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PLUTONIUM FINISHING PLANT WASTE COMPOSITION AND HIGH-EFFICIENCY PARTICULATE AIR FILTER LOADING

B.D. Zimmerman

Richland, WA 99352
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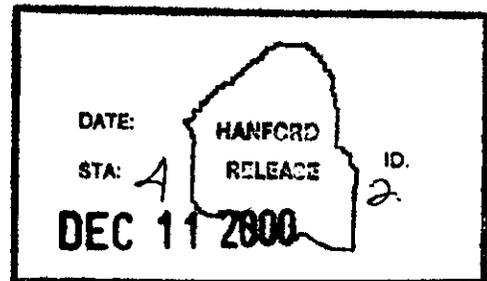
Key Words: Tank Farms, HEPA filter, A.C. 5.18, PFP, 244-TX, DCRT, Source Term, A.C. 5.8, Accident Analysis

Abstract: This analysis evaluates the effect of the PFP waste isotopic composition on Tank Farms FSAR accidents involving HEPA filter failure in Double-Contained Receiver Tanks (DCRTs). The HEPA Filter Failure - Exposure to High Temperature or Pressure, and Steam Intrusion From Interfacing Systems accidents are considered. The analysis concludes that dose consequences based on the PFP waste isotopic composition are bounded by previous FSAR analyses. This supports USQD TF-00-0768.

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**PLUTONIUM FINISHING PLANT WASTE COMPOSITION AND
HIGH-EFFICIENCY PARTICULATE AIR FILTER LOADING**

December 2000

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TERMS

AC	Administrative Control
DCRT	Double-Contained Receiver Tank
FSAR	Final Safety Analysis Report
HEPA	high-efficiency particulate air
PPF	Plutonium Finishing Plant

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1.0 INTRODUCTION

The Plutonium Finishing Plant (PFP) has notified Tank Farms of plans to transfer at least two batches of waste to Double-Contained Receiver Tank (DCRT) 244-TX. These batches are expected to be approximately 5,000 gal each. The first of these transfers is planned to occur in late November 2000 and the second in the spring of 2001.

Several accident scenarios analyzed in the Tank Farms *Tank Waste Remediation System Final Safety Analysis Report* (HNF-SD-WM-SAR-067) predict dose consequences, in part, based on an assumed tank ventilation system high-efficiency particulate air (HEPA) filter and prefilter maximum total waste loading. This waste loading is calculated based on a maximum HEPA filter contact dose measurement of 200 mrem/h of gamma radiation, which is the highest dose reading allowed by *Tank Waste Remediation System Technical Safety Requirements*, Administrative Control (AC) 5.18 (HNF-SD-WM-TSR-006). The PFP waste has a lower proportion of gamma emitting isotopes than typical Tank Farms waste. Consequently, a HEPA filter dose reading of 200 mrem/h resulting from PFP waste will correspond to a much higher filter waste loading, and a higher inhalation dose as a result of waste released from the filter, than previously assumed for single-shell and double-shell tank waste. This calculation note provides an analysis of the effect of the PFP isotopic composition on HEPA filter loading and the impact on HEPA Filter Failure — Exposure to High Temperature or Pressure and Steam Intrusion from Interfacing Systems Final Safety Analysis Report (FSAR) accidents as they relate to DCRTs. This calculation note also employs the new dose conversion factors, atmospheric dispersion coefficients, and breathing rate factors contained in *Radiological Source Terms for Tank Farms Safety Analysis* (RPP-5924).

This calculation note was prepared specifically to support Unreviewed Safety Question Screening/Determination USQD TF-00-0768, *Evaluation of PFP Transfer to DCRT 244-TX* (USQD TF-00-0768).

2.0 SCOPE OF ANALYSIS

This analysis is specific to the PFP waste isotopic composition data provided by CH2M HILL Hanford Group, Inc., Process Control Section (K. D. Fowler), a copy of which is included as Appendix A of this calculation note.

This analysis presents recalculated dose consequence results for the following FSAR accidents: HEPA Filter Failure - Exposure to High Temperature or Pressure, and Steam Intrusion from Interfacing Systems. Other accidents that include HEPA filter failure as part of the accident scenario, but are not considered in this analysis are Flammable Gas Deflagration, Organic Solvent Fire, In-Tank Fuel Fire/Deflagration, and Tank Bump. Reanalysis of these accidents was not requested to support USQD TF-00-0768 because for the first three accidents, the uncontrolled scenarios already have dose consequences that exceed dose guidelines and the controlled scenarios employ controls that are assumed to prevent the accidents. (An exception is lightning-initiated organic fires, which cannot be prevented. However, the bounding case is

already above guidelines.) The Tank Bump accident was not reanalyzed because it is not applicable to DCRTs.

It is anticipated that the PFP waste batches will be resident in 244-TX DCRT for several months before being transferred into Tank 241-SY-102. This calculation note only addresses PFP waste in DCRTs.

3.0 ACCIDENT SCENARIOS

3.1 HIGH-EFFICIENCY PARTICULATE AIR FILTER FAILURE — EXPOSURE TO HIGH TEMPERATURE OR PRESSURE

These two accidents were previously analyzed in *HEPA Filter Failure by Fire or Heater Overtemperature and Subsequent Unfiltered Release* (WHC-SD-WM-CN-062) and *Releases from Failed HEPA Filters Due to an Overpressurization Event* (WHC-SD-WM-CN-063), respectively. These two references considered accident scenarios involving HEPA filters and prefilters used in the ventilation systems for single-shell tanks, double-shell tanks, DCRTs, the 204-AR Waste Unloading Facility, the 244-AR Vault, the 213-W Dry Waste Compactor Facility, and 7 of 12 catch tanks. As mentioned in Section 2.0, this calculation note is only concerned with HEPA filters and prefilters installed in DCRT ventilation systems.

For the high temperature accident, it is postulated that a fire near the ventilation system, or the failure of an in-line heater, may cause a high temperature condition in the HEPA filter train, resulting in a short-term release of waste material that has collected on the filters, as well as an unfiltered pathway for long-term release of tank waste contents once the filters have ceased to be effective. For the overpressure accident, it is postulated that any of several (unspecified) conditions may lead to a pressurization of the headspace above the tank, also causing short-term and long-term release of waste material. For both accidents, the short-term release is considered to occur instantaneously, with both onsite and offsite dose consequences. The longer term unfiltered releases are analyzed as sources of chronic exposure occurring for periods of 12 hours and 1 year (onsite) and 24 hours and 1 year (offsite).

3.2 STEAM INTRUSION FROM INTERFACING SYSTEMS

This accident was previously analyzed in *Calculation Notes that Support Accident Scenario and Consequence Development for the Steam Intrusion from Interfacing Systems Accident* (WHC-SD-WM-CN-044). This accident scenario involves liquid waste being transferred to a tank using a steam jet as the motive force. Because of operator error or equipment failure, raw steam could be introduced directly into the double-shell tank or the DCRT, resulting in an overpressure condition in the tank headspace. This overpressure is postulated to result in HEPA filter and prefilter failure, release of waste material accumulated on the ventilation HEPA filters

and prefilters, and release of particulates from the tank headspace volume through the resulting unfiltered pathway. These releases are assumed to occur over a period of approximately 5.6 hours.

4.0 ANALYSIS METHODOLOGY

4.1 DOSE CONSEQUENCE CALCULATIONS

This calculation note revised the calculations included in WHC-SD-WM-CN-062, WHC-SD-WM-CN-063, and WHC-SD-WM-CN-044 for dose consequences resulting from HEPA filter and prefilter failure in a DCRT, using the PFP waste isotopic composition data (Appendix A). Onsite and offsite dose consequences were calculated consistent with the methodology presented in RPP-5924. This is essentially the same methodology used by WHC-SD-WM-CN-062, WHC-SD-WM-CN-063, and WHC-SD-WM-CN-044, except that RPP-5924 contains updates of standard calculational parameters (e.g., dose conversion factors, atmospheric dispersion coefficients, and breathing rates).

The equations used to calculate dose consequences as a result of HEPA filter releases are as shown below. Additional details may be obtained from WHC-SD-WM-CN-062, WHC-SD-WM-CN-063, and WHC-SD-WM-CN-044.

4.1.1 High-Efficiency Particulate Air Filter Failure — Exposure to High Temperature or Pressure

Using the methodology of WHC-SD-WM-CN-062 and WHC-SD-WM-CN-063, dose consequences due to initial filter release, and unfiltered release at various times following filter failure, were calculated.

Dose in Sieverts from HEPA Filter Release

$$D_{\text{onsite acute}} = Q(L) * RF * X/Q'(s/m^3) * BR(m^3/s) * ULD(Sv/L)$$

$$D_{\text{offsite acute}} = Q(L) * RF * X/Q'(s/m^3) * BR(m^3/s) * ULD(Sv/L) * 1.1$$

where

D	=	committed effective dose equivalent to receptor
Q	=	liters of tank waste on filters
RF	=	fraction of waste on filters that is released (respirable fraction = 1)
X/Q'	=	integrated atmospheric dispersion coefficient
BR	=	breathing rate
ULD	=	committed effective dose equivalent per liter inhaled.

(A factor of 1.1 has been included in the offsite equation to conservatively account for ingestion dose by the offsite receptor.)

Dose in Sieverts from Unfiltered Releases

$$\begin{aligned}
 D_{\text{onsite 12 hour}} &= Q(\text{L/s}) * PF * X/Q'(\text{s/m}^3) * BR(\text{m}^3/\text{s}) * \text{ULD}(\text{Sv/L}) * \text{time} \\
 D_{\text{onsite 1 year}} &= Q(\text{L/s}) * PF * X/Q'(\text{s/m}^3) * BR(\text{m}^3/\text{s}) * \text{ULD}(\text{Sv/L}) * \text{time} * OF \\
 D_{\text{offsite 24 hour}} &= Q(\text{L/s}) * PF * X/Q'(\text{s/m}^3) * BR(\text{m}^3/\text{s}) * \text{ULD}(\text{Sv/L}) * \text{time} * 1.1 \\
 D_{\text{offsite 1 year}} &= Q(\text{L/s}) * PF * X/Q'(\text{s/m}^3) * BR(\text{m}^3/\text{s}) * \text{ULD}(\text{Sv/L}) * \text{time} * 1.1
 \end{aligned}$$

where

D	=	committed effective dose equivalent to receptor
Q	=	ventilation system exhaust rate
PF	=	fraction of ventilation system exhaust that is waste
X/Q'	=	integrated atmospheric dispersion coefficient
BR	=	breathing rate
ULD	=	committed effective dose equivalent per liter inhaled
time	=	duration of the assumed release
OF	=	occupancy factor (0.228) representing the fraction of time the receptor is onsite.

(A factor of 1.1 has been included in the offsite equations to conservatively account for ingestion dose by the offsite receptor.)

4.1.2 Steam Intrusion from Interfacing Systems

Using the methodology of WHC-SD-WM-CN-044, the dose calculation is treated as a short-term release with atmospheric dispersion coefficients corresponding to 335 minutes.

Dose in Sieverts from HEPA Filter Release and Tank Headspace Release

$$\begin{aligned}
 D_{\text{onsite}} &= Q(\text{L}) * X/Q'(\text{s/m}^3) * BR(\text{m}^3/\text{s}) * \text{ULD}(\text{Sv/L}) \\
 D_{\text{offsite}} &= Q(\text{L}) * X/Q'(\text{s/m}^3) * BR(\text{m}^3/\text{s}) * \text{ULD}(\text{Sv/L}) * 1.1
 \end{aligned}$$

where

D	=	committed effective dose equivalent to receptor
Q	=	liters of respirable tank waste released
X/Q'	=	integrated atmospheric dispersion coefficient (corresponds to 335 minutes)
BR	=	breathing rate
ULD	=	committed effective dose equivalent per liter inhaled

According to the methodology of WHC-SD-WM-CN-044, Q(L) is the sum of waste released from the filters and waste released from the tank headspace. (A factor of 1.1 has been included in the offsite equation to conservatively account for ingestion dose by the offsite receptor.)

