5

ENGINEERING CHANGE NOTICE

1. ECN 638702

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	D. A. Himes, 403, B4-47, 376-8190	[] Yes [X] No	08/11/98
	6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.	8. Approval Designator
	Project W-320	Tank Farms	N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).	11. Related PO No.
	HNF-SD-WM-CN-099, Rev. 0	N/A	N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [] Yes [X] No

Replacement of Rev. 0 with Rev. 1.

The attached Calculation Note documents the originator's analysis only. It shall not be used as the final or sole document for affecting changes to an authorization basis or safety basis for a facility or activity.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[X]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Revision 0 has been updated to include additional system components and to include an additional ventilation system (296-C-006).

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution sheet.

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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): 638702

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

Signature	Date	Signature	Date
Design Authority N/A		Design Agent	
Cog. Eng. D. A. Himes (signature)	8/11/98	PE	
Cog. Mgr. B. E. Hey (signature)	8/11/98	QA	
QA N/A		Safety	
Safety N/A		Design	
Environ. N/A	8/11/98	Environ.	
Other DES&H Review G. W. Ryan (signature)		Other	

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems

D. A. Himes
Fluor Daniel Northwest, Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: HEPA failure, Tank bump, sluicing, C-106, AY-102

Abstract: This document contains supporting calculations for quantifying the radiological and toxicological risks from sluicing transfer operations between Tanks 241-C-106 (high heat, SST) and Tank 241-AY-102 (aging waste, DST).

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RECORD OF REVISION	(1) Document Number HNF-SD-WM-CN-099, Rev. 1	Page 1

(2) Title

Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initial document released via EDT#621243	R. J. Van Vleet 7/22/97	B. E. Hey 7/22/97
1 RS	Replace entire Rev. 0 document via ECN#638702	D. A. Himes 8/11/98	B. E. Hey 8/11/98

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Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems

Safety Analysis and Risk Assessment

D.A. Himes

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ATTACHMENTS

ACRONYMS

ARF	airborne release fraction
ARM	area radiation monitor
AWF	Aging Waste Facility
CAM	continuous air monitor
CEDE	committed effective dose equivalent
CVI	certified vendor information
DST	double-shell tank
HEGA	high efficiency gas absorber
HEME	high efficiency mist eliminator
HEMF	high efficiency metal filter
HEPA	high efficiency particulate air (filter)
RF	respirable fraction
SOF	sum-of-fractions
SST	single-shell tank
TRU	transuranic
TWRS	Tank Waste Remediation System
ULD	unit liter dose

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Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems

1.0 INTRODUCTION

The high heat content solids contained in Tank 241-C-106 are to be removed and transferred to Tank 241-AY-102 by sluicing operations, to be authorized under project W-320. While sluicing operations are underway, the state of these tanks will be transformed from "unagitated" to "agitated". This means that the partition fraction which describes the aerosol content of the head space will increase from 1E-10 to 1E-8 (see WHC-SD-WM-CN-062, Rev. 2 for discussion of partition fractions). The head space will become much more loaded with suspended material. Furthermore, the nature of this suspended material can change significantly: sluicing could bring up radioactive solids which normally would lay under many meters of liquid supernate. It is assumed that the headspace and filter aerosols in Tank 241-AY-102 are a 90/10 liquid/solid split. It is further assumed that the sluicing line, the headspace in Tank 241-C-106, and the filters on Tank 241-C-106 contain aerosols which are a 67/33 liquid/solid split. The bases of these assumptions are discussed in Section 3.0. These waste compositions (referred to as "mitigated" compositions) were used in Attachments 1 through 4 to calculate survey meter exposure rates per liter of inventory in the various system components.

Three accident scenarios are evaluated: a high temperature event which melts or burns the HEPA filters and causes releases from other system components; an overpressure event which crushes and blows out the HEPA filters and causes releases from other system components; and an unfiltered release of tank headspace air. The initiating event for the high temperature release is a fire caused by a heater malfunction inside the exhaust dust or a fire outside the duct. The initiating event for the overpressure event could be a steam bump which over pressurizes the tank and leads to a blowout of the HEPA filters in the ventilation system. The catastrophic destruction of the HEPA filters would release a fraction of the accumulated filter loadings and would lead to an unfiltered pathway from the radioactively contaminated and toxic aerosols in the head space (vapor space) of the tank into the outside environment. The initiator for the unfiltered (continuous) release scenario is wetting of the HEPA filters with an accompanying filter breach or failure of the seals surrounding the filter in the enclosure. No releases from the filters themselves are assumed in this scenario. In the absence of controls, the exhaust system would continue to expel the contaminated head space air into the outside environment in all three of these scenarios. The primary mitigator to limit releases of unfiltered headspace air is the safety class stack CAM-fan shutdown interlock on each system which is specified to shut down the exhaust fan 10 minutes after the release starts.

In order to assess the potential consequences of these accidents, it is necessary to calculate the radiological and toxicological source terms. This is carried out in Section 4.0. Atmospheric dispersion coefficients, breathing rates, and unit liter doses (ULDs) are applied, as described in Section 5.0, to derive the consequences onsite (at 100 meters downwind) and offsite (at the site boundary in the worst-case direction).

Both Tank 241-AY-102 and Tank 241-C-106 are assessed in this document. There are two alternative ventilation systems considered for Tank 241-AY-102: 241-A-702 (the existing ventilation system) and 241-AZ-702 (the new ventilation system installed by project W-030)(WHC-SD-W030-RD-001). For Tank 241-C-106 there are also two alternative ventilation systems: 296-P-16 (the existing ventilation system) and 296-C-006 (the new ventilation system installed by project W-320).

2.0 SUMMARY

Releases from the two ventilation systems associated with each of the tanks (241-AY-102 and 241-C-106) were evaluated by determining a maximum inventory for each of the system components and then applying an appropriate release fraction for the particular scenario. The component inventories were determined based on maximum radiation survey readings on the components coupled with calculations of expected survey readings assuming one liter equivalent of waste mix distributed through the component. These calculations were accomplished using various shielding codes and are documented in Attachments 1 through 4. Summary results of this procedure for the four ventilation systems are shown below.

System	Component	Radiological Control Point	Detector Reading per Unit Liter Waste Composition (mR/hr/l)	Estimated Waste Inventory at Control Point (l)
241-A-702 90/10 waste composition	Single HEPA element	200 mR/hr centered at middle via hand held	3900	0.051
	De-entrainer K1-5-1	Not controlled, inventory based on best engineering judgement	N/A	1.5[1]
	De-entrainer K1-5-2A	Not controlled, inventory based on best engineering judgement	N/A	1.5[1]
241-AZ-702 90/10 waste composition	Single HEPA element	200 mR/hr bottom center via hand held	2800	0.071
	HEGA AZ-K1-10-1A	2 mR/hr bottom center via hand held	860	0.0023
	HEME AZ-K1-9-1[2]	800 mR/hr contact	3423	0.23
296-P-16 67/33 waste composition	3x3 HEPA element array	200 mR/hr bottom center of unit via hand held	640	0.16 on each array
	De-entrainer DE-1	Surveyed at 100 mR/hr contact at top	67	1.5
296-C-006 67/33 waste composition	Single HEPA element	200 mR/hr centered at middle via hand held	4300	0.047
	HEME HME-1361	single probe located at side of both with 100 mR/hr alarm point	10.0	assume inventory contained on HMF-1361
	HEMF HMF-1361		5.26	19.0

[1]Inventory assumed to be same as that calculated for de-entrainer DE-1 on P-16 system.

[2]Per HNF-1892 this corresponds to 300 mR/hr at installed probe

Tables 1 through 8 give calculated releases and resulting doses from the ventilation systems on Tanks 241-AY-102 and 241-C-106 due to a high temperature (fire) event, a catastrophic overpressure event, and a filter failure (continuous unfiltered release). The calculations which support these numbers are found in Section 4.0.

3.0 MAJOR ASSUMPTIONS

1. Aerosols entrained in the filter elements and in the headspace of Tank 241-AY-102 are composed of 90% liquids and 10% solids. The liquids component is composed of 10% SST liquid plus 90% AWF liquid. The solids component is composed of 90% SST solid plus 10% AWF solid. The ULD, onsite SOF multiplier, and offsite SOF multiplier for this composition were calculated to be 3.9E+04 Sv/L, 1.3E+04 s/L, and 18 s/L, respectively. Details of these calculations are shown in Section 4.2.

   Basis: This is a key assumption based on the relative amounts of the various components in the tanks and the expected mixing of the components caused by the sluicing operation.

   Sensitivity: The radiological consequences are directly proportional to the ULD. The toxicological consequences are directly proportional to the SOF multiplier.

2. Aerosols coming from the slurry line and entrained in the filter elements and in the headspace of Tank 241-C-106 are composed of 67% liquids and 33% solids. The liquids component is composed of 10% SST liquid plus 90% AWF liquid. The solids component is composed of 90% SST solid plus 10% AWF solid. The ULD, onsite SOF multiplier, and offsite SOF multiplier for this composition were calculated to be 1.2E+05 Sv/L, 1.9E+04 s/L, and 40 s/L, respectively. Details of these calculations are shown in Section 4.2.

   Basis: This is a key assumption based on the expected mixing of the components in the tanks and the maximum solids fraction capable of being pumped through the slurry line from Tank 241-C-106 (which would be exposed in an agitated state to the tank void space).

   Sensitivity: The radiological consequences are directly proportional to the ULD. The toxicological consequences are directly proportional to the SOF multiplier.

3. Each HEPA and HEGA (High Efficiency Gas Adsorber) filter element is limited to a contact exposure rate equal to 200 mR/h and 2 mR/h, respectively.

   Basis: The survey limit requiring changeout on most HEPA filters is based primarily on personnel exposure considerations. However, for safety analysis purposes, the maximum contact dose rate also forms the basis for the maximum permissible filter loading and hence maximum release in any given scenario. The lower permitted limit on the HEGA filters derives from a higher release fraction in a fire scenario (see

Section 4.4.2). Because the geometry of each filter element and the duct work holdup characteristics in the 241-A-702 and 241-AZ-702 (Tank 241-AY-102) and 296-P-16 and 296-C-006 (Tank 241-C-106) ventilation systems are not identical, the loading corresponding to the contact dose rate limit will differ for each system. In addition, each combination of liquid/solid ratio has a unique set of radionuclide compositions so the isotopic mix on the various filter elements will be different.

Sensitivity: The aerosol loading on each filter element, and, therefore, the downwind inhalation dose is directly proportional to the assumed contact dose rate limit.

4. The airborne release fractions from the various ventilation system elements are as shown below. These elements include HEPA (High Efficiency Particulate Air) filters, HEGA (High Efficiency Gas Adsorber) filters, De-Entrainers, HEMEs (High Efficiency Mist Eliminators), and HEMFs (High Efficiency Metal Filters).

Element	Release Scenario	Release Fraction
HEPA Filter	High Temperature (Fire)	10^{-4}
	Overpressure (Shock)	10^{-2}
HEGA Filter	High Temperature (Fire)	1
	Overpressure (Shock)	10^{-2}
De-Entrainer and HEME	High Temperature (Fire)	10^{-4}
	Over Pressure (Shock)	10^{-2}
HEMF	High Temperature (Fire)	6E-5
	Overpressure (Shock)	10^{-2}

Basis: These release fractions (except the HEGAs) are based on recommended values in DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*. The release fraction recommendations in DOE-HDBK-3010-94 are in terms of ARF (airborne release fraction) and RF (respirable fraction, i.e., particles $< 10\ \mu m$). The term "respirable fraction" is based on the fact that only this size range in TRU (Transuranic) particles causes a significant inhalation dose. This consideration is not applicable to fission products such as tank waste. The RF is still normally retained as a factor in the release fraction, however, since particles $> 10\ \mu m$ have a high fallout rate they are assumed not to reach the onsite receptor in any significant quantity.

