.145 (NRC 1982) plume meander correction applied.

Population Weighted Atmospheric Dispersion Coefficients for 200-Area Tank Farm Acute Release to 50-Mile Population Located in Worst Sector.

Meteorological condition	Integrated x/Q' (person-s/m ³)
99.5 Percentile (bounding)	4.86 E-02 SE pop=114,734
Annual average	1.25 E-02 SE pop=114,734
50 Percentile	6.05 E-03 SE pop=114,734

Sum-of-Fraction of Risk Guidelines for a Unit Release of
Chemicals and Gases. (3 sheets)

*The sum of fractions are multiplied by the release rate for continuous release and release amount for a puff releases. Release rates for continuous releases are in units of liters per second for liquids and solids, and m³/s for gases. Puff release quantities are in units of liters for solids and liquids and m³ for gases.

Tank waste type (Units of sum of fractions follow tank waste type)	Maximum individual	Accident frequency, 1/yr		
		1 - 10 ⁻²	10 ⁻² - 10 ⁻⁴	10 ⁻⁴ - 10 ⁻⁶
DST or SST solid or liquid continuous release				
Single-shell liquids(s/L)	Onsite	9.6 E+03	7.5 E+02	2.0 E+02
Single-shell liquids(s/L)	Offsite	8.0 E+00	8.0 E+00	6.2 E+01
Single-shell solids(s/L)	Onsite	4.0 E+04	2.1 E+04	1.0 E+03
Single-shell solids(s/L)	Offsite	9.4 E+01	3.3 E+01	1.7 E+01
Double-shell liquids(s/L)	Onsite	1.0 E+04	7.5 E+02	2.1 E+02
Double-shell liquids(s/L)	Offsite	8.4 E+00	8.4 E+00	6.2 E+01
Double-shell solids (s/L)	Onsite	1.8 E+04	3.3 E+03	6.3 E+02
Double-shell solids(s/L)	Offsite	1.9 E+02	1.5 E+01	2.8 E+00
DST or SST liquid or solid puff release				
Single-shell liquids (L ⁻¹)	Onsite	2.8 E+03	2.2 E+02	5.7 E+01
Single-shell liquids (L ⁻¹)	Offsite	3.2 E+02	3.2 E+02	2.5 E+03
Single-shell solids (L ⁻¹)	Onsite	1.2 E+04	6.0 E+03	2.9 E+02
Single-shell solids (L ⁻¹)	Offsite	3.8 E+01	1.3 E+01	6.9 E+02
Double-shell liquids (L ⁻¹)	Onsite	2.9 E+03	2.2 E+02	6.0 E+01
Double-shell liquids (L ⁻¹)	Offsite	3.4 E+02	3.4 E+02	2.5 E+03
Double-shell solids (L ⁻¹)	Onsite	5.2 E+03	9.7 E+02	1.8 E+02
Double-shell solids (L ⁻¹)	Onsite	7.7 E+01	5.9 E+02	1.1 E+02
Flammable gas watch list composite				
Continuous Release (s/L)	Onsite	1.3 E+04	1.1 E+03	2.6 E+02
Continuous Release (s/L)	Offsite	1.4 E+01	7.2 E+00	6.1 E+01
Puff Release (L ⁻¹)	Onsite	3.7 E+03	3.2 E+02	7.7 E+01
Puff Release (L ⁻¹)	Offsite	3.4 E+02	1.7 E+02	1.4 E+03

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1

File Ref: _____

DOS File: FLEXPOOL.MS4

Date: ____/____/____

Run Date: August 12, 1996

By: _____

Run Time: 1:31 p.m. Monday

Checked: _____

Duration: 0:00:13

Case Title: Flex Bag Spill - Pool 1 cm Deep

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	10000.0	328.0	1.0
Dose point coordinate Y:	150.0	4.0	11.1
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	1.0	0.0	.4
Cylinder radius:	122.0	4.0	.0
Air Gap:	9878.0	324.0	1.0

Source Volume: 46759.5 cm³ 1.65129 cu ft. 2853.44 cu in.

MATERIAL DENSITIES (g/cm³)

Material	Source Shield	Transition Shield	Air Gap Shield	Immersion Shield
Air		0.00122	0.00122	0.00122
Water	1.0			

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE NUCLIDES

Nuclide	curies	$\mu\text{Ci}/\text{cm}^3$	Nuclide	curies	$\mu\text{Ci}/\text{cm}^3$
Ba-137m	2.6205e+001	5.6042e+002	Cs-137	2.7701e+001	5.9241e+002

===== RESULTS =====

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.6	8.724e+011	3.212e+001	1.427e+002	6.270e-002	2.785e-001
TOTAL:		8.724e+011	3.212e+001	1.427e+002	2.785e-001

MicroSkyshine

=====

(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1

File Ref: _____

File: FLEXBAG1.SKY

Date: ____/____/____

Run: 1:40 p.m.