**4.2 WASTE LOADING ON HIGH-EFFICIENCY PARTICULATE
AIR FILTER AND PREFILTER CORRESPONDING
TO 200 MREM/H**

The previous analyses performed for the HEPA Filter Failure — Exposure to High Temperature or Pressure, and Steam Intrusion from Interfacing Systems, accidents used HEPA filter and

prefilter loading estimates provided by *MICROSHIELD Dose Rate Calculations for HEPA Filters and Prefilters* (WHC-SD-WM-CN-033). This reference presents the results of calculations using the Microshield™ software and assumed isotopic composition data for single-shell tank solids and liquids and double-shell tank liquids. These calculations determined the contact millirem per hour reading at a specified location on a HEPA filter or prefilter housing, resulting from a 1 Ci total waste loading uniformly distributed within the filter. These calculations were performed for various filter configurations employed in Tank Farms. From these calculations, the filter waste loading (in curies) corresponding to a contact reading of 200 mrem/h for the various filter configurations was determined for accident analysis purposes. The 200 mrem/h contact dose reading corresponds to the maximum filter reading allowed by AC 5.18 (HNF-SD-WM-TSR-006).

The contact dose reading for a HEPA filter or prefilter results from gamma radiation, and determination of total filter loading from a contact dose reading requires that the proportion of total waste material that emits detectable gamma rays be known. The isotopic composition of the PFP waste planned for transfer has a much lower proportion of detectable gamma-emitting isotopes than was assumed for the WHC-SD-WM-SN-033 calculations. Consequently, a new Microshield run was performed using the isotopic composition for PFP waste (100% liquid waste was assumed). The results indicated that a waste loading of approximately 29,800 L per HEPA filter, and 18,000 L per prefilter, would be required to produce a contact dose reading of 200 mrem/h. Because this is clearly an unrealistic result, it was necessary to assume a lower but conservative waste loading. A report of the new Microshield results is included in Appendix B.

For purposes of this calculation note, a total (sum for all HEPA filters, prefilters, and duct work) waste loading of 10 L was assumed as the base case. Calculations were also performed for 1 L and 100 L total waste loadings. These waste loadings were assumed to be 100% liquid waste. Based on engineering judgment, 10 L of total waste loading is considered to be conservative. In particular, recent measurements obtained in the field on 244-TX DCRT ventilation filters (which have been in place for at least 6 years) gave dose readings of approximately 20 mrem/h (Appendix C contains the Radiological Survey Report). Using the assumptions of WHC-SD-WM-CN-062, this corresponds to a total waste loading of approximately 2.28×10^{-2} L. As the results presented in Section 6.0 indicate, even an assumed loading of 100 L (rather than 10 L) produces estimated dose consequences that are lower than previous analysis results.

5.0 INPUT ASSUMPTIONS AND BASES

Standard calculational parameters (dose conversion factors, atmospheric dispersion coefficients, and breathing rates) were taken from RPP-5924. Additional onsite dose conversion factors also were taken from "Dose Coefficients for Intakes of Radionuclides by Workers — Replacement of ICRP Publication 61" (ICRP-68). Isotopic concentration data presented in Appendix A were used to represent the PFP wastes for the calculation of unit liter dose values. Dose conversion

™ Microshield is a trademark of Grove Engineering, Inc.

factors used for this calculation note are provided in Appendix D. Release fractions and partition fractions were taken from WHC-SD-WM-CN-062, WHC-SD-WM-CN-063, and WHC-SD-WM-CN-044.

As stated in Section 4.0, calculations were performed for assumed total filter (HEPA filters, prefilters, and ducts) loadings of 1 L, 10 L, and 100 L of PFP waste. It was assumed that only the liquid portion of the waste would load the filters. This assumption is consistent with the previous analyses performed for these accidents. Source term (Q) values may equal the volume of waste assumed to be on the filters (High Temp/Press Acute releases), the ventilation rate for the tank (High Temp/Press 12 hr, 24 hr, or 1 year releases), or a combination of the volume of waste released from the filters and the volume of waste released from the headspace (Steam Injection).

Details of the calculations performed for this calculation note are provided in spreadsheet form in the attachment to Appendix D. A summary of calculational input parameters is provided below.

Table 1. Summary of Input Parameters.

Location	Source Term (Q) (L or L/s)	Release Fraction (RF) (filters)	Partition Fraction (PF) (headspace)	Atmospheric Dispersion Coefficient (X/Q') (s/m ³)	Breathing Rate (BR) (m ³ /s)	Unit Liter Dose (ULD) (Sv/L)
High Temperature or Pressure						
Onsite—Acute	1/10/100 (L)	1 E-4 / 1 E-2 ^a	-	3.28 E-2	3.33 E-4	4.51
Onsite—12 Hour	1.98 E+3 (L/s)	-	1 E-10 ^c	4.80 E-3	3.33 E-4	4.51
Onsite—1 Year	1.98 E+3 (L/s)	-	1 E-10 ^c	4.03 E-4	3.33 E-4	4.51
Offsite—Acute	1/10/100 (L)	1 E-4 / 1 E-2 ^a	-	2.22 E-5	2.57 E-4	7.05
Offsite—24 Hour	1.98 E+3 (L/s)	-	1 E-10 ^c	4.23 E-6	2.57 E-4	7.05
Offsite—1 Year	1.98 E+3 (L/s)	-	1 E-10 ^c	1.47 E-7	2.57 E-4	7.05
Steam Injection						
Onsite	4.11 E-2 1.31 E-1 1.03 ^b (L)	1 E-2	1 E-8 ^d	6.39 E-3	3.33 E-4	4.51
Offsite	4.11 E-2 1.31 E-1 1.03 ^b (L)	1 E-2	1 E-8 ^d	9.70 E-6	2.57 E-4	7.05

^a1 E-4 for high temperature, 1 E-2 for high pressure.

^bThese values correspond to 1, 10, and 100 liters of filter loading. They already include the release fraction of 1 E-2 and the partition fraction of 1 E-8. One headspace for a half-full double-shell tank is assumed to be vented.

^cThese partition fractions represent the portion of the ventilation flow rate that is released as contaminated air.

^dThese partition fractions represent the portion of headspace volume that is released as contaminated air.

6.0 RESULTS

Based on the calculations detailed in Appendix D, the following results were obtained. Note that these results correspond to uncontrolled scenarios.

Table 2. High-Efficiency Particulate Air Filter Failure — Exposure to High Temperature.

	Dose Consequence			
	Onsite HEPA Filter Release + 12 Hour Exposure (Sv)	Onsite HEPA Filter Release + 1 Year Exposure (Sv)	Offsite HEPA Filter Release + 24 Hour Exposure (Sv)	Offsite HEPA Filter Release + 1 Year Exposure (Sv)
1 L Total Filter Loading	6.66 E-8	8.67 E-7	1.49 E-10	1.83 E-9
10 L Total Filter Loading	1.11 E-7	9.11 E-7	1.88 E-10	1.87 E-9
100 L Total Filter Loading	5.55 E-7	1.35 E-6	5.87 E-10	2.27 E-9
Previous Results ^a	1.77E-4	2.16 E-3	2.44 E-7	2.37 E-6

^aWHC-SD-WM-CN-062, 1996, *HEPA Filter Failure by Fire or Heater Overtemperature and Subsequent Unfiltered Release*, Rev. 2, Duke Engineering & Services Hanford, Richland, Washington.

HEPA = high-efficiency particulate air.

Table 3. High-Efficiency Particulate Air Filter Failure — Exposure to High Pressure.

	Dose Consequence			
	Onsite HEPA Filter Release + 12 Hour Exposure (Sv)	Onsite HEPA Filter Release + 1 Year Exposure (Sv)	Offsite HEPA Filter Release + 24 Hour Exposure (Sv)	Offsite HEPA Filter Release + 1 Year Exposure (Sv)
1 L Total Filter Loading	5.55 E-7	1.35 E-6	5.87 E-10	2.27 E-9
10 L Total Filter Loading	4.99 E-6	5.79 E-6	4.57 E-9	6.25 E-9
100 L Total Filter Loading	4.93 E-5	5.01 E-5	4.44 E-8	4.61 E-8
Previous Results ^a	4.54 E-4	2.44 E-3	4.81 E-7	2.60 E-6

^aWHC-SD-WM-CN-063, 1996, *Releases From Failed HEPA Filters Due to an Overpressurization Event*, Rev. 2, Duke Engineering & Services Hanford, Richland, Washington.

HEPA = high-efficiency particulate air.

Table 4. Steam Intrusion from Interfacing Systems.

	Dose Consequence (Sv)	
	Onsite (Sv)	Offsite (Sv)
1 L Total Filter Loading	3.95 E-7	7.96 E-10
10 L Total Filter Loading	1.26 E-6	2.54 E-9
100 L Total Filter Loading	9.90 E-6	1.99 E-8
Previous Results ^a	4.90 E-4	7.60 E-7

^aWHC-SD-WM-CN-044, 1997, *Calculation Notes That Support Accident Scenario and Consequence Development for the Steam Intrusion From Interfacing Systems Accident*, Rev. 2, Duke Engineering & Services Hanford, Richland, Washington.

7.0 CONCLUSIONS

The purpose of this calculation note was to analyze the effect of the PFP waste isotopic distribution on the assumed ventilation HEPA filter and prefilter waste loading for DCRTs, and determine the impact of this waste loading on previously performed FSAR accident analyses as required to support USQ TF-00-0768. This analysis supports two upcoming PFP waste transfers.

As stated in Section 2.0, it was determined that only three previous FSAR accident analyses needed to be considered. These are the HEPA Filter Failure — Exposure to High Temperature or Pressure accidents, and the Steam Intrusion from Interfacing Systems accident.

Section 6.0 provides a summary of the results of reanalysis of these accidents as they apply to DCRTs. As Section 6.0 demonstrates, both the onsite and offsite dose consequences for these three accidents based on the PFP waste isotopic composition are bounded by the dose consequences currently assumed for these accidents in the FSAR.

8.0 REFERENCES

- HNF-SD-WM-SAR-067, 2000, *Tank Waste Remediation System (TWRS) Final Safety Analysis Report (FSAR)*, Rev. 1-O, CH2M HILL Hanford Group, Inc., Richland, Washington.
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WHC-SD-WM-CN-044, 1997, *Calculation Notes that Support Accident Scenario and Consequence Development for the Steam Intrusion from Interfacing Systems Accident*, Rev. 2, Duke Engineering & Services Hanford, Richland, Washington.

WHC-SD-WM-CN-062, 1996, *HEPA Filter Failure by Fire or Heater Overtemperature and Subsequent Unfiltered Release*, Rev. 2, Duke Engineering & Services Hanford, Richland, Washington.

WHC-SD-WM-CN-063, 1996, *Releases From Failed HEPA Filters Due to an Overpressurization Event*, Rev. 2, December, Duke Engineering & Services Hanford, Richland, Washington.

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APPENDIX A

**PLUTONIUM FINISHING PLANT WASTE
ISOTOPIC COMPOSITION DATA**

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APPENDIX A

PLUTONIUM FINISHING PLANT WASTE
ISOTOPIC COMPOSITION DATA**Zimmerman, Bruce D**

From: Fowler, Kenneth D (Kenny)
Sent: Friday, November 17, 2000 1:36 PM
To: Zimmerman, Bruce D
Cc: Stanton, George A Jr
Subject: PFP DATA

Bruce,
 Here are the values based on the 222-S Lab data from the PDP tank D-5.
 Not all of the analytes on the list were available.

If you have any questions please call.