An overpressure event is assumed to catastrophically destroy (crush) the HEPA filter elements in the ventilation system (ARF = 10^{-2}, RF = 1.0 from HDBK-3010-94

Section 5.4.2.2, p. 5-31). The de-entrainers and HEMEs incorporate bonded fiberglass beds and so are assumed to exhibit the same release fraction in a crushing/breaking type of event. The HEGAs are constructed of packed granular beds of activated charcoal in perforated steel boxes and are not considered crushable (but could still be subject a release due to mechanical shock). These filters are positioned between the primary and secondary HEPA filters in the 241-AZ-702 ventilation system. Any particulates stopped by the HEGA will therefore be very fine, having passed through one stage of HEPA filtration. For a high pressure shock, a release fraction of 10^{-2} was conservatively assumed for the HEGAs. The HEMF was modelled as metal surfaces with particulate material plated out in a hardened cohesive layer. Shock waves hitting such material tend to peel away material in relatively large chunks which then break up into smaller particles (ARF = 0.076, RF = 0.14 from HDBK-3010-94 Section 4.4.2.2.2, p. 4-67). The net release fraction for HEMFs was therefore also assumed to be 10^{-2}.

A high temperature event modelled as a fire either within the duct (due to a malfunctioning heater) or external to the filter enclosure is assumed to burn or melt the filters. For thermal stress of HEPA filters, experiments have shown that the molten glass tends to retain most of the particulate loading yielding a release fraction of 10^{-4} (ARF = 10^{-4}, RF = 1 from HDBK-3010-94 Section 5.4.1, p. 5-30). The HEGAs, however, can burn completely to form CO_2 gas. In addition, as already mentioned, any particulates retained by the HEGA will be very fine, having already passed through one stage of HEPA filtration. The release fraction for HEGAs in a fire scenario must, therefore, be assigned a value of 1. The de-entrainers and HEMEs incorporate bonded fiberglass beds and so are assumed to exhibit the same release fraction in a heat stress (or melting) type of event. The de-entrainers in the 241-A-702 and 296-P-16 systems are all upstream of any heaters and are located in massive caissons and so are not subject to a high temperature release scenario. Likewise the HEME in the 241-AZ-702 system is upstream of the heater and is contained in a closed concrete vault and is not subject to internal or external heat sources. The HEMF in the 296-C-006 system could be subjected to thermal stress in an external fire. Even though the filter material itself would not be affected and any material released would still have to pass through the filter (which is in the form of porous tubes), it is conservatively assumed that any material released would be released on the downstream side. The recommended release fraction for thermal stress of powder deposits on metal surfaces is 6E-5 (ARF = 6E-3, RF = 10^{-2} from HDBK-3010-94 Section 4.4.1, p. 4-61).

Sensitivity: The aerosol release from each element and therefore, the downwind inhalation dose, is directly proportional to the corresponding release fraction.

5. The partition fraction during sluicing operations is equal to the "agitated" partition fraction which is 10^{-8}. The "unagitated" partition fraction (during periods between sluicing operations) is 10^{-10}.

Basis: Experimentally measured "agitated" (i.e., with airlift circulators operating) and "unagitated" partition fractions are 10^{-8} and 10^{-10}, respectively. These partition fractions are consistent with those reported in WHC-SD-WM-CN-062.

Sensitivity: The suspended aerosol loading in the vapor space of the tank is directly proportional to the partition fraction. Therefore, the downwind dose accumulated continuously as the result of an unfiltered release is directly proportional to the partition fraction.

6. The flow rate out of the stack for the various systems are as shown below.

Tank	Ventilation System	Exhaust Flow Rate (L/s)
241-AY-102	241-A-702	1.89E+3 (4000 scfm)
	241-AZ-702	9.44E+2 (2000 scfm)
241-C-106	296-P-16	3.30E+3 (7000 scfm)
	296-C-006	1.70E+2 (360 scfm)

Basis: These are the maximum rated system exhaust flow rates.

Sensitivity. The downwind dose accumulated continuously as the result of an unfiltered release is directly proportional to the discharge flow rate.

7. HEPA filter, HEMF, de-entrainer and HEME hazardous material inventories are estimated based on particular detector locations. These locations are as specified in the attachments to this calculation note.

4.0 DETAILED CALCULATIONS OF MATERIAL RELEASED

4.1 DETERMINATION OF MAXIMUM SYSTEM ELEMENT INVENTORIES

The basic procedure consists of determining the gamma radiation field (mR/h) at the survey point assuming material corresponding to 1 L of tank waste to be uniformly mixed with the filter medium. Since only gamma radiation can penetrate the filter (or other element) enclosure, it is assumed that 1 mR/h = 1 mrem/h at the survey point. Bremsstrahlung radiation is neglected since the error introduced is insignificant and is in the conservative direction. The maximum allowed dose rate at the survey point is then divided by the dose rate per liter of waste to obtain the maximum inventory in terms of liters. In order to perform this calculation using a shielding code the geometry of the filter (or other element) and survey point must be known as well as the isotopic mix present on the filter. In addition, the density and composition of the filter medium, filter enclosure, and any other intervening material must be known or assumed. Note that these calculations assume the 1 liter of waste to be distributed uniformly throughout the filter medium. Because of the internal structure of the HEPA and HEGA filters (accordion pleats running the full depth of the filter), this is considered to be a good assumption.

The details of the parameters used in each case are contained in the MICROSHIELD™ and ISO-PC run files reproduced in Attachments 1 through 4 of this report. The filter geometries and survey instrument locations are given below for the various system filters. Considerations related to the other system components such as HEMEs, de-entrainers, etc. are discussed in the next section.

Tank	Ventilation System	Filter Geometry	Instrument Location
241-AY-102	241-A-702	2 ft x 2 ft x 1 ft - 2 single HEPA filters in series per train - 6 parallel trains	Middle center - 6 in. from side of each filter
	241-AZ-702	2 ft x 2 ft x 1 ft - 2 single HEPA filters and 1 HEGA filter in series per train - 2 parallel trains	Bottom center - 6 in. from side of each filter
241-C-106	296-P-16	2 ft x 2 ft x 1 ft - 2 3x3 arrays of HEPA filters in series - single train	Bottom center of space between HEPA filters - 6 in. from side of filters - single location for both filters
	296-C-006	2 ft x 2 ft x 1 ft - 2 single HEPA filters in series - single train	Middle center - 6 in. from side of each filter

4.2 WASTE COMPOSITIONS AND UNIT EFFECTS

Tank 241-C-106 contains a large amount of sludge (197 kgal or about 6 ft) but relatively little supernate (about 32 kgal) (HNF-EP-0182-120) while Tank 241-AY-102 has a very deep supernate layer (806 kgal) with little sludge (22 kgal) (HNF-EP-0182-120). During sluicing operations there will be a good deal of mixing of the waste between Tanks 241-C-106 and 241-AY-102. The sluicing liquid being pumped from 241-AY-102 to 241-C-106 will be composed mainly of 241-AY-102 supernate while the slurry pumped from 241-C-106 to 241-AY-102 will have a large fraction (based on the ability to pump the

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material) composed of solids from 241-C-106 mixed with the sluicing liquid. There is very little 241-C-106 supernate in the system compared to the large amount of 241-AY-102 supernate. The liquid and solid components in both the tank headspaces are therefore assumed to be constituted as described in assumption 1 of Section 3.0.

The aerosol in the 241-AY-102 headspace is assumed to be 90% liquids and 10% solids as defined in assumption 1. This will be the material on the filters and other components of the 241-AY-102 ventilation systems. Because the sluicing operation will be taking place in the 241-C-106 tank the headspace aerosol there is assumed to be 67% liquids with 33% solids as defined in assumption 2. This will be the material on the filters and other components of the 241-C-106 ventilation systems. The resulting compositions of the two aerosol particle mixes are given in terms of activity per liter of waste. The loadings on filters and other components in the tank ventilation systems are given in terms of equivalent liters of waste having these compositions. The resulting waste mix isotopic concentrations are shown below. To obtain the actual headspace air concentrations of the various nuclides these numbers should be multiplied by the partition factor (10^{-8} during sluicing operations, 10^{-10} at other times).

Nuclide	Activity per Unit Liter of Waste (Ci/L)	
	90/10 Mix	67/33 Mix
^{137m}Ba	2.14E+0	2.24E+0
^{60}Co	1.19E-3	3.84E-3
^{154}Eu	2.28E-2	6.06E-2
^{90}Sr, ^{90}Y	4.82E+0 (each)	1.55E+1 (each)

The consequences of the various accident releases considered here are calculated using Unit Liter Doses or ULDs (committed effective dose equivalent per liter of material inhaled) and Sum of Fraction (SOF) multipliers for each of the waste mixes. The rate of waste release (L/s) is multiplied by the SOF multipliers to obtain a total toxicological SOF for the receptor. Details of the methodology of using ULDs and SOF multipliers to obtain release consequences are described in Section 5.1.

The ULDs were derived from information in WHC-SD-WM-SARR-037, *Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations*. The following ULDs for the two waste types (SST and AWF) were used for this analysis.

Waste Form	Waste Type	Inhalation ULD (Sv/L)
Liquid	Single Shell Tank (SST)	1.1E+4
	Aging Waste Facility (AWF)	1.4E+3
Solid	Single Shell Tank (SST)	2.2E+5
	Aging Waste Facility (AWF)	1.7E+6

The components of the liquid and solid parts of the waste are assumed to be the same in both tanks considered here. The composition of the liquid component is 10% SST liquid and 90% AWF liquid. The corresponding ULD is (0.1)(1.1E+4 Sv/L) + (0.9)(1.4E+3 Sv/L) = 2.36E+3 Sv/L. The composition of the solids component is 90% SST solids and 10% AWF solids. The corresponding ULD is (0.9)(2.2E+5 Sv/L) + (0.1)(1.7E+6 Sv/L) = 3.68E+5 Sv/L.

Using these ULDs for the liquid and solid waste components, ULDs for the 90/10 mix for Tank 241-AY-102 and the 67/33 mix for Tank 241-C-106 can be calculated as follows. The 90/10 mix ULD is (0.9)(2.36E+3 Sv/L) + (0.1)(3.68E+5 Sv/L) = 3.9E+4 Sv/L. The 67/33 mix ULD is (0.67)(2.36E+3 Sv/L) + (0.33)(3.68E+5 Sv/L) = 1.2E+5 Sv/L.

The SOF multipliers were developed from information in WHC-SD-WM-SARR-011, *Toxic Chemical Considerations for Tank Farm Releases*. The following SOF multipliers for the two waste types (SST and AWF) were used for this analysis. Note that the AWF SOFs were listed in SARR-011 for double shell tank (DST) waste, however for toxicological calculations, DST and AWF waste are the same.

Waste Form	Waste Type	Sum of Fractions (SOF) Multiplier	
		Onsite	Offsite
Liquid	Single Shell Tank (SST)	9.6E+3	8.0E+0
	Aging Waste Facility (AWF)	1.0E+4	8.4E+0
Solid	Single Shell Tank (SST)	4.0E+4	9.4E+1
	Aging Waste Facility (AWF)	1.8E+4	1.9E+2

The components of the liquid and solid parts of the waste are assumed to be the same in both tanks considered here. The composition of the liquid component is 10% SST liquid and 90% AWF liquid. The corresponding onsite SOF multiplier is (0.1)(9.6E+3 s/L) + (0.9)(1.0E+4 s/L) = 9.96E+3 s/L. Similarly, the offsite SOF multiplier for the liquid component is 8.36E+0 s/L. The composition of the solids component is 90% SST solids and 10% AWF solids. The corresponding onsite SOF multiplier is (0.9)(4.0E+4 s/L) +

(0.1)(1.8E+4 s/L) = 3.78E+4 s/L. Similarly, the offsite SOF multiplier for the solid component is 1.04E+2 s/L.