By: _____

: August 12, 1996

Checked: _____

CASE: Flex Bag - Pool 1 cm Deep

GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector..... X 100.
Depth of source behind wall..... Y 0.01
Offset of detector..... Z 0.
Depth of dose point..... H 0.
Distance between center of source and wall... R1 0.62
Thickness of cover slab..... T1 0.
Thickness of second shield..... T2 0.
Radius of source..... W 0.61
Height of source..... L 0.01

INTEGRATION PARAMETERS:

Number of Radial Segments.....M 5
 Number of Circumferential Segments.....N 5
 Number of Vertical Segments.....C 5
 Quadrature Order..... 16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			1.0
Concrete			
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

Page 2

CASE: Flex Bag - Pool 1 cm Deep

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	2.6205e+01	Cs-137	2.7701e+01

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	.66	8.724e+11	7.495e-20	2.696e-01
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		8.724e+11		2.696e-01

CHECKLIST FOR PEER REVIEW

Document Reviewed: WHC-SD-WM-CN-061, Rev. 0, *Flexible Receiver Bag Failure in High Winds.*

Scope of Review: Entire document.

Yes No NA

- [X] [] [] * Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
- [X] [] [] Problem completely defined.
- [X] [] [] Accident scenarios developed in a clear and logical manner.
- [X] [] [] Necessary assumptions explicitly stated and supported.
- [X] [] [] Computer codes and data files documented.
- [X] [] [] Data used in calculations explicitly stated in document.
- [X] [] [] Data checked for consistency with original source information as applicable.
- [X] [] [] Mathematical derivations checked including dimensional consistency of results.
- [] [] [X] Models appropriate and used within range of validity or use outside range of established validity justified.
- [X] [] [] Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
- [X] [] [] Software input correct and consistent with document reviewed.
- [X] [] [] Software output consistent with input and with results reported in document reviewed.
- [X] [] [] Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
- [X] [] [] Safety margins consistent with good engineering practices.
- [X] [] [] Conclusions consistent with analytical results and applicable limits.
- [X] [] [] Results and conclusions address all points required in the problem statement.
- [X] [] [] Format consistent with appropriate NRC Regulatory Guide or other standards
- [] [] [X] * Review calculations, comments, and/or notes are attached.
- [X] [] [] Document approved

GRANT W. RYAN
Reviewer (Printed Name and Signature)

8/13/96
Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

HEDOP REVIEW CHECKLIST for **Radiological and Nonradiological Release Calculations**

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

WHC-SD-WM-CN-061, Rev. 0, *Flexible Receiver Bag Failure in High Winds.*

Submitted by: Don Slaughterbeck

Date Submitted: 8/13/96

Scope of Review: Radiological Dose and Toxicological Exposure Calculations.

YES NO* N/A

☒	☐	☐	1. A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
☒	☐	☐	2. Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
☐	☐	☒	3. HEDOP-approved code(s) were used.
☐	☐	☒	4. Receptor locations were selected according to HEDOP recommendations.
☒	☐	☐	5. All applicable environmental pathways and code options were included and are appropriate for the calculations.
☒	☐	☐	6. Hanford site data were used.
☒	☐	☒	7. Model adjustments external to the computer program were justified and performed correctly.
☒	☐	☐	8. The analysis is consistent with HEDOP recommendations.
☐	☐	☒	9. Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
☒	☐		10. Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

* All "NO" responses must be explained and use of nonstandard methods justified.

D.A. Hines
HEDOP-Approved Reviewer (Printed Name and Signature)

8/14/96
Date

COMMENTS (add additional signed and dated pages if necessary):

DISTRIBUTION SHEET

To	From	Page 1 of 1			
Distribution	D. C. Slaughterbeck	Date 9/7/96			
Project Title/Work Order		EDT No. 614557			
Releases from Failure of a Flexible Receiver Bag in High Winds, WHC-SD-WM-CN-061, Rev. 0		ECN No. N/A			
Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
E. R. Bruschi	A2-34	X			
C. Carro	A2-34	X			
D. S. Leach	A3-34	X			
TWRS S & L Project Files (6)	A2-26	X			
G. W. Ryan (3)	A3-37	X			
D. C. Slaughterbeck	A3-34	X			
Central Files (Original + 1)	A3-88	X			