Thanks,
 Kenny
 3-5930

PFP Tank D-5 based on 222-S Lab data Sept. 2000

	Liq (uCi/ml)	Sol (uCi/g)	Sol (uCi/ml)	total waste (uCi/ml)	total waste (Ci/l)	Comments
				liquid + solid fraction	liquid + solid fraction	
Co 60	2.94E-05	1.34E-02	1.74E-02	1.07E-03	1.07E-06	method detection limit
Sr 90	9.40E-06	4.01E-03	5.21E-03	3.21E-04	3.21E-07	data + 2 stdev
Y 90	9.40E-06	4.01E-03	5.21E-03	3.21E-04	3.21E-07	based on Sr 90
Tc 99	6.71E-06	3.26E-03	4.24E-03	2.61E-04	2.61E-07	method detection limit
Sb 125	7.01E-05	3.50E-02	4.55E-02	2.80E-03	2.80E-06	method detection limit
Cs 134	2.33E-05	1.11E-02	1.44E-02	8.88E-04	8.88E-07	method detection limit
Cs 137	1.29E-04	1.38E-01	1.79E-01	1.09E-02	1.09E-05	data + 2 stdev
Eu 154	8.84E-05	4.30E-02	5.59E-02	3.44E-03	3.44E-06	method detection limit
Eu 155	4.43E-05	2.12E-02	2.76E-02	1.70E-03	1.70E-06	method detection limit
Pu 239	3.66E-03	2.46E+01	3.19E+01	1.92E+00	1.92E-03	data + 2 stdev
Am 241	1.79E-04	1.63E+01	2.12E+01	1.27E+00	1.27E-03	data + 2 stdev
1.3	g/cc solids	density				
0.06	solids	fraction in waste stream				
0.94	liquids	fraction in waste stream				

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APPENDIX B

**MICROSHIELD RESULTS FOR PLUTONIUM
FINISHING PLANT WASTE**

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APPENDIX B

MICROSHIELD RESULTS FOR PLUTONIUM
FINISHING PLANT WASTE

Filter Evaluation for PFP Source Term

J. C. Van Keuren *JCVK*

Fluor Federal Services

The dose rate from a DCRT HEPA filter was calculated assuming 1 L of waste on the filter from a mix from PFP. The waste mix was furnished by the customer and is attached. Liquid was assumed as specified in the attached message. Activities in Ci/L were calculated by multiplying the data which is in $\mu\text{Ci/ml}$ by $(10^{-6} \text{ Ci}/\mu\text{Ci}) (1000 \text{ ml/L}) = 10^{-3}$. Dimensions for filter sampling points were taken from WHC-SD-WM-CN-033 (Savino, 1996) for a DCRT HEPA filter (page 25). Dimensions of the filter were 0.3 m x 0.3 m x 0.3 m (1 ft x 1 ft by 1ft.). The filter is surrounded by a 0.2 (0.08 inch) aluminum wall. The sampling point was at the midpoint of the side of the filter 1.3 cm (0.5 inches) from the filter. The dose rate was calculated with Microshield 5 (Himes 2000).

Bremsstrahlung radiation was neglected for these calculations. Sr-90 and Y-90 are the principal contributors to Bremsstrahlung radiation. Cs-137 is the dominant gamma emitter. For SST solids, the Sr-90 and Y-90 concentrations are over an order of magnitude higher than the Cs-137 but the dose from Bremsstrahlung is an order of magnitude less than the Cs-137. In this case, the Sr-90 and Y-90 concentrations are an order of magnitude less than the Cs-137, so the Bremsstrahlung will be less than 1% of the Cs-137 contribution. In any event, it is conservative to neglect the Bremsstrahlung in the calculation of the filter inventory since including Bremsstrahlung radiation will increase the dose rate and decrease the amount of material required to reach 200 mr/hr.

The dose rate from 1 L of the PFP waste is $6.72\text{E-}03$ mr/hr. The quantity of waste to produce a dose rate of 200 mr/hr is therefore

$$\frac{200 \text{ mr/hr}}{6.72\text{E-}03 \text{ mr/hr/L}} = 2.98 \text{ E+}04 \text{ L}$$

A calculation was made for the prefilter. The prefilter dimensions are 30.48 cm by 30.48 x 6.35 cm (1ft x 1 ft x 2.5 inches). The filter also is enclosed by aluminum wall. The dose was calculated at midpoint of the prefilter 0.5 inches from the aluminum wall. The prefilter was assumed to contain 1 L of waste. The dose rate was 0.01112 mr/hr. The filter inventory at 200 mr/hr is:

$$\frac{200 \text{ mr/hr}}{0.0112 \text{ mr/hr/L}} = 1.80 \text{ E+}04 \text{ L}$$

The Microshield 5 computer output is attached.

These waste quantities are obviously unreasonably high because the filter would plug before the waste accumulation could reach this value. The quantities are unrealistically high because the concentrations of gamma emitters are very low for this mix.

Several of the isotopes are introduced at minimum detection level including the Co-60. The Co-60 is a significant contributor at this concentration level. Including isotopes at the minimum detection limit is nonconservative for this calculation since the Co-60 concentration may be much lower, which would increase the number of liters to reach 200 mr/hr.

The calculation does not include any self-shielding from the waste. If the waste quantity was as large as calculated above, the self-shielding would be significant.

References

Himes, 2000, Memo, DA Himes to S.A. Fargo, *Verification of MICROSHIELD VERSION 5.05*, August 20, 2000, Fluor Federal Services, Richland WA.

Savino, A. V., 1996, *MICROSHIELD Dose Rate Calculations for HEPA Filters and Prefilters*, Westinghouse Hanford Co, Richland WA.

Hey, Brit E

From: Zimmerman, Bruce D
 Sent: Friday, November 17, 2000 2:19 PM
 To: Hey, Brit E
 Subject: FW: PFP DATA

Brit: Here is Kenny's full list of the isotopes that are available for the PFP waste. By the way, it appears that after looking at the FSAR accidents, we only need the Microshield calculations done for the PFP liquids.

-----Original Message-----

From: Fowler, Kenneth D (Kenny)
 Sent: Friday, November 17, 2000 1:36 PM
 To: Zimmerman, Bruce D
 Cc: Stanton, George A Jr
 Subject: PFP DATA

Bruce,
 Here are the values based on the 222-S Lab data from the PDP tank D-5.
 Not all of the analytes on the list were available.

If you have any questions please call.

Thanks,
 Kenny
 3-5930

PFP Tank D-5 based on 222-S Lab data Sept. 2000						
	Liq (uCi/ml)	Sol (uCi/g)	Sol (uCi/ml)	total waste (uCi/ml)	total waste (Ci/l)	Comments
				liquid + solid fraction	liquid + solid fraction	
Co 60	2.94E-05	1.34E-02	1.74E-02	1.07E-03	1.07E-06	method detection limit
Sr 90	9.40E-06	4.01E-03	5.21E-03	3.21E-04	3.21E-07	data + 2 stdev
Y 90	9.40E-06	4.01E-03	5.21E-03	3.21E-04	3.21E-07	based on Sr 90
Tc 99	5.71E-06	3.26E-03	4.24E-03	2.61E-04	2.61E-07	method detection limit
Sb 125	7.01E-05	3.50E-02	4.55E-02	2.80E-03	2.80E-06	method detection limit
Cs 134	2.33E-05	1.11E-02	1.44E-02	8.88E-04	8.88E-07	method detection limit
Cs 137	1.29E-04	1.38E-01	1.79E-01	1.09E-02	1.09E-05	data + 2 stdev
Eu 154	8.84E-05	4.30E-02	5.59E-02	3.44E-03	3.44E-06	method detection limit
Eu 155	4.43E-05	2.12E-02	2.76E-02	1.70E-03	1.70E-06	method detection limit.
Pu 239	3.66E-03	2.46E+01	3.19E+01	1.92E+00	1.92E-03	data + 2 stdev
Am 241	1.79E-04	1.63E+01	2.12E+01	1.27E+00	1.27E-03	data + 2 stdev
1.3	g/cc solids	density				
0.06	solids	fraction in waste stream				
0.94	liquids	fraction in waste stream				

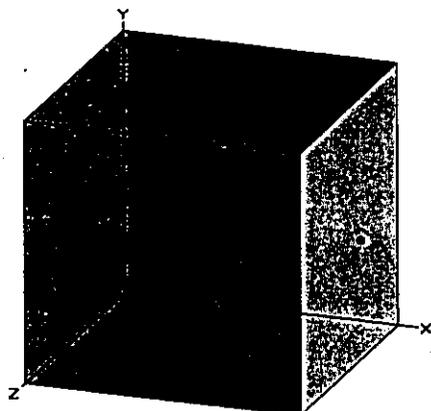
$$\begin{aligned} & \mu\text{Ci/mL} \times 10^6 \frac{\text{Ci}}{\text{mL}} \times 10^3 \frac{\text{mL}}{\text{L}} \\ & = 10^{-3} \frac{\text{Ci}}{\text{L}} \end{aligned}$$

MicroShield v5.05 (5.05-00321)
Fluor Daniel Northwest

Page : 1
DOS File: DCRTFILT.MS5
Run Date: November 17, 2000
Run Time: 2:58:51 PM
Duration: 00:00:19

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DCRT Filter
Description: Dose from 1 L of liquid mix in Zimmerman email 11/17/00
Geometry: 13 - Rectangular Volume



Source Dimensions			
Length	30.48 cm	1 ft	
Width	30.48 cm	1 ft	
Height	30.48 cm	1 ft	

Dose Points			
	X	Y	Z
# 1	32.004 cm	15.24 cm	15.24 cm
	1 ft 0.6 in	6.0 in	6.0 in

Shields			
Shield Name	Dimension	Material	Density
Source	2.83e+04 cm ³	Mixed ->	0.05
		Aluminum	0.03
		Carbon	0.02
Shield 1	.203 cm	Aluminum	2.702
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	1.7900e-007	6.6230e+003	6.3213e-006	2.3389e-001
Ba-137m	1.2200e-007	4.5140e+003	4.3084e-006	1.5941e-001
Co-60	2.9400e-008	1.0878e+003	1.0383e-006	3.8415e-002
Cs-134	2.3300e-008	8.6210e+002	8.2283e-007	3.0445e-002
Cs-137	1.2900e-007	4.7730e+003	4.5556e-006	1.6856e-001
Eu-154	8.8400e-008	3.2708e+003	3.1218e-006	1.1551e-001
Eu-155	4.4300e-008	1.6391e+003	1.5644e-006	5.7884e-002
Pu-239	3.6600e-006	1.3542e+005	1.2925e-004	4.7823e+000
Sb-125	7.0100e-008	2.5937e+003	2.4756e-006	9.1596e-002
Sr-90	9.4000e-009	3.4780e+002	3.3196e-007	1.2282e-002
Tc-99	6.7100e-009	2.4827e+002	2.3696e-007	8.7676e-003
Y-90	9.4000e-009	3.4780e+002	3.3196e-007	1.2282e-002

Buildup
The material reference is : Shield 1

Integration Parameters	
X Direction	20
Y Direction	20
Z Direction	20

Results

RPP-7396 REV 0

Page : 2
 DOS File: DCRTFILT.MS5
 Run Date: November 17, 2000
 Run Time: 2:58:51 PM
 Duration: 00:00:19