Using these SOF multipliers for the liquid and solid waste components, the 90/10 mix for Tank 241-AY-102 and the 67/33 mix for Tank 241-C-106 can be calculated as follows. The 90/10 mix onsite SOF multiplier is (0.9)(9.96E+3 s/L) + (0.1)(3.78E+4 s/L) = 1.3E+4 s/L. Similarly, the offsite SOF multiplier for the 90/10 mix is 1.8E+1 s/L. The 67/33 mix onsite ULD multiplier is (0.67)(9.96E+3 s/L) + (0.33)(3.78E+4 s/L) = 1.9E+4 s/L. Similarly, the offsite SOF multiplier for the 67/33 mix is 4.0E+1 s/L.

In summary, the unit liter doses or ULDs (committed effective dose equivalent per liter of material inhaled) are 3.9E+04 Sv/L and 1.2E+05 Sv/L for the 90/10 and 67/33 mixes, respectively. For the onsite receptor, the SOF (sum of fractions) multipliers are 1.2E+04 and 1.9E+04, while for the offsite receptor the SOF multipliers are 18 and 40 for the 90/10 and 67/33 mixes respectively.

4.3 CONSEQUENCES OF 241-A-702 VENTILATION SYSTEM RELEASES

4.3.1 System Description

This system services Tank 241-AY-102 whose deep supernate layer will be used as the source of sluicing liquid for sludge removal operations in Tank 241-C-106. The sludge pumped out of Tank 241-C-106 will be deposited in Tank 241-AY-102 through a slurry distributor located deep within the supernate layer at a point just above the top of the sludge layer. The 241-A-702 ventilation system exhausts head space air through a de-entrainer (K1-5-1), condensers, a second de-entrainer (K1-5-2A), a heater, six parallel HEPA filter trains, and two exhaust fans to a single stack (A-702). Each HEPA filter train consists of two single HEPA filters in series. Each filter is 2 ft x 2 ft x 1 ft thick (in direction of air flow) (61 cm x 61 cm x 30.5 cm). The two de-entrainers are in caissons for shielding purposes. The maximum rated exhaust flow for this system is 4000 scfm (1.89 m^3/s).

4.3.2 Waste Inventories in System Components

Each individual HEPA filter is surveyed using a hand-held detector at a point on the outside of the enclosure which is approximately 6 inches from the center of the side of the filter. The maximum reading before the filter must be changed out is conservatively specified to be 200 mR/h for safety analysis purposes. Assuming 1 liter of 90/10 waste mix to be uniformly spread through the filter medium, a calculated exposure rate of 3900 mR/h (= mrem/h for γ) was predicted at the survey point. The detailed documentation of this calculation, along with the computer code run file, are reported in Attachment 1. Dividing the 200 mR/h limit by 3900 mR/hL yields a maximum waste inventory of 5.1E-2 L per HEPA filter. The two de-entrainers in this system are in caissons. The associated inventories cannot be determined and are not controlled. De-entrainer DE-1 in the 296-P-16 ventilation system at the 241-C tank farm is of a similar type. A recent radiation survey indicates a 100 mR/h contact reading at the top of this de-entrainer. Inventory analysis of the 296-P-16 de-entrainer indicates the presence of 1.5 L of waste (see Attachment 3). It is assumed for this analysis that each of the de-entrainers in the 241-A-702 system contains the same amount of waste. It is further assumed that the non-filter components of the system, including ducting, heater and condensers, are internally contaminated with a total inventory equal to one fully loaded HEPA filter.

The total system inventory is then 5.1E-2 L on each of 12 HEPA filters plus one equivalent HEPA to account for contamination in the duct work and non-filter components for a total of 6.63E-1 L of waste. In addition, the two de-entrainers are assumed to contain 1.5 L each for a total contribution of 3.0 L.

4.3.3 Release Scenarios

Three release scenarios are analyzed for this ventilation system:

1. A high temperature event involving a heater failure and fire within the duct work or a fire external to the duct which leads to the melting/burning of the HEPA filters. Note that the two de-entrainers are upstream of the heater and are not subject to release scenarios involving only high temperatures (or fire). Although this type of release could be expected to take some time, it is conservatively assumed for purposes of calculating toxicological release rates that the release takes place uniformly over 2 minutes (120 s).

2. A fast overpressure event caused by a steam explosion ("steam bump") or hydrogen deflagration in the tank. For conservatism, the event is assumed to involve a shock wave traversing the system which crushes and fails the HEPA filters and the fiberglass mats in the de-entrainers. It is assumed for purposes of calculating toxicological release rates that the release takes place uniformly over 2 minutes (120 s) based on the expected duration of a steam bump (see Section 5.4).

3. A continuous unfiltered release event where it is assumed that the HEPA filters fail due to wetting, seal failure, or to one of the scenarios above. No credit is taken for any filtration in the de-entrainers. Normally this type of release is mitigated by a CAM which continuously samples the stack exhaust and shuts down the exhaust fan on detection of radiation in the stack gas above a defined setpoint. If the CAM and fan interlock function as intended, the release is assumed to be stopped after 10 minutes. In the unmitigated case the release is assumed to continue unabated, exposing the onsite receptor for 12 hours and the offsite receptor for 24 hours.

The total releases for the first two scenarios are the sums of the "instantaneous" releases due to the high temperature or overpressure events and the continuous release which follows.

The third scenario produces only the unfiltered release from the tank headspace, i.e., no releases from the ventilation system itself are included. Radiological evaluations of all three scenarios therefore produce two cases each: with and without the CAM-fan interlock. The evaluation of toxicological releases using the SOF multipliers depend only on the release rate (instead of the integrated release) and therefore are not affected by the functioning of the CAM-fan interlock.

4.3.4 Consequence Calculations

Releases from the various components were calculated as shown below for the high temperature and overpressure scenarios. Note that the HEPA inventory includes 1 HEPA equivalent for the duct and non-filter components. The release fractions for these metal components are essentially the same as those for HEPA filters as shown in Section 3.0. The release fraction applied in each case is shown in brackets. Recall also that the de-entrainer in this system is not subject to a high temperature release.

Component	Inventory (L)	Releases (Equivalent liters of Waste) [RF]	
		High Temperature	Overpressure
HEPA Filters (13)	6.63E-1	6.63E-5 [10^{-4}]	6.63E-3 [10^{-2}]
De-Entrainers (2)	3.00E+0	0	3.00E-2 [10^{-2}]
Totals (Q) ==>		6.63E-5	3.66E-2

Radiological doses corresponding to these "instantaneous" releases were calculated using the methodology shown in Section 5.1.1 and are reported in the last column of Table 1. Recall that this waste mix (90/10) has a ULD of 3.9E+4 Sv/L.

The continuous release rate through the failed filters in equivalent liters of waste per second is the ventilation exhaust rate multiplied by the partition fraction (in this case 10^{-8}) or (1.89E+3 L/s)(10^{-8}) = 1.89E-5 L/s. The unfiltered release quantities in 10 minutes, 12 hours, and 24 hours are 1.13E-2 L, 8.16E-1 L and 1.63E+0 L, respectively. The corresponding doses are reported in the last column of Table 1.

The toxicological consequences were calculated as shown in Section 5.1.2 for an assumed release time of 120 seconds for both scenarios (see Section 5.4). The release rates for the high temperature and overpressure scenarios are therefore (6.63E-5 L)/(120 s) = 5.53E-7 L/s and (3.66E-2 L)/(120 s) = 3.05E-4 L/s, respectively. The release rate for the continuous unfiltered release is 1.89E-5 L/s as calculated above. The corresponding onsite and offsite toxicological SOFs are then obtained by multiplying by the appropriate SOF multiplier (1.3E+4 s/L for onsite and 18 s/L for offsite). The results are reported in the bottom section of Table 1.

The total radiological doses and toxicological consequences for the high temperature and overpressure releases are the combined effects of the "instantaneous" releases from the ventilation system components and the continuous release from the tank head space through the failed filters. The effect of the continuous release component depends on whether or not the fan is shut down after 10 minutes. The resulting combined radiological doses and toxicological consequences are reported in Table 2. Note that the "No CAM-Fan Interlock" column contains the 12-hour (onsite) and 24-hour (offsite) continuous releases while the "With CAM-Fan Interlock" column incorporates the 10-minute continuous release. The toxicological effects depend only on air concentration at the receptor, and therefore release rate, so the fan shutdown has no effect.

4.4 CONSEQUENCES OF 241-AZ-702 VENTILATION SYSTEM RELEASES

4.4.1 System Description

This system services Tank 241-AY-102 whose deep supernate layer will be used as the source of sluicing liquid for sludge removal operations in Tank 241-C-106. The sludge pumped out of Tank 241-C-106 will be deposited in Tank 241-AY-102 through a distributor located deep within the supernate layer at a point just above the top of the sludge layer. The 241-AZ-702 ventilation system exhausts head space air through a condenser, a HEME (High Efficiency Mist Eliminator), two parallel filter trains, and two exhaust fans to a single stack (296-A-42). Each filter train consists of a heater and two single HEPA filters in series with a single HEGA (High Efficiency Gas Adsorber) filter between the two HEPA filters. Each filter is 2 ft x 2 ft x 1 ft thick (in direction of air flow) (61 cm x 61 cm x 30.5 cm). The HEME and each filter train are in separate concrete vaults with a concrete fire wall between the two filter trains. The normal mode of operation is to have only one of the filter trains on line at any given time, however for safety analysis purposes both filter trains are assumed to be operating. The maximum rated exhaust flow for this system is 2000 scfm (0.944 m^3/s).

4.4.2 Waste Inventories in System Components

Each individual HEPA and HEGA filter is surveyed using a hand-held detector at a point on the outside of the enclosure which is approximately 6 inches from the bottom center of the side of the filter. The maximum reading before a HEPA filter must be changed out is conservatively specified to be 200 mR/h for safety analysis purposes. The maximum allowed survey reading for the HEGA filter is 2 mR/hr. Because of interfering background radiation from the adjacent HEPA filters, the HEGA filter could be surveyed whenever a HEPA filter is changed out (thus reducing the background). Conservatively assuming the HEPA filter upstream of the HEGA filter to pass 0.1% of the particulates which strike it and that the HEGA retains the entire amount, the upstream HEPA would have to be changed out 32 times with a full load (corresponding to 200 mR/hr survey reading) before the HEGA would reach a loading corresponding to 2 mR/hr on the HEGA. One way to proceed, therefore, would be to change out the HEGA filter whenever the upstream HEPA has been changed out 30 times or if the upstream HEPA is changed out due to being breached.

Assuming 1 liter of 90/10 waste mix to be uniformly spread through the HEPA filter medium, a calculated exposure rate of 2800 mR/h (= mrem/h for γ) was predicted at the survey point. Similar calculations for the HEGA filter and the HEME predicted exposure rates of 860 mR/h and 3423 mR/h, respectively, per liter of waste inventory. The detailed documentation of these calculations, along with the computer code run files, are reported in Attachment 2. Dividing the 200 mR/h limit by 2800 mR/hL yields a maximum waste inventory of 7.1E-2 L per HEPA filter. The 2 mR/h limit on the HEGA filter implies an inventory equivalent to 2.3E-3 L of waste. Similarly, the 800 mR/hr contact limit on the HEME (corresponding to 300 mR/h at the installed probe) indicates an inventory of 2.3E-1 L of waste. As before, it is assumed that the non-filter components of the system, including ducting, heater and condensers, are internally contaminated with a total inventory equal to one fully loaded HEPA filter.

As mentioned previously, both filter trains are assumed to be operating, placing the entire inventory at risk. The total system inventory with respect to the overpressure release is then 7.1E-2 L on each of 4 HEPA filters plus one equivalent HEPA to account for contamination in the duct work and non-filter components for a total of 3.55E-1 L of waste on the HEPAs. In addition, the two HEGA filters contain 2.3E-3 L each for a total of 4.6E-3 L. In the case of the high temperature (fire) release, however, the fact that the heater associated with each of the filter trains is downstream of the separation point and that each filter train is in a vault separated by a fire wall, precludes such a release from both filter trains. With respect to the high temperature release scenario, therefore, the involved inventory would include two HEPA filters plus one HEPA equivalent for the duct making a total of 2.13E-1 L. Similarly, only one HEGA would be involved for a total of 2.3E-3 L. In both cases the one HEME would contribute 2.3E-1 L to the total inventory.

4.4.3 Release Scenarios

Three release scenarios are analyzed for this ventilation system:

1. A high temperature event involving a heater failure and fire within the duct work or a fire external to the duct which leads to the melting/burning of the HEPA filters and combustion of the activated charcoal beds in the HEGA filter. Since the two filter trains each contain their own heater and the two filter trains are separated by a fire wall, only one of the filter trains is expected to participate in a high temperature release. In addition, since the HEME is in a concrete vault and upstream of the heaters, it is not subject to high temperature releases. Although this type of release could be expected to take some time, it is conservatively assumed for purposes of calculating toxicological release rates that the release takes place approximately uniformly over 2 minutes (120 s).

2. A fast overpressure event caused by a steam explosion ("steam bump") or Hydrogen deflagration in the tank. For conservatism the event is assumed to involve a shock wave traversing the system which crushes and fails the HEPA filters and the fiberglass beds in the HEME. The granular activated charcoal beds in the HEGAs are contained within perforated steel plates and are assumed to exhibit the same release characteristics (i.e., release fraction) as HEPAs in this scenario. It is assumed for purposes of calculating toxicological release rates that the release takes place approximately uniformly over 2 minutes (120 s) based on the expected duration of a steam bump (see Section 5.4).

3. A continuous unfiltered release event where it is assumed that the HEPA filters fail due to wetting or to one of the scenarios above. No credit is taken for any filtration in the HEME or the HEGAs. Normally this type of release is mitigated by a CAM which continuously samples the stack exhaust and shuts down the exhaust fan on detection of radiation in the stack gas above a defined setpoint. If the CAM and fan interlock function as intended, the release is assumed to be stopped after 10 minutes. In the unmitigated case the release is assumed to continue unabated, exposing the onsite receptor for 12 hours and the offsite receptor for 24 hours.

The total releases for the first two scenarios are the sums of the "instantaneous" releases due to the high temperature or overpressure events and the continuous release which follows. The third scenario caused by filter wetting produces only the unfiltered release from the tank headspace. Radiological evaluations of all three scenarios therefore produce two cases each: with and without the CAM-fan interlock. The evaluation of toxicological releases using the SOF multipliers depend only on the release rate (instead of the integrated release) and therefore are not affected by the functioning of the CAM-fan interlock.

4.4.4 Consequence Calculations

Releases from the various components were calculated as shown below for the high temperature and overpressure scenarios. Note that the HEPA inventory includes 1 HEPA equivalent for the duct and non-filter components. The release fractions for these metal components are essentially the same as those for HEPA filters as shown in Section 3.0. The release fraction applied in each case is shown in brackets. Recall also that the HEME in this system is not subject to a high temperature release.

Component		Inventory (L)	Releases (Equivalent liters of Waste) [RF]	
			High Temperature	Overpressure
HEPA Filters	(5)	3.55E-1	--	3.55E-3 [10^{-2}]
	(3)	2.13E-1	2.13E-5 [10^{-4}]	--
HEGA Filters	(2)	4.60E-3	--	4.60E-5 [10^{-2}]
	(1)	2.30E-3	2.30E-3 [1]	--
HEME (1)		2.30E-1	0	2.30E-3 [10^{-2}]
Totals (Q) ==>			2.32E-3	5.90E-3

Radiological doses corresponding to these "instantaneous" releases were calculated using the methodology shown in Section 5.1.1 and are reported in the last column of Table 3. Recall that this waste mix (90/10) has a ULD of 3.9E+4 Sv/L.

The continuous release rate through the failed filters in equivalent liters of waste per second is the ventilation exhaust rate multiplied by the partition fraction (in this case 10^{-8}) or (9.44E+2 L/s)(10^{-8}) = 9.44E-6 L/s. The unfiltered release quantities in 10 minutes, 12 hours and 24 hours are 5.66E-3 L, 4.08E-1 L, and 8.16E-1 L, respectively. The corresponding doses are reported in the last column of Table 3.

The toxicological consequences were calculated as shown in Section 5.1.2 for an assumed release time of 120 seconds for both scenarios (see Section 5.4). The release rates for the high temperature and overpressure scenarios are therefore (2.32E-3 L)/(120 s) = 1.93E-5 L/s and (5.90E-3 L)/(120 s) = 4.92E-5 L/s, respectively. The release rate for the continuous unfiltered release is 9.44E-6 L/s as calculated above. The corresponding onsite and offsite toxicological SOFs are then obtained by multiplying by the appropriate SOF multiplier (1.3E+4 s/L for onsite and 18 s/L for offsite). The results are reported in the bottom section of Table 3.

The total radiological doses and toxicological consequences for the high temperature and overpressure releases are the combined effects of the "instantaneous" releases from the ventilation system components and the continuous release from the tank head space through the failed filters. The effect of the continuous release component depends on whether or not the fan is shut down after 10 minutes. The resulting combined radiological doses and toxicological consequences are reported in Table 4. Note that the "No CAM-Fan Interlock" column contains the 12-hour (onsite) and 24-hour (offsite) continuous releases while the "With CAM-Fan Interlock" column incorporates the 10-minute continuous release. The toxicological effects depend only on air concentration at the receptor, and therefore release rate, so the fan shutdown has no effect.

4.5 CONSEQUENCES OF 296-P-16 VENTILATION SYSTEM RELEASES

4.5.1 System Description

This system services Tank 241-C-106 from which the sludge is to be moved to Tank 241-AY-102 by means of a sluicing system using high pressure supernate from Tank 241-AY-102. The sludge pumped out of Tank 241-C-106 will be deposited in Tank 241-AY-102 through a slurry distributor located deep within the supernate layer at a point just above the top of the sludge layer. The 296-P-16 ventilation system exhausts head space air through a de-entrainer (DE-1), a heater, a HEPA filter train, and an exhaust fan to a stack. The HEPA filter train consists of two 3x3 HEPA filters arrays in series. Each filter is 2 ft x 2 ft x 1 ft thick (in direction of air flow) (61 cm x 61 cm x 30.5 cm). A 2.5 inch thick prefilter array is located on the upstream side of the first HEPA filter array. This prefilter array is attached to the first HEPA filter array and cannot be monitored separately so it is treated as part of the first HEPA filter array. The de-entrainer is situated above grade in a caisson shield. The maximum rated exhaust flow for this system is 7000 scfm (3.30 m^3/s). The primary purpose of this system is to provide cooling and hydrogen removal in Tank 241-C-106 during the periods between sluicing operations. This system also acts as a safety backup to system 296-C-006 (the sluicing ventilation system). However, in case of failure of the 296-C-006 system, sluicing operations must be stopped before the 296-P-16 system is activated.

4.5.2 Waste Inventories in System Components

Both filter arrays are surveyed at a single location midway between the filters using a hand-held detector. The survey point is on the outside of the enclosure approximately 6 inches from the bottom center of the sides of the filters. The maximum reading before the filter must be changed out is conservatively specified to be 200 mR/h for safety analysis purposes. Assuming 1 liter of 67/33 waste mix to be uniformly spread through the mediums of both filter arrays (i.e., 0.5 L per 3x3 array), a calculated exposure rate of 640 mR/h (= mrem/h for γ) was predicted at the survey point. The detailed documentation of the shielding calculations associated with system 296-P-16 HEPA filters, along with the computer code run files, are reported in Attachment 1. Dividing the 200 mR/h limit by 640 mR/hL yields a maximum waste inventory of 3.2E-1 L in both filters or 1.6E-1 L per 3x3 HEPA filter array. De-entrainer DE-1 in the 296-P-16 ventilation system is above ground (although surrounded by a caisson for shielding), and can therefore by surveyed and controlled. A recent radiation survey indicates a 100 mR/h contact reading at the top of the de-entrainer. Assuming 1 liter of 67/33 waste mix to be uniformly spread through the medium of the de-entrainer, a calculated exposure rate of 67 mR/h (= mrem/h for γ) was predicted at the survey point. The detailed documentation of the shielding calculations associated with the system 296-P-16 de-entrainer, along with the computer code run file, are reported in Attachment 3. Dividing the measured 100 mR/h contact exposure reading by 67 mR/hL yields a waste inventory of 1.5E+0 L in the de-entrainer. It is further assumed that the non-filter components of the system, including ducting and heater, are internally contaminated with a total inventory equal to one fully loaded 3x3 HEPA filter array.

The total system inventory is then 1.6E-1 L on each of 2 HEPA filter arrays plus one equivalent HEPA array to account for contamination in the duct work and non-filter components for a total of 4.8E-1 L of waste. In addition, the de-entrainer is assumed to contain 1.5 L of waste equivalent.

4.5.3 Release Scenarios

Three release scenarios are analyzed for this ventilation system:

1. A high temperature event involving a heater failure and fire within the duct work or a fire external to the duct which leads to the melting/burning of the HEPA filters. Note that the de-entrainer is upstream of the heater and is not subject to release scenarios involving only high temperatures. Although this type of release could be expected to take some time, it is conservatively assumed for purposes of calculating toxicological release rates that the release takes place uniformly over 2 minutes (120 s).

2. A fast overpressure event caused by a steam explosion ("steam bump") or hydrogen deflagration in the tank. For conservatism, the event is assumed to involve a shock wave traversing the system which crushes and fails the HEPA filters and the fiberglass mats in the de-entrainer. It is assumed for purposes of calculating toxicological release rates that the release takes place uniformly over 2 minutes (120 s) based on the expected duration of a steam bump (see Section 5.4).

3. A continuous unfiltered release event where it is assumed that the HEPA filters fail due to wetting or to one of the scenarios above. No credit is taken for any filtration in the de-entrainer. Normally this type of release is mitigated by a CAM which continuously samples the stack exhaust and shuts down the exhaust fan on detection of radiation in the stack gas above a defined setpoint. If the CAM and fan interlock function as intended, the release is assumed to be stopped after 10 minutes. In the unmitigated case the release is assumed to continue unabated, exposing the onsite receptor for 12 hours and the offsite receptor for 24 hours.

The total releases for the first two scenarios are the sums of the "instantaneous" releases due to the high temperature or overpressure events and the continuous release which follows. The third scenario caused by filter wetting produces only the unfiltered release from the tank headspace. Radiological evaluations of all three scenarios therefore produce two cases each: with and without the CAM-fan interlock. The evaluation of toxicological releases using the SOF multipliers depend only on the release rate (instead of the integrated release) and therefore are not affected by the functioning of the CAM-fan interlock.

The 296-P-16 ventilation system will only be operated during periods between sluicing operations to cool the tank. The continuous release calculations for simple filter failure (due to wetting), and for the continuous release adder to the high temperature (fire) scenario, assumed a tank head space partition fraction of 10^{-10} (unagitated conditions). The overpressure release scenario, however, implies a considerable amount of tank agitation. For the continuous release associated with the overpressure event, therefore, the agitated partition fraction (10^{-8}) corresponding to approximately 20 mg/m^3 in the head space was assumed for the 10 minute, 12 hour, and 24 hour releases.