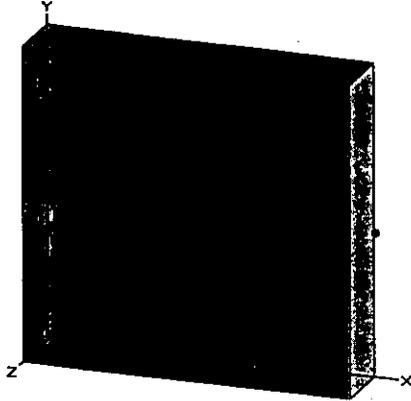
Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		<u>No Buildup</u> MeV/cm ² /sec	<u>With Buildup</u> MeV/cm ² /sec	<u>No Buildup</u> mR/hr	<u>With Buildup</u> mR/hr
0.03	1.608e+03	3.769e-03	4.696e-03	3.735e-05	4.654e-05
0.04	1.135e+03	6.704e-03	9.160e-03	2.965e-05	4.051e-05
0.05	2.657e+02	2.483e-03	3.407e-03	6.615e-06	9.077e-06
0.06	2.411e+03	3.008e-02	4.469e-02	5.976e-05	8.877e-05
0.08	5.090e+02	9.262e-03	1.331e-02	1.466e-05	2.106e-05
0.1	1.734e+03	4.093e-02	5.689e-02	6.262e-05	8.704e-05
0.15	6.510e+00	2.401e-04	3.133e-04	3.954e-07	5.159e-07
0.2	4.202e+02	2.111e-02	2.643e-02	3.726e-05	4.665e-05
0.3	1.112e+01	8.606e-04	1.023e-03	1.632e-06	1.940e-06
0.4	8.354e+02	8.770e-02	1.012e-01	1.709e-04	1.973e-04
0.5	2.882e+02	3.831e-02	4.330e-02	7.520e-05	8.500e-05
0.6	6.304e+03	1.016e+00	1.130e+00	1.983e-03	2.206e-03
0.8	2.087e+03	4.553e-01	4.964e-01	8.659e-04	9.442e-04
1.0	2.118e+03	5.840e-01	6.287e-01	1.077e-03	1.159e-03
1.5	2.390e+03	1.007e+00	1.063e+00	1.694e-03	1.789e-03
TOTALS:	2.212e+04	3.303e+00	3.623e+00	6.115e-03	6.723e-03

MicroShield v5.05 (5.05-00321)
Fluor Daniel Northwest

Page : 1
DOS File: DCRTPREF.MS5
Run Date: November 17, 2000
Run Time: 4:55:02 PM
Duration: 00:00:19

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: DCRT PreFilter
Description: Dose from 1 L of liquid mix in Zimmerman email 11/17/00
Geometry: 13 - Rectangular Volume



Source Dimensions
Length 30.48 cm 1 ft
Width 6.35 cm 2.5 in
Height 30.48 cm 1 ft

Dose Points
1 X Y Z
32.004 cm 15.24 cm 3.175 cm
1 ft 0.6 in 6.0 in 1.3 in

Shields
Shield Name Dimension Material Density
Source 5899.343 cm³ Mixed ->0.05
Aluminum 0.03
Carbon 0.02
Shield 1 .203 cm Aluminum 2.702
Air Gap Air 0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Am-241	1.7900e-007	6.6230e+003	3.0342e-005	1.1227e+000
Ba-137m	1.2200e-007	4.5140e+003	2.0680e-005	7.6517e-001
Co-60	2.9400e-008	1.0878e+003	4.9836e-006	1.8439e-001
Cs-134	2.3300e-008	8.6210e+002	3.9496e-006	1.4613e-001
Cs-137	1.2900e-007	4.7730e+003	2.1867e-005	8.0907e-001
Eu-154	8.8400e-008	3.2708e+003	1.4985e-005	5.5443e-001
Eu-155	4.4300e-008	1.6391e+003	7.5093e-006	2.7784e-001
Pu-239	3.6600e-006	1.3542e+005	6.2041e-004	2.2955e+001
Sb-125	7.0100e-008	2.5937e+003	1.1883e-005	4.3966e-001
Sr-90	9.4000e-009	3.4780e+002	1.5934e-006	5.8956e-002
Tc-99	6.7100e-009	2.4827e+002	1.1374e-006	4.2084e-002
Y-90	9.4000e-009	3.4780e+002	1.5934e-006	5.8956e-002

Buildup
The material reference is : Shield 1

Integration Parameters
X Direction 20
Y Direction 20
Z Direction 20

Results

RPP-7396 REV 0

Page : 2
 DOS File: DCRTPREF.MS5
 Run Date: November 17, 2000
 Run Time: 4:55:02 PM
 Duration: 00:00:19

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u> <u>No. Buildup</u>	<u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>mR/hr</u> <u>No. Buildup</u>	<u>mR/hr</u> <u>With Buildup</u>
0.03	1.608e+03	8.000e-03	9.781e-03	7.928e-05	9.694e-05
0.04	1.135e+03	1.273e-02	1.673e-02	5.629e-05	7.397e-05
0.05	2.657e+02	4.512e-03	5.841e-03	1.202e-05	1.556e-05
0.06	2.411e+03	5.354e-02	7.366e-02	1.063e-04	1.463e-04
0.08	5.090e+02	1.619e-02	2.158e-02	2.562e-05	3.415e-05
0.1	1.734e+03	7.102e-02	9.204e-02	1.087e-04	1.408e-04
0.15	6.510e+00	4.132e-04	5.089e-04	6.804e-07	8.381e-07
0.2	4.202e+02	3.616e-02	4.312e-02	6.382e-05	7.610e-05
0.3	1.112e+01	1.466e-03	1.678e-03	2.780e-06	3.182e-06
0.4	8.354e+02	1.488e-01	1.665e-01	2.899e-04	3.244e-04
0.5	2.882e+02	6.482e-02	7.134e-02	1.272e-04	1.400e-04
0.6	6.304e+03	1.715e+00	1.865e+00	3.348e-03	3.639e-03
0.8	2.087e+03	7.661e-01	8.197e-01	1.457e-03	1.559e-03
1.0	2.118e+03	9.804e-01	1.039e+00	1.807e-03	1.914e-03
1.5	2.390e+03	1.684e+00	1.757e+00	2.832e-03	2.956e-03
TOTALS:	2.212e+04	5.563e+00	5.982e+00	1.032e-02	1.112e-02

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: FILTER EVALUATION FOR PFP SOURCE TERM
 Title:
 Author: J C Von KEUREN
 Date: 11/17/00
 Scope of Review: ENTIRE DOCUMENT

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

Donald R. Porten, Donald R. Porten
 Reviewer (printed name and signature)

11/17/00
 Date

• All "no" responses must be explained below or on an additional sheet.

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

APPENDIX C

RADIOLOGICAL SURVEY REPORT

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APPENDIX C

RADIOLOGICAL SURVEY REPORT

PROJECT HANFORD RADIOLOGICAL SURVEY REPORT				Survey Report No.		Page 3 of 2					
Date 9-21-00		Time (Start/Stop) 0700 / 1630		Area/Bldg./Room/Location 2JWJ / 244 -TX		F.C. SST					
RWP Number 2W-048 RWD		Work Package/Job Control Package/JSA 2W-00-00466		Routine Surveillance Task Number - MA -		Radiological Shipping Rec. Number - MA -					
Purpose of Survey (check appropriate box(es)): <input checked="" type="checkbox"/> Job Coverage, <input type="checkbox"/> Required Task, <input type="checkbox"/> Material Release, <input type="checkbox"/> Ram Shipment											
Contamination Incident: <input type="checkbox"/> Skin, <input type="checkbox"/> Clothing, <input type="checkbox"/> Spill											
Alarm Response: <input type="checkbox"/> Cam, <input type="checkbox"/> ARM, <input type="checkbox"/> APM											
<input type="checkbox"/> Exposure Incident <input type="checkbox"/> HRA/VHRA Work Other: - MA -											
Job Description: Coverage of work taking filter readings @ 244-T2 DIRT PIT, Temporary zone set up for job (CALBA) around cover blocks. (SEE REVERSE)											
DOSE RATE MEASUREMENTS Note: F = Field (≥30 cm) C = Contact (≤1 cm)											
No.	Description	Dist. (cm) Note	WO (mR/hr)	WC (mR/hr)	CF _B	CF _T	Neutron Dose (mrem/hr)	Shallow Dose (mrem/hr)	Deep Dose (mrem/hr)		
A	Work Area (Above cover blocks) ^{PRE Survey}	"F"	20.5	20.5	2	1	N/A	20.5	20.5		
B	Work Area (cover block removed)	"F"	20.5	20.5	2	1	N/A	20.5	20.5		
C	Filter 1 (highest) ^{Extend to 100"}	"C"	N/A	20	N/A	N/A	N/A	N/A	N/A		
D	Filter 2 (highest)	"C"	N/A	18	N/A	N/A	N/A	N/A	N/A		
E	Filter 3 (highest)	"C"	N/A	22	N/A	N/A	N/A	N/A	N/A		
F	valve handles	"C"	20.5	20.5	2	1	N/A	20.5	20.5		
G	Landfill, waste bags	"C"	20.5	20.5	2	1	N/A	20.5	20.5		
CONTAMINATION MEASUREMENTS											
No.	Description	Direct		Background		Total dpm/100 cm ²		Removable dpm/100 cm ²			
		Gross cpm/PAE ^γ	Gross cpm/PAE ^α	B _γ (cpm)	B _α (cpm)	B _γ	α	B _γ	α		
1	Cover Blocks (PRE Survey)	100	0	100	0	N/A	<100	<1K	<20		
2	hard hats, (ALL)	100	0	100	0	<5K	<100	<1K	<20		
3	Crane #10-1TT-56B2	100	0	100	0	<5K	<100	<1K	<20		
4	Paperwork, cellphone, radio ^(PC)	100	0	100	0	<5K	<100	<1K	<20		
5	Instruments (HR's)	100	0	100	0	<5K	<100	<1K	<20		
6	Checkers, hucks (riggers)	100	0	100	0	<5K	<100	<1K	<20		
7	sniffer equipment (sniffers)	100	0	100	0	<5K	<100	<1K	<20		
8	valve handles	100	0	100	0	N/A	N/A	<1K	<20		
9	Remotes cover block	100	0	100	0	N/A	N/A	<1K	<20		
10	Cover Blocks (POST Survey)	100	0	100	0	N/A	N/A	<1K	<20		
11	Landfill, waste bags	100	0	100	0	N/A	N/A	<1K	<20		
AIR SAMPLE MEASUREMENTS (μCi/m ³)											
a ¹	BZ	GA	Inlet	Decay	a ²	BZ	GA	Inlet	Decay	Sample Counter Log Number or Sample ID Number	
a ¹		✓	6.86E-11	1hr	a ²	✓		2.4E-10	1hr	1.82E-12	N / SST-092526
a ²	N/A				a ²	N/A					N

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Map/Sketch							
LEGEND (S) Smear (A) Air Sample (R) LAW (N) Neutron * Contact Reading ----- (designation inside) ----- Radiological Area Boundary Dose Rates in mrem/h unless otherwise noted							
COMMENTS: (Additional information as necessary to interpret results)							
<p><i>No removable contamination encountered during job evolution.</i></p> <p><i>Items released on reverse using 95% confidence level to personal listed in ().</i></p> <p><i>Due to water on cover blocks left AREA listed CA until dries out.</i></p> <p><i>Initial A/S counted @ 1400 Hrs. Due to instrument failure - Air sampler #2, air sampler #3 used for measurements - management notified.</i></p>							
Instr./Probe Model RB-35 (CP) R-20	GM Model g-m probe	PAM	John E. Extender	SAIC	SAIC	R-7	
Serial No. ICEN4-0034	(M) 01-0181	ALN01-0004	XEVB2-0002	0498	0367	R-7 0013	
Efficiency (used) NA	DITHC-0384 10%	DTHN3-0089 14%	N/A	N/A	N/A	R-7 0000 N/A	
RCT: Date: 9-21-00	Payroll No.: KCT06/02666	Reviewer: Date: 9-25-00	Payroll No.: 56973				
Name (Print): <i>IL Huesner / K. S. Ly</i>			Name (Print): <i>J. Padgett</i>				
Signature: <i>[Signature]</i>			Signature: <i>[Signature]</i>				

APPENDIX D

DETAILED CALCULATIONS

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APPENDIX D

DETAILED CALCULATIONS

**Table D1. Summary Of Results
Over Temperature Accident**

	Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
1 Liter	6.66E-08	8.67E-07	1.49E-10	1.83E-09
10 Liters	1.11E-07	9.11E-07	1.88E-10	1.87E-09
100 Liters	5.55E-07	1.35E-06	5.87E-10	2.27E-09