4.5.4 Consequence Calculations

Releases from the various components were calculated as shown below for the high temperature and overpressure scenarios. Note that the HEPA inventory includes 1 HEPA array equivalent for the duct and non-filter components. The release fractions for these metal components are essentially the same as those for HEPA filters as shown in Section 3.0. The release fraction applied in each case is shown in brackets. Recall also that the de-entrainer in this system is not subject to a high temperature release.

Component	Inventory (L)	Releases (Equivalent liters of Waste) [RF]	
		High Temperature	Overpressure
HEPA Filter Arrays (3)	4.80E-1	4.80E-5 [10^{-4}]	4.80E-3 [10^{-2}]
De-Entrainers (1)	1.50E+0	0	1.50E-2 [10^{-2}]
Totals (Q) ==>		4.80E-5	1.98E-2

Radiological doses corresponding to these "instantaneous" releases were calculated using the methodology shown in Section 5.1.1 and are reported in the last column of Table 5. Recall that this waste mix (67/33) has a ULD of 1.2E+5 Sv/L.

The continuous release rate through the failed filters in equivalent liters of waste per second (for filter failure only or high temperature event) is the ventilation exhaust rate multiplied by the partition fraction (in this case 10^{-10}) or (3.30E+3 L/s)(10^{-10}) = 3.30E-7 L/s. The unfiltered release quantities in 10 minutes, 12 hours, and 24 hours are 1.98E-4 L, 1.43E-2 L and 2.85E-2 L, respectively. The corresponding doses are reported in the last column of Table 5.

The toxicological consequences were calculated as shown in Section 5.1.2 for an assumed release time of 120 seconds for both scenarios (see Section 5.4). The release rates for the high temperature and overpressure scenarios are therefore (4.80E-5 L)/(120 s) = 4.00E-7 L/s and (1.98E-2 L)/(120 s) = 1.65E-4 L/s, respectively. The release rate for the continuous unfiltered release is 3.30E-7 L/s as calculated above. The corresponding onsite and offsite toxicological SOFs are then obtained by multiplying by the appropriate SOF multiplier (1.9E+4 s/L for onsite and 40 s/L for offsite). The results are reported in the bottom section of Table 5.

The total radiological doses and toxicological consequences for the high temperature and overpressure releases are the combined effects of the "instantaneous" releases from the ventilation system components and the continuous release from the tank head space through the failed filters. Since in this case the agitated partition fraction was assumed for the overpressure event, the continuous release doses and SOFs were multiplied by 100 before being added to the "instantaneous" component. The dose from the continuous release component depends on whether or not the fan is shut down after 10 minutes. The resulting combined radiological doses and toxicological consequences are reported in Table 6. Note that the "No CAM-Fan Interlock" column contains the 12-hour (onsite) and 24-hour (offsite) continuous releases while the "With CAM-Fan Interlock" column incorporates the 10-minute continuous release. The toxicological effects depend only on air concentration at the receptor, and therefore release rate, so the fan shutdown has no effect.

4.6 CONSEQUENCES OF 296-C-006 VENTILATION SYSTEM RELEASES

4.6.1 System Description

This system services Tank 241-C-106 from which the sludge is to be moved to Tank 241-AY-102 by means of a sluicing system using high pressure supernate from Tank 241-AY-102. The sludge pumped out of Tank 241-C-106 will be deposited in Tank 241-AY-102 through a slurry distributor located deep within the supernate layer at a point just above the top of the sludge layer. The 296-C-006 ventilation system exhausts head space air through a HEME (High Efficiency Mist Eliminator), a HEMF (High Efficiency Metal Filter), a heater, a single HEPA filter train, and an exhaust fan to a stack. The HEPA filter train consists of two single HEPA filters in series. Each filter is 2 ft x 2 ft x 1 ft thick (in direction of air flow) (61 cm x 61 cm x 30.5 cm). The HEME and the HEMF are located in an unmanned process building with the heater, HEPA filters and fan located on a separate exhaust skid. The maximum rated exhaust flow for this system is 360 scfm (1.70E-1 m^3/s). The primary function of this system is to provide recirculation flow in Tank 241-C-106 during sluicing operations to maintain visibility for direction of the sluicing nozzle by operating personnel.

4.6.2 Waste Inventories in System Components

Each individual HEPA filter is surveyed using a hand-held detector at a point on the outside of the enclosure which is approximately 6 inches from the center of the side of the filter. The maximum reading before the filter must be changed out is conservatively specified to be 200 mR/h for safety analysis purposes. Assuming 1 liter of 67/33 waste mix to be uniformly spread through the filter medium, a calculated exposure rate of 4300 mR/h

(= mrem/h for γ) was predicted at the survey point. The detailed documentation of the 296-C-006 HEPA filter calculation, along with the computer code run file, are reported in Attachment 1. Dividing the 200 mR/h limit by 4300 mR/hL yields a maximum waste inventory of 4.7E-2 L per HEPA filter. The HEME and HEMF are monitored by a single installed probe located about 6 inches from the side of the HEME and about 12 inches from the HEMF. This detector probe is set to alarm at 100 mR/h. The calculated detector readings for 1 liter of waste in the HEME or the HEMF are 10.0 mR/h and 5.26 mR/h, respectively. The detailed documentation of the 296-C-006 HEME and HEMF calculations, along with the computer code run files, are reported in Attachment 4. It is therefore conservative to assume that the entire total holdup in the HEME and HEMF resides in the HEMF (maximum of 19.0 L) since this will produce the greatest release. In addition, the HEME is to be washed down at short intervals (presently planned as once per hour) during system operation to keep the fiberglass beds wet. (The wash water will go to a seal pot and thence to Tank 241-C-106.) Very little material is therefore expected to accumulate on the HEME. It is further assumed that the non-filter components of the system, including ducting, heater and condensers, are internally contaminated with a total inventory equal to one fully loaded HEPA filter.

The total system inventory is then 4.7E-2 L on each of 2 HEPA filters plus one equivalent HEPA to account for contamination in the duct work and non-filter components for a total of 1.41E-1 L of waste. In addition, the HEMF is assumed to contain 19 L.

4.6.3 Release Scenarios

Three release scenarios are analyzed for this ventilation system:

1. A high temperature event involving a heater failure and fire within the duct work or a fire external to the duct which leads to the melting/burning of the HEPA filters. Note that the HEME and the HEMF are upstream of the heater and are not subject to release scenarios involving a heater failure. They could, however, be affected by a fire external to the system in the process building. Although this type of release could be expected to take some time, it is conservatively assumed for purposes of calculating toxicological release rates that the release takes place uniformly over 2 minutes (120 s).

2. A fast overpressure event caused by a steam explosion ("steam bump") or Hydrogen deflagration in the tank. For conservatism the event is assumed to involve a shock wave traversing the system which crushes and fails the HEPA filters and fails the metal filter elements in the HEME. It is assumed for purposes of calculating toxicological release rates that the release takes place uniformly over 2 minutes (120 s) based on the expected duration of a steam bump (see Section 5.4).

3. A continuous unfiltered release event where it is assumed that the HEPA filters fail due to wetting or to one of the scenarios above. No credit is taken for any

filtration in the HEME or HEMF. Normally this type of release is mitigated by a CAM which continuously samples the stack exhaust and shuts down the exhaust fan on detection of radiation in the stack gas above a setpoint. If the CAM and fan interlock function as intended, the release is assumed to be stopped after 10 minutes. In the unmitigated case, the release is assumed to continue unabated, exposing the onsite receptor for 12 hours and the offsite receptor for 24 hours.

The total releases for the first two scenarios are the sums of the "instantaneous" releases due to the high temperature or overpressure events and the continuous release which follows. The third scenario caused by filter wetting produces only the unfiltered release from the tank head space. Radiological evaluations of all three scenarios therefore produce two cases each: with and without the CAM-fan interlock. The evaluation of toxicological releases using the SOF multipliers depend only on the release rate (instead of the integrated release) and therefore are not affected by the functioning of the CAM-fan interlock.

4.6.4 Consequence Calculations

Releases from the various components were calculated as shown below for the high temperature and overpressure scenarios. Note that the HEPA inventory includes 1 HEPA equivalent for the duct and non-filter components. The release fractions for these metal components are essentially the same as those for HEPA filters as shown in Section 3.0. The release fraction applied in each case is shown in brackets.

Component	Inventory	Releases (Equivalent liters of Waste) [RF]	
		High Temperature	Overpressure
HEPA Filters (3)	1.41E-1	1.41E-5 [10^{-4}]	1.41E-3 [10^{-2}]
HEME (1)	0	--	--
HEMF (1)	1.90E+1	1.14E-3 [6E-5]	1.90E-1 [10^{-2}]
Totals (Q) ==>		1.15E-3	1.91E-1

Radiological doses corresponding to these "instantaneous" releases were calculated using the methodology shown in Section 5.1.1 and are reported in the last column of Table 7. Recall that this waste mix (67/33) has a ULD of 1.2E+5 Sv/L.

The continuous release rate through the failed filters in equivalent liters of waste per second is the ventilation exhaust rate multiplied by the partition fraction (in this case 10^{-8}) or (1.70E+2 L/s)(10^{-8}) = 1.70E-6 L/s. The unfiltered release quantities in 10 minutes, 12 hours, and 24 hours are 1.02E-3 L, 7.34E-2 L and 1.47E-1 L, respectively. The corresponding doses are reported in the last column of Table 7.

The toxicological consequences were calculated as shown in Section 5.1.2 for an assumed release time of 120 seconds for both scenarios (see Section 5.4). The release rates for the high temperature and overpressure scenarios are therefore (1.15E-3 L)/(120 s) = 9.58E-6 L/s and (1.91E-1 L)/(120 s) = 1.59E-3 L/s, respectively. The release rate for the continuous unfiltered release is 1.70E-6 L/s as calculated above. The corresponding onsite and offsite toxicological SOFs are then obtained by multiplying by the appropriate SOF multiplier (1.9E+4 s/L for onsite and 40 s/L for offsite). The results are reported in the bottom section of Table 7.

The total radiological doses and toxicological consequences for the high temperature and overpressure releases are the combined effects of the "instantaneous" releases from the ventilation system components and the continuous release from the tank head space through the failed filters. The effect of the continuous release component depends on whether or not the fan is shut down after 10 minutes. The resulting combined radiological doses and toxicological consequences are reported in Table 8. Note that the "No CAM-Fan Interlock" column contains the 12-hour (onsite) and 24-hour (offsite) continuous releases while the "With CAM-Fan Interlock" column incorporates the 10-minute continuous release. The toxicological effects depend only on air concentration at the receptor, and therefore release rate, so the fan shutdown has no effect.

5.0 PARAMETERS FOR THE ATMOSPHERIC DISPERSION CALCULATIONS

5.1 METHODOLOGY

5.1.1 Radiological Consequences

The following equation is used to calculate the committed effective dose equivalent (CEDE) for the consequences of crushing the HEPA filters and releasing the material downwind:

$$Q * ULD * R * OF * \frac{\chi}{Q} = CEDE$$

where

Q	=	amount of material released (L), see Table 1, 3, 5, and 7
ULD	=	unit liter dose (Sv/L), see Section 4.2
R	=	breathing rate (m^3/s), see Section 5.5
OF	=	occupancy factor, applicable only to onsite receptor for exposures $\geq$ 24 hours, fraction of air breathed at

		work (= 0.286)
χ/Q	=	atmospheric dispersion coefficient (s/m^3), at a given downwind distance, see Section 5.6
CEDE	=	committed effective dose equivalent (Sv).

The following equation is used to calculate the committed effective dose equivalent (CEDE) for the consequences of continuously ventilating the (now unfiltered) tank head space and releasing the material downwind:

$$\frac{dQ}{dt} * ULD * R * OF * \frac{\chi}{Q} * t = CEDE$$

where

dQ/dt	=	effective volume release rate of waste material (L/s)
ULD	=	unit liter dose (Sv/L), see Section 4.2
R	=	breathing rate (m^3/s), see Section 5.5
OF	=	occupancy factor, applicable only to onsite receptor for exposures $\geq$ 24 hours, fraction of air breathed at work (= 0.286)
χ/Q	=	atmospheric dispersion coefficient (s/m^3), at a given downwind distance, see Section 5.6
t	=	time duration of the continuous release (s)
CEDE	=	committed effective dose equivalent (Sv).

Note that continuous release doses are reported only for 12 hours of exposure for the onsite receptor and 24 hours of exposure for the offsite receptor. Assuming the dose rate to be uniform, these doses can be extrapolated to annual average doses by the use of simple multipliers. In the case of the onsite receptor, corrections must be made for the increase in exposure time (8766 h/12 h), the change in X/Q (4.03E-4/5.54E-3) (see Section 5.6), and onsite occupancy or the fraction of air breathed at work (0.286). In the case of the offsite receptor, corrections must only be made for the increase in exposure time (8766 h/24 h) and the change in X/Q (1.24E-7/4.62E-6). The resulting multipliers are 15.2 and 9.80 for the onsite and offsite receptors, respectively.

5.1.2 Toxicological Consequences

The following equations are used to calculate the sum-of-fractions for the chemically hazardous material that is released downwind: for releases from the ventilation system components,

$$\frac{dQ}{dt} = \frac{Q}{\Delta t}$$

and for the continuously vented head space aerosols,

$$\frac{dQ}{dt} = exhaust\ flowrate\ *\ partition\ fraction$$

And for both release types,

$$\frac{dQ}{dt} * SOF = T$$

where

Q	=	amount of material released (L), see Table 1, 3, 5, and 7
Δt	=	duration of release (s)
dQ/dt	=	rate of material release (L/s)
SOF	=	sum-of-fraction multiplier for the specific receptor (s/L)
T	=	the cumulative sum-of-fractions

5.2 Q, AMOUNT OF MATERIAL RELEASED

See Tables 1, 3, 5, and 7 for a summary and Section 4 for details of the calculations.

5.3 PARTITION FRACTION

A partition fraction equal to 10^{-8}, corresponding to tanks in an "agitated" state is used to multiply the exhaust flow rate in order to derive an effective rate of aerosol material being continuously released downwind through an unfiltered pathway. The 296-P-16 ventilation system, however, will only be used to cool Tank 241-C-106 between sluicing campaigns so a partition fraction of 10^{-10} is assumed for the unfiltered release and high temperature events. The overpressure event is assumed to imply agitation of the tank contents so 10^{-8} partition fraction is assumed for this event. See Section 3.0 for the exhaust flow rates appropriate for each ventilation system.

5.4 RATE OF MATERIAL RELEASE, dQ/dt

For the radiological and toxicological consequences of material being continuously vented from the tank head space through an unfiltered pathway into the outside environment, the dQ/dt (L/s) is equal to the exhaust flow rate (L/s) times the partition fraction.

For the toxicological consequences of crushed HEPA material being released, dQ/dt is assumed to be equal to $Q/\Delta t$, where Δt = 120 seconds. The duration of the steam bump was calculated to be 2 minutes in WHC-SD-WM-CN-022, *Evaluation of Potential and Consequences of Steam Bump in High Heat Waste Tanks and Assessment and Validation of GOTH Computer Code.*

5.5 BREATHING RATE, R

The breathing rate for exposure durations $\leq$ 12 hours is assumed to be 3.3E-4 m^3/sec (the light activity breathing rate). For 24 hours or longer the 24 hour average breathing rate of 2.7E-4 m^3/sec is assumed. These values are consistent with WHC-SD-WM-SARR-016.

5.6 ATMOSPHERIC DISPERSION COEFFICIENT, χ/Q

The following atmospheric dispersion coefficients are used, consistent with the guidance given in WHC-SD-WM-SARR-016, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments.*

Receptor	Release Duration	χ/Q (s/m^3)	Basis
Onsite	$\leq$ 1 hour	3.41E-2	Table 4 of SARR-016
	12 hours	5.54E-3	Logarithmic Average (see p. 2-5 of SARR-016)
	1 year	4.03E-4	Table 9 of SARR-016 (Chronic Annual Release)
Offsite	$\leq$ 1 hour	2.83E-5	Table 5 of SARR-016
	24 hours	4.62E-6	Logarithmic Average (see p. 2-5 of SARR-016)
	1 year	1.24E-7	Table 9 of SARR-016 (Chronic Annual Release)

Table 1. Radiological and Toxicological Consequences for Airborne Releases of 90/10 Aerosols from the 241-A-702 Ventilation System.

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	6.63E-5	--	3.30E-4	3.41E-2	--	2.91E-5
Overpressure Instantaneous Release, Onsite	3.66E-2	--	3.30E-4	3.41E-2	--	1.61E-2
Continuous Unfiltered Release, 10 Minutes, Onsite	--	1.89E-5	3.30E-4	3.41E-2	6.00E+2	4.96E-3
Continuous Unfiltered Release, 12 Hours, Onsite	--	1.89E-5	3.30E-4	5.54E-3	4.32E+4	5.82E-2
High Temperature Instantaneous Release, Offsite	6.63E-5	--	3.30E-4	2.83E-5	--	2.41E-8
Overpressure Instantaneous Release, Offsite	3.66E-2	--	3.30E-4	2.83E-5	--	1.33E-5
Continuous Unfiltered Release, 10 Minutes, Offsite	--	1.89E-5	3.30E-4	2.83E-5	6.00E+2	4.12E-6
Continuous Unfiltered Release, 24 Hours, Offsite	--	1.89E-5	2.70E-4	4.62E-6	8.64E+4	7.93E-5
Toxicological						
Item	dQ/dt (L/s)	SOF	Item	dQ/dt (L/s)	SOF	
High Temp., Onsite	5.53E-7	7.19E-3	High Temp., Offsite	5.53E-7	9.95E-6	
Over Press., Onsite	3.05E-4	3.97E+0	Over Press., Offsite	3.05E-4	5.49E-3	
Continuous, Onsite	1.89E-5	2.46E-1	Continuous, Offsite	1.89E-5	3.40E-4	

Table 2. Summary Radiological and Toxicological Consequences for Airborne Releases of 90/10 Aerosols from the 241-A-702 Ventilation System. (Note: See attachment 7 for total doses including ingestion.)

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxic SOF
Onsite	High Temperature (Fire)	5.8E-2 (12 hr)	5.0E-3 (10 min)	2.5E-1
	Overpressure[1] (Steam Bump)	7.4E-2 (12 hr)[2]	2.1E-2 (10 min)[2]	4.2E+0[2]
	Filter Failure (Wetting)	5.8E-2 (12 hr)[3]	5.0E-3 (10 min)	2.5E-1
Offsite	High Temperature (Fire)	7.9E-5 (24 hr)	4.1E-6 (10 min)	3.5E-4
	Overpressure[1] (Steam Bump)	9.3E-5 (24 hr)[2]	1.7E-5 (10 min)[2]	5.8E-3[2]
	Filter Failure (Wetting)	7.9E-5 (24 hr)[3]	4.1E-6 (10 min)	3.4E-4

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

Table 3. Radiological and Toxicological Consequences for Airborne Releases of 90/10 Aerosols from the 241-AZ-702 Ventilation System.

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	2.32E-3	--	3.30E-4	3.41E-2	--	1.02E-3
Overpressure Instantaneous Release, Onsite	5.90E-3	--	3.30E-4	3.41E-2	--	2.59E-3
Continuous Unfiltered Release, 10 Minutes, Onsite	--	9.44E-6	3.30E-4	3.41E-2	6.00E+2	2.48E-3
Continuous Unfiltered Release, 12 Hours, Onsite	--	9.44E-6	3.30E-4	5.54E-3	4.32E+4	2.91E-2
High Temperature Instantaneous Release, Offsite	2.32E-3	--	3.30E-4	2.83E-5	--	8.45E-7
Overpressure Instantaneous Release, Offsite	5.90E-3	--	3.30E-4	2.83E-5	--	2.15E-6
Continuous Unfiltered Release, 10 Minutes, Offsite	--	9.44E-6	3.30E-4	2.83E-5	6.00E+2	2.06E-6
Continuous Unfiltered Release, 24 Hours, Offsite	--	9.44E-6	2.70E-4	4.62E-6	8.64E+4	3.97E-5
Toxicological						
Item	dQ/dt (L/s)	SOF	Item	dQ/dt (L/s)	SOF	
High Temp., Onsite	1.93E-5	2.51E-1	High Temp., Offsite	1.93E-5	3.48E-4	
Over Press., Onsite	4.92E-5	6.40E-1	Over Press., Offsite	4.92E-5	8.85E-4	
Continuous, Onsite	9.44E-6	1.23E-1	Continuous, Offsite	9.44E-6	1.70E-4	

Table 4. Summary Radiological and Toxicological Consequences for Airborne Releases of 90/10 Aerosols from the 241-AZ-702 Ventilation System. (Note: See attachment 7 for total doses including ingestion.)

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxicological SOF
Onsite	High Temperature (Fire)	3.0E-2 (12 hr)	3.5E-3 (10 min)	3.7E-1
	Overpressure[1] (Steam Bump)	3.2E-2 (12 hr)[2]	5.1E-3 (10 min)[2]	7.6E-1[2]
	Filter Failure (Wetting)	2.9E-2 (12 hr)[3]	2.5E-3 (10 min)	1.2E-1
Offsite	High Temperature (Fire)	4.1E-5 (24 hr)	2.9E-6 (10 min)	5.2E-4
	Overpressure[1] (Steam Bump)	4.2E-5 (24 hr)[2]	4.2E-6 (10 min)[2]	1.1E-3[2]
	Filter Failure (Wetting)	4.0E-5 (24 hr)[3]	2.1E-6 (10 min)	1.7E-4

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

Table 5. Radiological and Toxicological Consequences for Airborne Releases of 67/33 Aerosols from the 296-P-16 Ventilation System.

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	4.80E-5	--	3.30E-4	3.41E-2	--	6.48E-5
Overpressure Instantaneous Release, Onsite	1.98E-2	--	3.30E-4	3.41E-2	--	2.67E-2
Continuous Unfiltered Release, 10 Minutes, Onsite	--	3.30E-7	3.30E-4	3.41E-2	6.00E+2	2.67E-4
Continuous Unfiltered Release, 12 Hours, Onsite	--	3.30E-7	3.30E-4	5.54E-3	4.32E+4	3.14E-3
High Temperature Instantaneous Release, Offsite	4.80E-5	--	3.30E-4	2.83E-5	--	5.38E-8
Overpressure Instantaneous Release, Offsite	1.98E-2	--	3.30E-4	2.83E-5	--	2.22E-5
Continuous Unfiltered Release, 10 Minutes, Offsite	--	3.30E-7	3.30E-4	2.83E-5	6.00E+2	2.22E-7
Continuous Unfiltered Release, 24 Hours, Offsite	--	3.30E-7	2.70E-4	4.62E-6	8.64E+4	4.27E-6

Toxicological					
Item	dQ/dt (L/s)	SOF	Item	dQ/dt (L/s)	SOF
High Temp., Onsite	4.00E-7	7.60E-3	High Temp., Offsite	4.00E-7	1.60E-5
Over Press., Onsite	1.65E-4	3.14E+0	Over Press., Offsite	1.65E-4	6.60E-3
Continuous, Onsite	3.30E-7	6.27E-3	Continuous, Offsite	3.30E-7	1.32E-5

Table 6. Summary Radiological and Toxicological Consequences for Airborne Releases of 67/33 Aerosols from the 296-P-16 Ventilation System. (Note: See attachment 7 for total doses including ingestion.)