Table D3. 12 Hour Unfiltered Release - Onsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.80E-03	3.33E-04	4.51E+00	43,200	6.16E-08

Table D4. Annual Unfiltered Release - Onsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.03E-04	3.33E-04	4.51E+00	31536000	0.228	8.62E-07

Table D5. 24 Hour Unfiltered Release - Offsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.23E-06	2.57E-04	7.05E+00	86,400	1.10E+00	1.44E-10

Table D6. Annual Unfiltered Release - Offsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	1.47E-07	2.57E-04	7.05E+00	31,536,000	1.10E+00	1.83E-09

**Table D7.
Comparison Of Results With
Previous FSAR Results
Over Temperature Accident
(10 Liter Loading)**

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
1.11E-07	9.11E-07	1.88E-10	1.87E-09
1.77E-04	2.16E-03	2.44E-07	2.37E-06

Previous FSAR Results in Gray

Table D8. X/Q Log Interpolation

Time	$\frac{[\text{Log}(2\text{hr}) - \text{Log}(X\text{hr})]}{[\text{Log}(2\text{hr}) - \text{Log}(8760\text{hr})]}$	$\frac{\text{Log}(X/Q \text{ Acute}) - \text{Log}(X/Q \text{ Chronic})}{\text{Log}(X/Q \text{ Acute})}$	$\text{Log}(X/Q \text{ Acute})$	$\text{Log}(X/Q \text{ for time } X)$	$X/Q \text{ for time } X$	
12 hr	0.21369128	1.3678228	-2.0268721	-2.3191639	0.004796	Onsite
24 hr	0.29635835	2.0732319	-4.7594508	-5.3738703	4.23E-06	Offsite

Table D10. 12 Hour Unfiltered Release - Onsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.80E-03	3.33E-04	4.51E+00	43,200	6.16E-08

1.74E-04

Table D11. Annual Unfiltered Release - Onsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.03E-04	3.33E-04	4.51E+00	31536000	0.228	8.62E-07

2.16E-03

Table D12. 24 Hour Unfiltered Release - Offsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.23E-06	2.57E-04	7.05E+00	86,400	1.10E+00	1.44E-10

2.41E-07

Table D13. Annual Unfiltered Release - Offsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	1.47E-07	2.57E-04	7.05E+00	31,536,000	1.10E+00	1.83E-09

2.36E-06

**Table D14.
Comparison Of Results With
Previous FSAR Results
Over Temperature Accident
(1 Liter Loading)**

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
6.66E-08	8.67E-07	1.49E-10	1.83E-09
1.77E-04	2.16E-03	2.44E-07	2.37E-06

Previous FSAR Results in Gray

Over Temperature Accident (100 Liter Filter Loading)

Table D15. HEPA Filter Release (100 Liter Loading)

	Liq (uCi/ml) (PFP Data)	uCi per Liter	Bq per liter		Sv/Bq Onsite Dose Conversion Factor (5924 App.B & ICRP-68)	Sv per Liter Onsite		Sv/Bq Offsite Dose Conversion Factor (5924 App. B)	Sv per Liter Offsite
Co 60	2.94E-05	2.94E-02	1.09E+03		1.70E-08	1.85E-05		1.00E-08	1.09E-05
Sr 90	9.40E-06	9.40E-03	3.48E+02		3.00E-08	1.04E-05		3.60E-08	1.25E-05
Y 90	9.40E-06	9.40E-03	3.48E+02		1.70E-09	5.91E-07		1.40E-09	4.87E-07
Tc 99	6.71E-06	6.71E-03	2.48E+02		3.20E-09	7.94E-07		4.00E-09	9.93E-07
Sb 125	7.01E-05	7.01E-02	2.59E+03		3.30E-09	8.56E-06		4.80E-09	1.24E-05
Cs 134	2.33E-05	2.33E-02	8.62E+02		9.69E-09	8.35E-06		6.60E-09	5.69E-06
Cs 137	1.29E-04	1.29E-01	4.77E+03		6.70E-09	3.20E-05		4.60E-09	2.20E-05
Eu 154	8.84E-05	8.84E-02	3.27E+03		3.50E-08	1.14E-04		5.30E-08	1.73E-04
Eu 155	4.43E-05	4.43E-02	1.64E+03		4.70E-09	7.70E-06		6.90E-09	1.13E-05
Pu 239	3.66E-03	3.66E+00	1.35E+05		3.20E-05	4.33E+00		5.00E-05	6.77E+00
Am 241	1.79E-04	1.79E-01	6.62E+03		2.70E-05	1.79E-01		4.20E-05	2.78E-01
					TOTAL Sv/L	4.51E+00		TOTAL Sv/L	7.05E+00
	Loading On Filter (L)	Sv per Liter	Release Fraction From Filter (1 E-4) (CN-062)	X/Q (5924 Table 5-2, Table 5-3) (s/m ³)	Breathing Rate (5924 Section 6.2) (m ³ /s)	Multiply by Ingestion Dose Multiplier (1.1) (5924 Section 6.2)	Total Dose From Filter Release (Sv)	Sv	
Onsite	100	4.51E+00	1.00E-04	3.28E-02	3.33E-04	1.00E+00	4.93E-07	2.82E-06	
Offsite	100	7.05E+00	1.00E-04	2.22E-05	2.57E-04	1.10E+00	4.42E-10	2.38E-09	

Previous FSAR Results in Gray

Table D16. 12 Hour Unfiltered Release - Onsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.80E-03	3.33E-04	4.51E+00	43,200	6.16E-08

1.74E-04

Table D17. Annual Unfiltered Release - Onsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.03E-04	3.33E-04	4.51E+00	31536000	0.228	8.62E-07

2.16E-03

Table D18. 24 Hour Unfiltered Release - Offsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.23E-06	2.57E-04	7.05E+00	86,400	1.10E+00	1.44E-10

2.41E-07

Table D19. Annual Unfiltered Release - Offsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	1.47E-07	2.57E-04	7.05E+00	31,536,000	1.10E+00	1.83E-09

2.36E-06

**Table D20.
Comparison Of Results With
Previous FSAR Results
Over Temperature Accident
(100 Liter Loading)**

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
5.55E-07	1.35E-06	5.87E-10	2.27E-09
1.77E-04	2.16E-03	2.44E-07	2.37E-06

Previous FSAR Results in Gray

**Table D21. Summary Of Results
Over Pressure Accident**

	Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
1 Liter	5.55E-07	1.35E-06	5.87E-10	2.27E-09
10 Liters	4.99E-06	5.79E-06	4.57E-09	6.25E-09
100 Liters	4.93E-05	5.01E-05	4.44E-08	4.61E-08

Table D23. 12 Hour Unfiltered Release - Onsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.80E-03	3.33E-04	4.51E+00	43,200	6.17E-08

1.74E-04

Table D24. Annual Unfiltered Release - Onsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.03E-04	3.33E-04	4.51E+00	31536000	0.228	8.62E-07

2.16E-03

Table D25. 24 Hour Unfiltered Release - Offsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.23E-06	2.57E-04	7.05E+00	86,400	1.1	1.44E-10

2.41E-07

Table D26. Annual Unfiltered Release - Offsite (10 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	1.47E-07	2.57E-04	7.05E+00	31,536,000	1.1	1.83E-09

2.36E-06

**Table D27.
Comparison Of Results With
Previous FSAR Results
Over Pressure Accident
(10 Liter Loading)**

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
4.99E-06	5.79E-06	4.57E-09	6.25E-09
4.54E-04	2.44E-03	4.81E-07	2.60E-06

Previous FSAR Results in Gray

Over Pressure Accident

(1 Liter Filter Loading)

Table D28. HEPA Filter Release (1 Liter Loading)

	Liq (uCi/ml) (PFP Data)	uCi on Filters for 1 Liter	Bq on Filters for 1 Liter		Sv/Bq Onsite Dose Conversion Factor (5924 App.B & ICRP-68)	Sv for 1 Liter Onsite		Sv/Bq Offsite Dose Conversion Factor (5924 App. B)	Sv for 1 Liter Offsite
Co 60	2.94E-05	2.94E-02	1.09E+03		1.70E-08	1.85E-05		1.00E-08	1.09E-05
Sr 90	9.40E-06	9.40E-03	3.48E+02		3.00E-08	1.04E-05		3.60E-08	1.25E-05
Y 90	9.40E-06	9.40E-03	3.48E+02		1.70E-09	5.91E-07		1.40E-09	4.87E-07
Tc 99	6.71E-06	6.71E-03	2.48E+02		3.20E-09	7.94E-07		4.00E-09	9.93E-07
Sb 125	7.01E-05	7.01E-02	2.59E+03		3.30E-09	8.56E-06		4.80E-09	1.24E-05
Cs 134	2.33E-05	2.33E-02	8.62E+02		9.69E-09	8.35E-06		6.60E-09	5.69E-06
Cs 137	1.29E-04	1.29E-01	4.77E+03		6.70E-09	3.20E-05		4.60E-09	2.20E-05
Eu 154	8.84E-05	8.84E-02	3.27E+03		3.50E-08	1.14E-04		5.30E-08	1.73E-04
Eu 155	4.43E-05	4.43E-02	1.64E+03		4.70E-09	7.70E-06		6.90E-09	1.13E-05
Pu 239	3.66E-03	3.66E+00	1.35E+05		3.20E-05	4.33E+00		5.00E-05	6.77E+00
Am 241	1.79E-04	1.79E-01	6.62E+03		2.70E-05	1.79E-01		4.20E-05	2.78E-01
					TOTAL Sv/L	4.51E+00		TOTAL Sv/L	7.05E+00
	Loading On Filter (L)	Sv per Liter	Release Fraction From Filter (1 E-2) (CN-063)	X/Q (5924 Table 5-2, Table 5-3) (s/m ³)	Breathing Rate (5924 Section 6.2) (m ³ /s)	Multiply by Ingestion Dose Multiplier (1.1) (5924 Section 6.2)	Total Dose From Filter Release (Sv)	Sv	
Onsite	1	4.51E+00	1.00E-02	3.28E-02	3.33E-04	1.00E+00	4.93E-07	2.82E-04	
Offsite	1	7.05E+00	1.00E-02	2.22E-05	2.57E-04	1.10E+00	4.42E-10	2.38E-07	

Previous FSAR Results in Gray

Table D29. 12 Hour Unfiltered Release - Onsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.80E-03	3.33E-04	4.51E+00	43,200	6.17E-08

Table D30. Annual Unfiltered Release - Onsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.03E-04	3.33E-04	4.51E+00	31536000	0.228	8.62E-07

Table D31. 24 Hour Unfiltered Release - Offsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.23E-06	2.57E-04	7.05E+00	86,400	1.1	1.44E-10

Table D32. Annual Unfiltered Release - Offsite (1 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	1.47E-07	2.57E-04	7.05E+00	31,536,000	1.1	1.83E-09

**Table D33.
Comparison Of Results With
Previous FSAR Results
Over Pressure Accident
(1 Liter Loading)**

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
5.55E-07	1.35E-06	5.87E-10	2.27E-09
4.54E-04	2.44E-03	4.81E-07	2.60E-06

Previous FSAR Results in Gray

Over Pressure Accident

(100 Liter Filter Loading)

Table D34. HEPA Filter Release (100 Liter Loading)