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxic SOF
Onsite	High Temperature (Fire)	3.2E-3 (12 hr)	3.3E-4 (10 min)	1.4E-2
	Overpressure[1] (Steam Bump)	3.4E-1 (12 hr)[2]	5.3E-2 (10 min)[2]	3.8E+0[2]
	Filter Failure (Wetting)	3.1E-3 (12 hr)[3]	2.7E-4 (10 min)	6.3E-3
Offsite	High Temperature (Fire)	4.3E-6 (24 hr)	2.8E-7 (10 min)	2.9E-5
	Overpressure[1] (Steam Bump)	4.5E-4 (24 hr)[2]	4.4E-5 (10 min)[2]	7.9E-3[2]
	Filter Failure (Wetting)	4.3E-6 (24 hr)[3]	2.2E-7 (10 min)	1.3E-5

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

Table 7. Radiological and Toxicological Consequences for Airborne Releases of 67/33 Aerosols from the 296-C-006 Ventilation System.

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	1.15E-3	--	3.30E-4	3.41E-2	--	1.55E-3
Overpressure Instantaneous Release, Onsite	1.91E-1	--	3.30E-4	3.41E-2	--	2.58E-1
Continuous Unfiltered Release, 10 Minutes, Onsite	--	1.70E-6	3.30E-4	3.41E-2	6.00E+2	1.38E-3
Continuous Unfiltered Release, 12 Hours, Onsite	--	1.70E-6	3.30E-4	5.54E-3	4.32E+4	1.61E-2
High Temperature Instantaneous Release, Offsite	1.15E-3	--	3.30E-4	2.83E-5	--	1.29E-6
Overpressure Instantaneous Release, Offsite	1.91E-1	--	3.30E-4	2.83E-5	--	2.14E-4
Continuous Unfiltered Release, 10 Minutes, Offsite	--	1.70E-6	3.30E-4	2.83E-5	6.00E+2	1.14E-6
Continuous Unfiltered Release, 24 Hours, Offsite	--	1.70E-6	2.70E-4	4.62E-6	8.64E+4	2.20E-5
Toxicological						
Item	dQ/dt (L/s)	SOF	Item	dQ/dt (L/s)	SOF	
High Temp., Onsite	9.58E-6	1.82E-1	High Temp., Offsite	9.58E-6	3.83E-4	
Over Press., Onsite	1.59E-3	3.02E+1	Over Press., Offsite	1.59E-3	6.37E-2	
Continuous, Onsite	1.70E-6	3.23E-2	Continuous, Offsite	1.70E-6	6.80E-5	

Table 8. Summary Radiological and Toxicological Consequences for Airborne Releases of 67/33 Aerosols from the 296-C-006 Ventilation System. (Note: See attachment 7 for total doses including ingestion.)

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxic SOF
Onsite	High Temperature (Fire)	1.8E-2 (12 hr)	2.9E-3 (10 min)	2.1E-1
	Overpressure[1] (Steam Bump)	2.7E-1 (12 hr)[2]	2.6E-1 (10 min)[2]	3.0E+1[2]
	Filter Failure (Wetting)	1.6E-2 (12 hr)[3]	1.4E-3 (10 min)	3.2E-2
Offsite	High Temperature (Fire)	2.3E-5 (24 hr)	2.4E-6 (10 min)	4.5E-4
	Overpressure[1] (Steam Bump)	2.4E-4 (24 hr)[2]	2.1E-4 (10 min)[2]	6.4E-2[2]
	Filter Failure (Wetting)	2.2E-5 (24 hr)[3]	1.1E-6 (10 min)	6.8E-5

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

6.0 REFERENCES

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WHC-SD-WM-SARR-016, 1996, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments*, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SARR-037, 1996, *Development of Radiological Concentration and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

PEER REVIEW CHECKLIST

Document Reviewed: CN-99 Rev. 1 Exclusive of Attachments
Author: David Himes
Date: August 7, 1998
Scope of Review: Entire CN-99 Rev. 1 Exclusive of Attachments

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] [ ] [X] REH 8/9/98	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.**

Brit E. Hey [signature] 8/9/98

Reviewer (Printed Name and Signature) Date

HEDOP REVIEW CHECKLIST

Document Reviewed: CN-99 Rev. 1 Exclusive of Attachments
Author: David Himes
Date: August 7, 1998
Scope of Review: Entire CN-99 Rev. 1 Exclusive of Attachments

YES	NO*	N/A		
[X]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[ ]	[ ]	[X]	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[ ]	[ ]	[X]	3.	HEDOP-approved code(s) were used.
[ ]	[ ]	[X]	4.	Receptor locations were selected according to HEDOP recommendations.
[X]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[X]	[ ]	[ ]	6.	Hanford site data were used.
[X]	[ ]	[ ]	7.	Model adjustments external to the computer program were justified and performed correctly.
[ ]	[ ]	[X]	8.	The analysis is consistent with HEDOP recommendations.
[ ]		[X]	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.)
[X]	[ ]		**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.

Brit E. Hey [signature] 8/9/98 HEDOP-Approved
Reviewer (Printed Name and Signature) Date

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

ATTACHMENT 1
CALCULATIONS OF EXPOSURE RATE PER LITER OF CHARACTERIZED WASTE ACTIVITY FOR THE 296-P-16, 241-A-702, AND 296-C-006 FILTER ASSEMBLIES

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Calculations of Exposure Rate per liter of Characterized Waste Activity for the 296-P-16, 241-A-702, and 296-C-006 Filter Assemblies

Robert H. Ruben
Fluor Daniel Northwest

1.0 Purpose

This analysis considers the exposure rate per liter of activity on HEPA filter assemblies for the 296-P-16, 241-A-702, and 296-C-006 systems.

2.0 Methodology

The exposure rates for all HEPA assemblies were calculated utilizing the computer program, Microshield 4 (Grove 1992). Bremsstrahlung was not considered in any of the cases in this analysis. Its significance is small, since heavy shielding is not used, and therefore there is no incidence of "beam hardening". Also, not considering bremsstrahlung, for purposes of this document, is a conservative assumption.

The general approach to the calculations was to first calculate the dose with already characterized waste. Only isotopes present in significant activities were considered.

For the filter assemblies, configuration, materials, and geometry were obtained from the facility, and from vendor information. Where no information was available, conservative assumptions were made.

3.0 Calculations

3.1 The 296-P-16 HEPA Assembly

The 296-P-16 HEPA assembly was modeled as two rectangular solids each composed of a 3 x 3 array of HEPAs (Figure 1), as in Calcnote 033 (Savino 1996). Each HEPA has dimensions of 60.96 cm (2 ft.) L x 60.96 cm (2 ft.) H x 30.48 cm (1 ft.) W. There is an array of prefilters on the upstream side of the assembly, with dimensions of 60.96 cm (2 ft.) L x 60.96 cm (2 ft.) H x 6.34 cm (2.5 in.) W, but for the sake of model symmetry, and because the prefilters do not contribute significantly to the exposure, it is considered to be part of the first filter array and effectively ignored. The aluminum panel was modeled as an aluminum shield of 0.2 cm (0.08 in.) thickness. Composition of the filter material was the same as described in Savino (1996). This consisted of a combination of aluminum (density of 0.03 g/cm^3), and glass (density of 0.02 g/cm^3).

The characterized waste used was mitigated 67/33 waste, as described in Section 4.2 of the main document. The 1.0 L load of waste was assumed to be uniformly distributed between the two filter arrays. The model is symmetric between the two filter arrays, so a full 1L load on one of the arrays will give the same exposure rate as an even distribution between the two arrays.

The exposure rate meter is placed between the two filter arrays, at the base of the assembly, and 30.48 cm (1 ft.) from the downstream (i.e. inner) surface of the first filter array. The exposure measurement point was 15.24 cm (6 in.) from the side of the HEPA assembly, measured from the HEPA face (see Figure 1). The dose point location is based on assumptions using estimated data provided by facility operations.

The results of this calculation are:

1 L of waste, distributed uniformly between the two filter arrays will give an exposure rate of 636 mR/hr in air.

3.2 The 296-C-006 HEPA Assembly

For the purpose of exposure calculation, the 296-C-006 HEPA assembly was modeled as a single HEPA, a rectangular solid. Although there are two HEPAs in the assembly, the exposure measurement is taken separately for each of the HEPAs. It is assumed that the contribution to exposure from the other HEPA in the assembly will not be significant. The dimensions of this solid are 60.96 cm (24 in.) L x 60.96 cm (24 in.) H x 30.48 cm (12 in.) W. The covering was modeled as an aluminum shield of 0.2 cm (0.08 in.) thickness. The filter material was modeled the same as in Savino (1996). The characterized waste used was mitigated 67/33 waste. The exposure rate meter was placed at the side of the filter, at its base, and midway along the width. The point of measurement was estimated at 15.24 cm (6 in.) from the HEPA (see Figure 2.)

The results of this calculation are:

1 L of waste will give an exposure rate of 4282 mR/hr in air.

3.3 The 241-A-702 HEPA Assembly

The 241-A-702 HEPA assembly was modeled the same as the 296-C-006 assembly (see Figure 3), except that 90/10 mitigated waste was used as a source term.

The results of this calculation are:

1 L of waste will give an exposure rate of 3933 mR/hr in air.

4.0 References

Grove, 1992, *Microshield Version 4 User's Manual*, Grove 92-2, Groves Engineering. Inc., Rockville, Maryland.

Savino, A. V., 1996, *MICROSHIELD Dose Rate Calculations for HEPA Filters and Prefilters*, WHC-SD-WM-CN-033, Rev.0, Westinghouse Hanford Company, Richland, Washington.