	Liq (uCi/ml) (PFP Data)	uCi on Filters for 1 Liter	Bq on Filters for 1 Liter		Sv/Bq Onsite Dose Conversion Factor (5924 App.B & ICRP-68)	Sv for 1 Liter Onsite		Sv/Bq Offsite Dose Conversion Factor (5924 App. B)	Sv for 1 Liter Offsite
Co 60	2.94E-05	2.94E-02	1.09E+03		1.70E-08	1.85E-05		1.00E-08	1.09E-05
Sr 90	9.40E-06	9.40E-03	3.48E+02		3.00E-08	1.04E-05		3.60E-08	1.25E-05
Y 90	9.40E-06	9.40E-03	3.48E+02		1.70E-09	5.91E-07		1.40E-09	4.87E-07
Tc 99	6.71E-06	6.71E-03	2.48E+02		3.20E-09	7.94E-07		4.00E-09	9.93E-07
Sb 125	7.01E-05	7.01E-02	2.59E+03		3.30E-09	8.56E-06		4.80E-09	1.24E-05
Cs 134	2.33E-05	2.33E-02	8.62E+02		9.69E-09	8.35E-06		6.60E-09	5.69E-06
Cs 137	1.29E-04	1.29E-01	4.77E+03		6.70E-09	3.20E-05		4.60E-09	2.20E-05
Eu 154	8.84E-05	8.84E-02	3.27E+03		3.50E-08	1.14E-04		5.30E-08	1.73E-04
Eu 155	4.43E-05	4.43E-02	1.64E+03		4.70E-09	7.70E-06		6.90E-09	1.13E-05
Pu 239	3.66E-03	3.66E+00	1.35E+05		3.20E-05	4.33E+00		5.00E-05	6.77E+00
Am 241	1.79E-04	1.79E-01	6.62E+03		2.70E-05	1.79E-01		4.20E-05	2.78E-01
					TOTAL Sv/L	4.51E+00		TOTAL Sv/L	7.05E+00
	Loading On Filter (L)	Sv per Liter	Release Fraction From Filter (1 E-2) (CN-063)	X/Q (5924 Table 5-2, Table 5-3) (s/m ³)	Breathing Rate (5924 Section 6.2) (m ³ /s)	Multiply by Ingestion Dose Multiplier (1.1) (5924 Section 6.2)	Total Dose From Filter Release (Sv)	Sv	
Onsite	100	4.51E+00	1.00E-02	3.28E-02	3.33E-04	1.00E+00	4.93E-05	2.82E-04	
Offsite	100	7.05E+00	1.00E-02	2.22E-05	2.57E-04	1.10E+00	4.42E-08	2.38E-07	

Previous FSAR Results in Gray

Table D35. 12 Hour Unfiltered Release - Onsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.80E-03	3.33E-04	4.51E+00	43,200	6.17E-08

1.74E-04

Table D36. Annual Unfiltered Release - Onsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.03E-04	3.33E-04	4.51E+00	31536000	0.228	8.62E-07

2.16E-03

Table D37. 24 Hour Unfiltered Release - Offsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	4.23E-06	2.57E-04	7.05E+00	86,400	1.1	1.44E-10

2.41E-07

Table D38. Annual Unfiltered Release - Offsite (100 Liter Loading)

Exhaust Rate (L/sec) (CN-062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv
1.98E+03	1.00E-10	1.98E-07	1.47E-07	2.57E-04	7.05E+00	31,536,000	1.1	1.83E-09

2.36E-06

**Table D39.
Comparison Of Results With
Previous FSAR Results
Over Pressure Accident
(100 Liter Loading)**

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
4.93E-05	5.01E-05	4.44E-08	4.61E-08
4.54E-04	2.44E-03	4.81E-07	2.60E-06

Previous FSAR Results in Gray

Table D40.
Summary Of Results
Steam Intrusion Accident

	Onsite (Sv)	Offsite (Sv)
1 Liter	3.95E-07	7.96E-10
10 Liters	1.26E-06	2.54E-09
100 Liters	9.90E-06	1.99E-08

Steam Intrusion Accident (10 Liter Filter Loading)

Table D41. Material Released (10 Liter Loading)

Amount of Headspace Material Released (L) (CN-044 pg. 14)	Amount of Material Assumed on Filters (L)	Release Fraction for Filters (CN-044 pg 13)	Amount of Material Released from Filters (L)	Total Amount of Material Released in Accident (L)
3.11E-02	10	1.00E-02	1.00E-01	1.31E-01

Table D42. Dose Consequence - Onsite (10 Liter Loading)

Material Released (L)	X/Q Onsite (5924 Table 5-2) (s/m ³)	Breathing Rate Onsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Onsite (Sv/L)	Dose Consequence Onsite (Sv)
1.31E-01	6.39E-03	3.33E-04	4.51	1.26E-06

4.90E-04

Table D43. Dose Consequence - Offsite (10 Liter Loading)

Material Released (L)	X/Q Offsite (5924 Table 5-3) (s/m ³)	Breathing Rate Offsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Offsite (Sv/L)	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Offsite (Sv)
1.31E-01	9.70E-06	2.57E-04	7.05	1.10E+00	2.54E-09

7.60E-07

Previous FSAR Results in Gray

Table D44. X/Q Log Interpolation

Time	[Log(2hr)-Log(Xhr)]/[Log(2hr)-Log(8760hr)]	Log(X/Q Acute) Log(X/Q Chronic)	Log(X/Q Acute)	Log(X/Q for time X)	X/Q for time X	
335 minutes	0.12236918	1.367822807	-2.02687215	-2.194251503	6.3936E-03	Onsite
335 minutes	0.12236918	2.073231914	-4.75945075	-5.013150442	9.7017E-06	Offsite

Steam Intrusion Accident

(1 Liter Filter Loading)

Table D45. Material Released (1 Liter Loading)

Amount of Headspace Material Released (L) (CN-044 pg. 14)	Amount of Material Assumed on Filters (L)	Release Fraction for Filters (CN-044 pg 13)	Amount of Material Released from Filters (L)	Total Amount of Material Released in Accident (L)
3.11E-02	1	1.00E-02	1.00E-02	4.11E-02

Table D46. Dose Consequence - Onsite (1 Liter Loading)

Material Released (L)	X/Q Onsite (5924 Table 5-2) (s/m ³)	Breathing Rate Onsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Onsite (Sv/L)	Dose Consequence Onsite (Sv)
4.11E-02	6.39E-03	3.33E-04	4.51	3.95E-07

4.90E-04

Table D47. Dose Consequence - Offsite (1 Liter Loading)

Material Released (L)	X/Q Offsite (5924 Table 5-3) (s/m ³)	Breathing Rate Offsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Offsite (Sv/L)	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Offsite (Sv)
4.11E-02	9.70E-06	2.57E-04	7.05	1.10E+00	7.96E-10

7.60E-07

Previous FSAR Results in Gray

Steam Intrusion Accident

(100 Liter Filter Loading)

Table D48. Material Released (100 Liter Loading)

Amount of Headspace Material Released (L) (CN-044 pg.14)	Amount of Material Assumed on Filters (L)	Release Fraction for Filters (CN-044 pg 13)	Amount of Material Released from Filters (L)	Total Amount of Material Released in Accident (L)
3.11E-02	100	1.00E-02	1.00E+00	1.03E+00

Table D49. Dose Consequence - Onsite (100 Liter Loading)

Material Released (L)	X/Q Onsite (5924 Table 5-2) (s/m ³)	Breathing Rate Onsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Onsite (Sv/L)	Dose Consequence Onsite (Sv)
1.03E+00	6.39E-03	3.33E-04	4.51	9.90E-06

~~4.90E-04~~

Table D50. Dose Consequence - Offsite (100 Liter Loading)

Material Released (L)	X/Q Offsite (5924 Table 5-3) (s/m ³)	Breathing Rate Offsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Offsite (Sv/L)	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Offsite (Sv)
1.03E+00	9.70E-06	2.57E-04	7.05	1.10E+00	1.99E-08

~~7.60E-07~~

Previous FSAR Results in Gray

ATTACHMENT D1

SPREADSHEET FORMULAS

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	A	B	C	D	E	F	G																				
68	<p style="text-align: center;">Table D1. Summary Of Results Over Temperature Accident</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th>Onsite HEPA + 12 hr (Sv)</th> <th>Onsite HEPA + Annual (Sv)</th> <th>Offsite HEPA + 24 hr (Sv)</th> <th>Offsite HEPA + Annual (Sv)</th> </tr> </thead> <tbody> <tr> <td>1 Liter</td> <td>=AF53</td> <td>=AH53</td> <td>=AF57</td> <td>=AH57</td> </tr> <tr> <td>10 Liters</td> <td>=H53</td> <td>=J53</td> <td>=H57</td> <td>=J57</td> </tr> <tr> <td>100 Liters</td> <td>=T53</td> <td>=V53</td> <td>=T57</td> <td>=V57</td> </tr> </tbody> </table>								Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)	1 Liter	=AF53	=AH53	=AF57	=AH57	10 Liters	=H53	=J53	=H57	=J57	100 Liters	=T53	=V53	=T57	=V57
								Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)																
1 Liter								=AF53	=AH53	=AF57	=AH57																
10 Liters								=H53	=J53	=H57	=J57																
100 Liters								=T53	=V53	=T57	=V57																
69																											
70																											
71																											
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83																											
84																											
85																											

	C	C	E	F	G	H	I	J	K	L
2	Over Temperature Accident									
3	(10 Liter Filter Loading)									
4	Table D2. HEPA Filter Release (10 Liter Loading)									
5		Lq (uCi/mg) (FFP Data)	uCi per Liter	Bq per liter	SV/Bq Onsite Dose Conversion Factor (5924 App. B & C/P.4-68)	SV per Liter Onsite	SV/Bq Offsite Dose Conversion Factor (5924 App. E)	SV per Liter Offsite		
6	Co	0.000284	=077*1000	=37000E7	0.00000017	=F7*H7	0.00000001	=F7*K7		
7	Cr	0.000084	=081*1000	=37000E8	0.00000003	=F8*H8	0.00000006	=F8*K8		
8	Y	0.000084	=081*1000	=37000E8	0.00000003	=F9*H9	0.00000006	=F9*K9		
9	Co	0.000071	=071*1000	=37000E10	0.00000032	=F10*H10	0.00000004	=F10*K10		
10	Cr	0.000071	=071*1000	=37000E10	0.00000032	=F11*H11	0.00000004	=F11*K11		
11	Y	0.000071	=071*1000	=37000E10	0.00000032	=F12*H12	0.00000006	=F12*K12		
12	Co	0.000025	=025*1000	=37000E13	0.00000069	=F13*H13	0.00000006	=F13*K13		
13	Cr	0.000025	=025*1000	=37000E13	0.00000069	=F14*H14	0.00000006	=F14*K14		
14	Y	0.000025	=025*1000	=37000E13	0.00000069	=F15*H15	0.00000006	=F15*K15		
15	Co	0.000043	=043*1000	=37000E16	0.00000047	=F16*H16	0.00000005	=F16*K16		
16	Cr	0.000043	=043*1000	=37000E16	0.00000047	=F17*H17	0.00000005	=F17*K17		
17	Y	0.000043	=043*1000	=37000E16	0.00000047	=F18*H18	0.00000005	=F18*K18		
18					TOTAL SWL	**SUM(I7:17)	TOTAL SWL	**SUM(K7:L17)		
19										
20										
21										
22		Loading On Filter (L)	SV per Liter	Release Fraction From Filter (1 E-4) (CA-362)	Breathing Rate (5924 Section 6.2) (m ³ /s)	Multiply by Ingestion Dose Multiplier (1.1) (5924 Section 6.2)	Total Dose From Filter Release (Sv)	SV		
23	Onsite	10	=10	0.0001	0.000033	1	=0.000033			
24	Offsite	10	=10	0.0001	0.000033	1	=0.000033			
25										

	B	C	D	E	F	G	H	I	J	K	L	M
30	Table D3. 12 Hour Unfiltered Release - Onsite (10 Liter Loading)											
31	Exhaust Rate (L/sec) (CM 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ²)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquid) Sv/L	12 hrs	Dose Consequence Sv				
32	1860	0.000000001	1.83E-03	0.0007959	0.0000333	1.11E-01	43200	4.69E-04				
33	Table D4. Annual Unfiltered Release - Onsite (10 Liter Loading)											
34	Exhaust Rate (L/sec) (CM 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ²)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquid) Sv/L	8760 hrs	Occupancy Factor	Dose Consequence Sv			
35	1860	0.000000001	1.83E-03	0.000403	0.0000333	1.11E-01	43200	0.333	1.57E-07			
36	Table D5. 24 Hour Unfiltered Release - Offsite (10 Liter Loading)											
37	Exhaust Rate (L/sec) (CM 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ²)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquid) Sv/L	24 hrs	Multiply by Ingestion Dose Multiplier (1,1)	Dose Consequence Sv			
38	1860	0.000000001	1.83E-03	0.00004923	0.000025	1.11E-01	86400	1.1	1.45E-08			
39	Table D6. Annual Unfiltered Release - Offsite (10 Liter Loading)											
40	Exhaust Rate (L/sec) (CM 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ²)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquid) Sv/L	8760 hrs	Multiply by Ingestion Dose Multiplier (1,1)	Dose Consequence Sv			
41	1860	0.000000001	1.83E-03	0.0000147	0.000025	1.11E-01	3136000	1.1	4.67E-08			

98	G	H	I	J	K	L	M	N	O
99									
100									
101									
102									
103									
104									
105									
106									
107									
108									
109									
110									
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113									
114									
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116									
117									
118									
119									
120									
121									

**Table D7.
Comparison Of Results With
Previous FSAR Results
Over Temperature Accident
(10 Liter Loading)**

	Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv) Offsite HEPA + Annual (Sv)
	=S.523+S.K331	=S.523+S.L337	=S.524+S.L343
	0.003177	0.00216	0.00000244
			0.00000237

Previous FSAR Results in Grey

Table D8. X/Q Log Interpolation

Time	$[(\text{Log}(2\text{hr})-\text{Log}(X\text{hr})) / (\text{Log}(2\text{hr})-\text{Log}(8760\text{hr}))]$	$\text{Log}(X/Q \text{ Acute}) - \text{Log}(X/Q \text{ Chronic})$	$\text{Log}(X/Q \text{ Acute})$	$\text{Log}(X/Q \text{ for time X})$	X/Q for time X
12 hr	$=(\text{LOG}(2)-\text{LOG}(12)) / (\text{LOG}(2)-\text{LOG}(8760))$	$-\text{LOG}(0.0094) - \text{LOG}(0.000403)$	$-\text{LOG}(0.0094)$	$-(11.6 - 11.16 - K11.6)$	$=10^{-(L11.6)}$
24 hr	$=(\text{LOG}(2)-\text{LOG}(24)) / (\text{LOG}(2)-\text{LOG}(8760))$	$-\text{LOG}(0.0000174) - \text{LOG}(0.00000147)$	$-\text{LOG}(0.0000174)$	$-(11.7 - 11.17 - K11.7)$	$=10^{-(L11.7)}$

	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
2	Over Temperature Accident									
3	(1 Liter Filter Loading)									
4	Table D9. HEPA Filter Release (1 Liter Loading)									
5		L _q (uCi/m) (FPF Data)	uCi per Liter	Bq per liter		Sv/Bq Onsite Dose Conversion Factor (5924 App B & ICRP-68)	Sv per Liter Onsite		Sv/Bq Offsite Dose Conversion Factor (5924 App B)	Sv per Liter Offsite
6	Ca-90	0.0000294	=AB7*1000	=37000*AC7		=AD7*AF7			=AD7*AI7	
7	Co-60	0.0000394	=AB8*1000	=37000*AC8		=AD8*AF8			=AD8*AI8	
8	Co-60	0.0000394	=AB9*1000	=37000*AC9		=AD9*AF9			=AD9*AI9	
9	Co-60	0.0000671	=AB10*1000	=37000*AC10		=AD10*AF10			=AD10*AI10	
10	Co-60	0.0000701	=AB11*1000	=37000*AC11		=AD11*AF11			=AD11*AI11	
11	Co-60	0.000233	=AB12*1000	=37000*AC12		=AD12*AF12			=AD12*AI12	
12	Co-60	0.00129	=AB13*1000	=37000*AC13		=AD13*AF13			=AD13*AI13	
13	Co-60	0.000884	=AB14*1000	=37000*AC14		=AD14*AF14			=AD14*AI14	
14	Co-60	0.000443	=AB15*1000	=37000*AC15		=AD15*AF15			=AD15*AI15	
15	Co-60	0.00366	=AB16*1000	=37000*AC16		=AD16*AF16			=AD16*AI16	
16	Co-60	0.000179	=AB17*1000	=37000*AC17		=AD17*AF17			=AD17*AI17	
17										
18						TOTAL Sv/L	=+SUM(AG7:AG17)		TOTAL Sv/L	=+SUM(AJ7:AJ17)
19										
20										
21										
22		Loading On Filter (L)	Sv per Liter	Release Fraction From Filter (1 E-4) (CN-062)	X/IQ (5924 Table 5-2, Table 5-3) (s/m ³)	Breathing Rate (5924 Section 6.2) (m ³ /s)	Multiply by Ingestion Dose Multiplier (1.1) (5924 Section 6.2)	Total Dose From Filter Release (Sv)	Sv	
23	Onsite	1	=AG19	0.0001	0.0328	0.000333	1	=AB23*AC23*AD23*AE23*AF23*AG23	0.00000282	
24	Offsite	1	=AJ18	0.0001	0.000022	0.000257	1.1	=AB24*AC24*AD24*AE24*AF24*AG24	0.0000000238	
25										Previous FSAR Results in Gray
26										

	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
27	Table D10. 12 Hour Unfiltered Release - Onsite (1 Liter Loading)										
28											
29											
30											
31	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv			
32	1980	0.000000001	**AB37AC31	0.0047955	0.000333	=AG18	13200	=AD37AE37AF37AG37AH37AI37	0.000114		
33											
34	Table D11. Annual Unfiltered Release - Onsite (1 Liter Loading)										
35											
36											
37	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor			
38	1980	0.000000001	**AB37AC37	0.000403	0.000333	=AG18	=8760*3600	=AD37AE37AF37AG37AH37AI37	0.000116		
39											
40	Table D12. 24 Hour Unfiltered Release - Offsite (1 Liter Loading)										
41											
42											
43	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)			
44	1980	0.000000001	**AB43AC43	0.000004228	0.000257	=AJ18	86400	=AD43AE43AF43AG43AH43AI43	0.00000543		
45											
46	Table D13. Annual Unfiltered Release - Offsite (1 Liter Loading)										
47											
48											
49	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)			
50	1980	0.000000001	**AB49AC49	0.000000147	0.000257	=AJ18	31536000	=AD49AE49AF49AG49AH49AI49	0.00000236		
51											

	AD	AE	AF	AG	AH	AI
76						
77						
78						
79						
80						
81						
	Table D14. Comparison Of Results With Previous FSAR Results Over Temperature Accident (1 Liter Loading)					
		Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)	
82		=\$A\$23+\$A\$31	=\$A\$23+\$A\$37	=\$A\$24+\$A\$43	=\$A\$24+\$A\$49	
83		0.000177	0.00216	0.00000244	0.00000237	
84						
85		Previous FSAR Results in Gray				
86						
87						
88						
89						
90						

	O	P	Q	R	S	T	U	V	W	X
Over Temperature Accident										
(100 Liter Filter Loading)										
Table D15. HEPA Filter Release (100 Liter Loading)										
2										
3										
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8										
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10										
11										
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18										
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21										
22										
23										
24										
25										

	O	P	Q	R	S	T	U	V	W	X	Y
27	Table D16. 12 Hour Unfiltered Release - Onsite (100 Liter Loading)										
28											
29											
30	Exhaust Rate (L/Sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/Sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv			
31	1990	0.0000000001	=P31*Q31	0.0047955	0.000333	=U18	43200	=R31*S31*T31*U31*V31			
32											
33											
34	Table D17. Annual Unfiltered Release - Onsite (100 Liter Loading)										
35											
36	Exhaust Rate (L/Sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/Sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Occupancy Factor	Dose Consequence Sv		
37	1990	0.0000000001	=P37*Q37	0.006403	0.000333	=U18	=8760*3600	0.228	=R37*S37*T37*U37*V37*W37		
38											
39											
40	Table D18. 24 Hour Unfiltered Release - Offsite (100 Liter Loading)										
41											
42	Exhaust Rate (L/Sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/Sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv		
43	1990	0.0000000001	=P43*Q43	0.000064228	0.000257	=X18	86400	1.1	=R43*S43*T43*U43*V43*W43		
44											
45											
46	Table D19. Annual Unfiltered Release - Offsite (100 Liter Loading)										
47											
48	Exhaust Rate (L/Sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/Sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Sv		
49	1990	0.0000000001	=P49*Q49	0.00000147	0.000257	=X18	31536000	1.1	=R49*S49*T49*U49*V49*W49		
50											
51											

	R	S	T	U	V	W												
76	<p>Table D20. Comparison Of Results With Previous FSAR Results Over Temperature Accident (100 Liter Loading)</p>																	
77																		
78																		
79																		
80																		
81																		
82	<table border="1"> <thead> <tr> <th>Onsite HEPA + 12 hr (Sv)</th> <th>Onsite HEPA + Annual (Sv)</th> <th>Offsite HEPA + 24 hr (Sv)</th> <th>Offsite HEPA + Annual (Sv)</th> </tr> </thead> <tbody> <tr> <td>=\$V\$23+\$W\$31</td> <td>=\$V\$23+\$X\$37</td> <td>=\$V\$24+\$X\$43</td> <td>=\$V\$24+\$X\$49</td> </tr> <tr> <td>0.000177</td> <td>0.00215</td> <td>0.000000244</td> <td>0.00000237</td> </tr> </tbody> </table>						Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)	=\$V\$23+\$W\$31	=\$V\$23+\$X\$37	=\$V\$24+\$X\$43	=\$V\$24+\$X\$49	0.000177	0.00215	0.000000244	0.00000237
Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)															
=\$V\$23+\$W\$31	=\$V\$23+\$X\$37	=\$V\$24+\$X\$43	=\$V\$24+\$X\$49															
0.000177	0.00215	0.000000244	0.00000237															
83	Previous FSAR Results in Gray																	
84																		
85																		
86																		
87																		
88																		

	D	E	F	G	H	I	J
66	Table D21. Summary Of Results Over Pressure Accident						
67							
68							
69							
70							
71			Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)	
72		1 Liter	=AF53	=AH53	=AF57	=AH57	
73		10 Liters	=H53	=J53	=H57	=J57	
74		100 Liters	=T53	=V53	=T57	=V57	
75							
76							
77							
78							
79							

C	D	E	F	G	H	I	J	K	L
Over Pressure Accident (10 Liters Filter Loading)									
Table D22. HEPA Filter Release (10 Liter Loading)									
2									
3									
4									
5									
6									
7	CR 68	0.0000294	=D7*1000	=37000*E7					=F7*K7
8	EV 90	0.0000094	=D8*1000	=37000*E8					=F8*K8
9	Y 90	0.0000094	=D9*1000	=37000*E9					=F9*K9
10	CS 98	0.00000671	=D10*1000	=37000*E10					=F10*K10
11	SA 124	0.00002721	=D11*1000	=37000*E11					=F11*K11
12	CA 134	0.0000283	=D12*1000	=37000*E12					=F12*K12
13	CA 137	0.0000129	=D13*1000	=37000*E13					=F13*K13
14	EA 154	0.00000884	=D14*1000	=37000*E14					=F14*K14
15	EA 158	0.00000443	=D15*1000	=37000*E15					=F15*K15
16	PA 238	0.00366	=D16*1000	=37000*E16					=F16*K16
17	AM1241	0.000179	=D17*1000	=37000*E17					=F17*K17
18				TOTAL Sv/L				TOTAL Sv/L	=SUM(L7:L17)
19									
20									
21									
22									
23	Onsite	10	=L18	0.0328	0.000333	1			=D23*E23*F23*G23*H23*I23
24	Offsite	10	=L18	0.000222	0.000257	1.1			=D24*E24*F24*G24*H24*I24
25									Previous FSAR Results in Gray
26									

	I	J	K	L	M	N
79	<p>Table D27. Comparison Of Results With Previous FSAR Results Over Pressure Accident (10 Liter Loading)</p>					
80						
81						
82						
83						
84						
85						
86						
87						
88						
89						
90						

Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)
=\$J\$23+\$K\$31	=\$J\$23+\$L\$37	=\$J\$24+\$L\$43	=\$J\$24+\$L\$49
0.000454	0.00244	0.00000481	0.0000026

Previous FSAR Results in Gray

AA	AB	AC	AD	AE	AF	AG	AH	AJ	AK
27	Table D29. 12 Hour Unfiltered Release - Onsite (1 Liter Loading)								
28	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	12 Hrs	Dose Consequence Sv	
29	1980	0.0000000001	0.0048	0.000333	43200				
30									
31									
32									
33									
34	Table D30. Annual Unfiltered Release - Onsite (1 Liter Loading)								
35	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Onsite ULD (100% liquids) Sv/L	8760 Hrs	Dose Consequence Sv	
36	1980	0.0000000001	0.0048	0.000333	376416				
37									
38									
39									
40									
41	Table D31. 24 Hour Unfiltered Release - Offsite (1 Liter Loading)								
42	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	24 Hrs	Dose Consequence Sv	
43	1980	0.0000000001	0.0048	0.000257	18400				
44									
45									
46	Table D32. Annual Unfiltered Release - Offsite (1 Liter Loading)								
47	Exhaust Rate (L/sec) (CN 062 Table 3)	Partition Fraction	Particulate Release Rate (L/sec)	X/Q (s/m ³)	Breathing Rate (m ³ /s)	Offsite ULD (100% liquids) Sv/L	8760 Hrs	Dose Consequence Sv	
48	1980	0.0000000001	0.0048	0.000257	161616				
49									
50									

	AE	AF	AG	AH	AI	AJ												
79	<p style="text-align: center;">Table D33. Comparison Of Results With Previous FSAR Results Over Pressure Accident (1 Liter Loading)</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Onsite HEPA + 12 hr (Sv)</th> <th>Onsite HEPA + Annual (Sv)</th> <th>Offsite HEPA + 24 hr (Sv)</th> <th>Offsite HEPA + Annual (Sv)</th> </tr> </thead> <tbody> <tr> <td>-\$AHS23+\$AIS31</td> <td>-\$AHS23+\$AJS37</td> <td>-\$AHS24+\$AJ\$43</td> <td>-\$AHS24+\$AJ\$49</td> </tr> <tr> <td>0.000454</td> <td>0.00241</td> <td>0.00000481</td> <td>0.0000026</td> </tr> </tbody> </table> <p>Previous FSAR Results in Gray</p>						Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)	-\$AHS23+\$AIS31	-\$AHS23+\$AJS37	-\$AHS24+\$AJ\$43	-\$AHS24+\$AJ\$49	0.000454	0.00241	0.00000481	0.0000026
Onsite HEPA + 12 hr (Sv)							Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)									
-\$AHS23+\$AIS31							-\$AHS23+\$AJS37	-\$AHS24+\$AJ\$43	-\$AHS24+\$AJ\$49									
0.000454							0.00241	0.00000481	0.0000026									
80																		
81																		
82																		
83																		
84																		
85																		
86																		
87																		
88																		
89																		
90																		
91																		
92																		

	Q	P	G	R	S	T	U	V	W	X	Y
27											
28	Table D35. 12 Hour Unfiltered Release - Onsite (100 Liter Loading)										
29											
30											
31											
32											
33											
34											
35	Table D36. Annual Unfiltered Release - Onsite (100 Liter Loading)										
36											
37											
38											
39											
40											
41											
42											
43	Table D37. 24 Hour Unfiltered Release - Offsite (100 Liter Loading)										
44											
45											
46											
47											
48											
49	Table D38. Annual Unfiltered Release - Offsite (100 Liter Loading)										
50											

	S	T	U	V	W	X												
78	<p style="text-align: center;">Table D39. Comparison Of Results With Previous FSAR Results Over Pressure Accident (100 Liter Loading)</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Onsite HEPA + 12 hr (Sv)</th> <th>Onsite HEPA + Annual (Sv)</th> <th>Offsite HEPA + 24 hr (Sv)</th> <th>Offsite HEPA + Annual (Sv)</th> </tr> </thead> <tbody> <tr> <td>=V\$23+W\$31</td> <td>=V\$23+X\$37</td> <td>=V\$24+X\$43</td> <td>=V\$24+X\$49</td> </tr> <tr> <td>0.000454</td> <td>0.00244</td> <td>0.000000481</td> <td>0.0000026</td> </tr> </tbody> </table> <p style="text-align: center;">Previous FSAR Results in Gray</p>						Onsite HEPA + 12 hr (Sv)	Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)	=V\$23+W\$31	=V\$23+X\$37	=V\$24+X\$43	=V\$24+X\$49	0.000454	0.00244	0.000000481	0.0000026
Onsite HEPA + 12 hr (Sv)							Onsite HEPA + Annual (Sv)	Offsite HEPA + 24 hr (Sv)	Offsite HEPA + Annual (Sv)									
=V\$23+W\$31							=V\$23+X\$37	=V\$24+X\$43	=V\$24+X\$49									
0.000454							0.00244	0.000000481	0.0000026									
79																		
80																		
81																		
82																		
83																		
84																		
85																		
86																		
87																		
88																		
89																		
90																		

	B	C	D	E	F				
28	Table D40. Summary Of Results Steam Intrusion Accident								
29									
30									
31									
32									
33									
34									
35						1 Liter	=O13		=P18
36						10 Liters	=G13		=H18
37						100 Liters	=W13		=X18
38									
39									
40									
41									

	B	C	D	E	F	G	H	I
2	Steam Intrusion Accident							
3	(10 Liter Filter Loading)							
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								

Amount of headspace material released (L) (CN-044 Pg. 14)	Amount of Material Assumed on Filters (L)	Release Fraction for Filters (CN-044 pg. 13)	Amount of Material Released from Filters (L)	Total Amount of Material Released in Accident (L)
0.031149	10	0.01	=D8*E8	=F8+G8

Material Released (L)	X/Q Onsite (5924 Table 5-2) (s/m ³)	Breathing Rate Onsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Onsite (Sv/L)	Dose Consequence Onsite (Sv)
=G8	=H24	0.000333	4.51	=C13*D13*E13*F13

Material Released (L)	X/Q Offsite (5924 Table 5-3) (s/m ³)	Breathing Rate Offsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Offsite (Sv/L)	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Offsite (Sv)
=G8	=H25	0.000257	7.05	1.1	=C18*D18*E18*F18*G18

Previous FSAR Results in Gray

Time	$[\text{Log}(2\text{hr}) - \text{Log}(X\text{hr})] / [\text{Log}(2\text{hr}) - \text{Log}(8760\text{hr})]$	$\text{Log}(X/Q \text{ Acute}) - \text{Log}(X/Q \text{ Chronic})$	$\text{Log}(X/Q \text{ Acute})$	$\text{Log}(X/Q \text{ for time X})$	X/Q for time X
335 minutes	$=*(\text{LOG}(2)-\text{LOG}(6.58))/(\text{LOG}(2)-\text{LOG}(8760))$	$=\text{LOG}(0.0094)-\text{LOG}(0.000403)$	$=\text{LOG}(0.0094)$	$=(\text{D24}+\text{E24}-\text{F24})$	$=10^{(\text{G24})}$
335 minutes	$=*(\text{LOG}(2)-\text{LOG}(6.58))/(\text{LOG}(2)-\text{LOG}(8760))$	$=\text{LOG}(0.0000174)-\text{LOG}(0.00000147)$	$=\text{LOG}(0.0000174)$	$=(\text{D25}+\text{E25}-\text{F25})$	$=10^{(\text{G25})}$

	J	K	L	M	N	O	P	Q
2	Steam Intrusion Accident							
3	(1 Liter Filter Loading)							
4								
5								
6	Table D45. Material Released (1 Liter Loading)							
7	Amount of headspace material released (L) (CN-044 pg. 14)	Amount of Material Assumed on Filters (L)	Release Fraction for Filters (CN-044 pg 13)	Amount of Material Released from Filters (L)	Total Amount of Material Released in Accident (L)			
8	0.031149	1	0.01	=L8*M8	=N8+K8			
9								
10	Table D46. Dose Consequence - Onsite (1 Liter Loading)							
11	Material Released (L)	X/Q Onsite (5924 Table 5) 2) (s/m ³)	Breathing Rate Onsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Onsite (Sv/L)	Dose Consequence Onsite (Sv)			
12	=O8	=H24	0.000333	4.51	=K13*L13*M13*N13			
13								
14								
15	Table D47. Dose Consequence - Offsite (1 Liter Loading)							
16	Material Released (L)	X/Q Offsite (5924 Table 5) 3) (s/m ³)	Breathing Rate Offsite (5924 Section 6.2) (m ³ /s)	100% Liquid ULD Offsite (Sv/L)	Multiply by Ingestion Dose Multiplier (1.1)	Dose Consequence Offsite (Sv)		
17	=O8	=H25	0.000257	7.05	1.1	=K18*L18*M18*N18*O18		
18								
19								
20	Previous FSAR Results in Gray							

	R	S	T	U	V	W	X	Y
2	Steam Intrusion Accident							
3	(100 Liter Filter Loading)							
4								
5	Table D48. Material Released (100 Liter Loading)							
6	Amount of headspace material released (L) (CN-044 pg. 14)		Release Fraction for Filters (CN-044 pg 13)		Amount of Material Released from Filters (L)		Total Amount of Material Released in Accident (L)	
7								
8	0.031149		0.01		=18*U8		=V8*S8	
9								
10	Table D49. Dose Consequence - Onsite (100 Liter Loading)							
11	Material Released (L)		X/Q Onsite (5924 Table 5-2) (sm ³)		Breathing Rate Onsite (5924 Section 6.2) (m ³ /s)		100% Liquid ULD Onsite (Sv/L)	
12								
13	=W8		=H24		0.000333		4.51	
14								
15								
16	Table D50. Dose Consequence - Offsite (100 Liter Loading)							
17	Material Released (L)		X/Q Offsite (5924 Table 5-3) (sm ³)		Breathing Rate Offsite (5924 Section 6.2) (m ³ /s)		100% Liquid ULD Offsite (Sv/L)	
18								
19	=W8		=H25		0.000257		7.05	
20							1.1	

Previous FSAR Results in Gray

0.00960076

=S18*T18*U18*V18*W18

=S13*T13*U13*V13

APPENDIX E

PEER REVIEW CHECKLIST

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APPENDIX E

PEER REVIEW CHECKLIST

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Scope of Review:

Yes No NA

- Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
- Problem is completely defined.
- Accident scenarios are developed in a clear and logical manner.
- Necessary assumptions are explicitly stated and supported.
- Computer codes and data files are documented.
- Data used in calculations are explicitly stated.
- Data were checked for consistency with original source information as applicable.
- Mathematical derivations were checked including dimensional consistency of results.
- Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
- Spreadsheet results and all hand calculations were verified.
- Software input is correct and consistent with the document reviewed.
- Software output is consistent with the input and with the results reported in the document reviewed. *Microshield calcs not reviewed by me.*
- Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references.
- Safety margins are consistent with good engineering practices.
- Conclusions are consistent with analytical results and applicable limits.
- Results and conclusions address all points in the purpose.
- The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
- Concurrence

J. M. GREGORY / [Signature] 12/1/00
 Reviewer (Printed Name and Signature) Date

* FOR THE SCOPE ADDRESSED IN USQE TF-00-0768 ONLY.
 ** Microshield calcs not reviewed by me. Previously checked by others.
 *** However for this limited scope, format is acceptable for understanding the analysis performed.

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