Figure 1. 296-P-16 HEPA

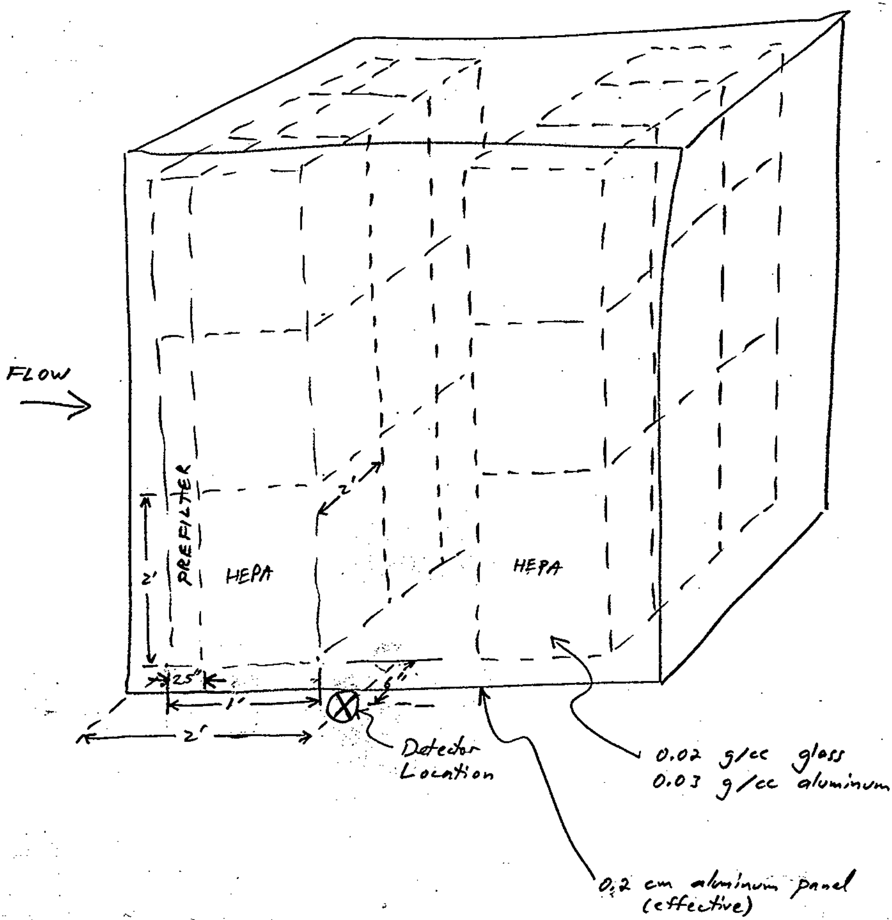


Figure 2. 296-C-006 HEPA

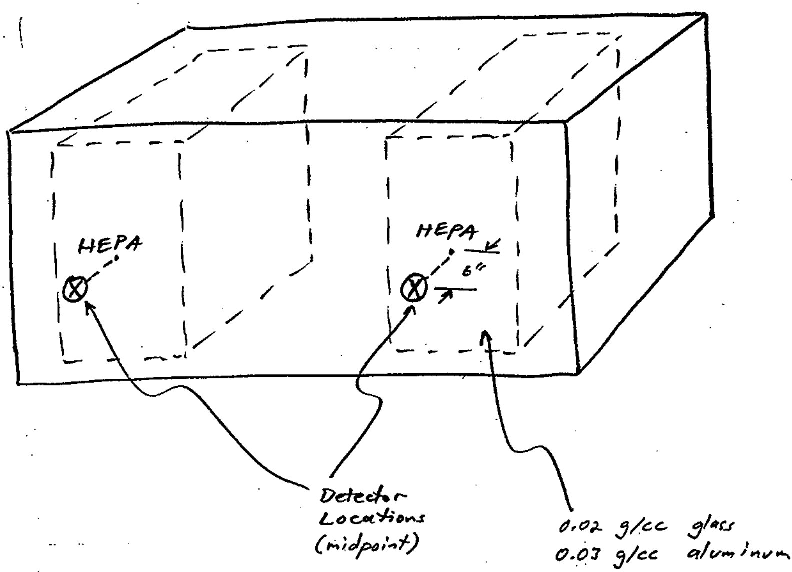
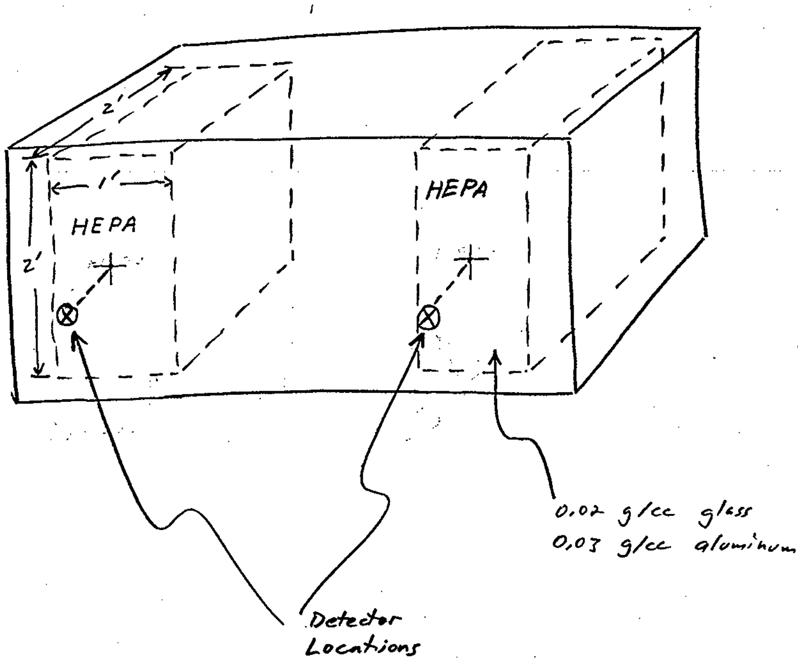


Figure 3. 241-A-702 HEPA



MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page	: 1	File Ref:	________
DOS File:	P16M.MS4	Date:	__/__/__
Run Date:	July 23, 1998	By:	________
Run Time:	11:20 a.m. Thursday	Checked:	________
Duration:	0:00:16		

Case Title: P-16 HEPA with 66/33 mitigated waste composition

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	198.12	6.0	6.0
Dose point coordinate Y:	60.96	2.0	.0
Dose point coordinate Z:	91.44	3.0	.0
Rectangular volume width :	182.88	6.0	.0
Rectangular volume length:	182.88	6.0	.0
Rectangular volume height:	30.48	1.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	15.0368	0.0	5.9

Source Volume: 1.01941e+6 cm^3 36 cu ft. 62208. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap	Immersion Shield
Air			0.00122	0.00122
Aluminum	0.03	2.702		
glass	0.02			

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	2.2400e+000	2.1974e+000	Co-60	3.8400e-003	3.7669e-003
Eu-154	6.0600e-002	5.9446e-002			

Page : 2
DOS File: P16M.MS4
Run Date: July 23, 1998
Run Time: 11:20 a.m. Thursday
Title : P-16 HEPA with 66/33 mitigated waste composition

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
0.1	9.073e+008	4.331e+002	7.083e+002	6.626e-001	1.084e+000
0.2	1.531e+008	1.607e+002	2.259e+002	2.836e-001	3.987e-001
0.4	1.600e+007	3.587e+001	4.461e+001	6.989e-002	8.693e-002
0.5	4.855e+006	1.387e+001	1.672e+001	2.723e-002	3.281e-002
0.6	7.476e+010	2.603e+005	3.063e+005	5.082e+002	5.978e+002
0.8	8.744e+008	4.155e+003	4.740e+003	7.903e+000	9.015e+000
1.0	8.319e+008	5.025e+003	5.622e+003	9.262e+000	1.036e+001
1.5	1.017e+009	9.474e+003	1.029e+004	1.594e+001	1.732e+001
TOTAL:	7.856e+010	2.796e+005	3.279e+005	5.423e+002	6.361e+002

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page	: 1	File Ref:	________
DOS File:	702-A.MS4	Date:	__/__/__
Run Date:	July 28, 1998	By:	________
Run Time:	7:48 a.m. Tuesday	Checked:	________
Duration:	0:00:15		

Case Title: 702-A HEPA with 90/10 mitigated composition

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	76.2	2.0	6.0
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	15.0368	0.0	5.9

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	2.1400e+000	1.8893e+001	Co-60	1.1900e-003	1.0506e-002
Eu-154	2.2800e-002	2.0129e-001			

Page : 2
DOS File: 702-A.MS4
Run Date: July 28, 1998
Run Time: 7:48 a.m. Tuesday
Title : 702-A HEPA with 90/10 mitigated composition

============================== 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
0.1	3.414e+008	1.228e+003	1.731e+003	1.879e+000	2.649e+000
0.2	5.761e+007	4.424e+002	5.585e+002	7.808e-001	9.858e-001
0.4	6.019e+006	9.671e+001	1.122e+002	1.884e-001	2.187e-001
0.5	1.827e+006	3.718e+001	4.221e+001	7.298e-002	8.286e-002
0.6	7.131e+010	1.760e+006	1.966e+006	3.436e+003	3.838e+003
0.8	3.290e+008	1.100e+004	1.203e+004	2.092e+001	2.288e+001
1.0	3.036e+008	1.283e+004	1.385e+004	2.365e+001	2.553e+001
1.5	3.732e+008	2.412e+004	2.552e+004	4.058e+001	4.294e+001
TOTAL:	7.273e+010	1.810e+006	2.020e+006	3.524e+003	3.933e+003

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1
DOS File: C006M.MS4
Run Date: July 23, 1998
Run Time: 10:35 a.m. Thursday
Duration: 0:00:15

File Ref: ________
Date: ___/___/___
By: ________
Checked: ________

Case Title: C-106 HEPA with 67/33 mitigated composition

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	76.2	2.0	6.0
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	15.0368	0.0	5.9

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	2.2400e+000	1.9776e+001	Co-60	3.8400e-003	3.3902e-002
Eu-154	6.0600e-002	5.3502e-001			

Page : 2
DOS File: C006M.MS4
Run Date: July 23, 1998
Run Time: 10:35 a.m. Thursday
Title : C-106 HEPA with 67/33 mitigated composition

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
0.1	9.073e+008	3.264e+003	4.602e+003	4.994e+000	7.041e+000
0.2	1.531e+008	1.176e+003	1.484e+003	2.075e+000	2.620e+000
0.4	1.600e+007	2.571e+002	2.983e+002	5.009e-001	5.812e-001
0.5	4.855e+006	9.883e+001	1.122e+002	1.940e-001	2.202e-001
0.6	7.476e+010	1.845e+006	2.061e+006	3.602e+003	4.023e+003
0.8	8.744e+008	2.923e+004	3.198e+004	5.561e+001	6.082e+001
1.0	8.319e+008	3.517e+004	3.796e+004	6.482e+001	6.997e+001
1.5	1.017e+009	6.572e+004	6.955e+004	1.106e+002	1.170e+002
TOTAL:	7.856e+010	1.980e+006	2.207e+006	3.841e+003	4.282e+003

CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW
DOCUMENT REVIEWED
NUMBER:______________________________
TITLE: Calculations of Exposure Rate per Liter of Characterized Waste Activity for the P-16, 702-A, and C-006 Filter Assemblies
AUTHOR(s): ~~R. F. Richard~~ Bob Rober

I. Method(s) of Review
- (X) Input data checked for accuracy
- ( ) Independent calculation performed
  - ( ) Hand calculation
  - ( ) Alternate computer code:______________
- ( ) Comparison to experiment or previous results
- ( ) Alternate method (define)_______________

II. Checklist (either check or enter NA if not applied)
- (X) Task completely defined
- (X) Activity consistent with task specification
- (X) Necessary assumptions explicitly stated and supported
- (X) Resources properly identified and referenced
- (X) Resource documentation appropriate for this application
- (X) Input data explicitly stated
- (X) Input data verified to be consistent with original source
- (X) Geometric model adequate representation of actual geometry
- (X) Material properties appropriate and reasonable
- (NA) Mathematical derivations checked including dimensional consistency
- (NA) Hand calculations checked for errors
- (X) Assumptions explicitly stated and justified
- (X) Computer software appropriate for task and used within range of validity
- (NA) Use of resource outside range of established validity is justified
- (X) Software runstreams correct and consistent with results
- (X) Software output consistent with input
- (NA) Results consistent with applicable previous experimental or analytical findings
- (X) Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
- (X) Conclusions consistent with analytical results and established limits
- (NA) Uncertainty assessment appropriate and reasonable
- ( ) Other (define)______________________

III. Comments:____

IV. REVIEWER: Robert F. Richard / Robert F. Richard DATE: 7/30/98

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ATTACHMENT 2
CALCULATIONS OF EXPOSURE RATE PER LITER OF CHARACTERIZED WASTE ACTIVITY FOR THE HEPA, HEGA, AND HEME IN THE 241-AZ-702 SYSTEM

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Calculations of Exposure Rate per liter of Characterized Waste Activity for the HEPA, HEGA, and HEME in the 241-AZ-702 System

Robert H. Ruben
Fluor Daniel Northwest

1.0 Purpose

One accident scenario to be considered is a blowout of one or more air filter assemblies, causing the release of airborne radioactivity. This analysis considers two such assemblies in the 702-AZ building, AZ-K1-10-1A and 1B, a HEPA/HEGA/HEPA filter train, and AZ-K1-9-1, a HEME. To consider the consequences of a filter blowout, it is necessary to estimate what the activity load is on the filter. One parameter needed to accomplish the estimation of activity load is the exposure rate per liter of activity on the filter assembly. This parameter is calculated for several combinations of waste characterizations and filter assemblies in this report.

2.0 Methodology

For AZ-K1-10-1A exposure calculations were done for one HEPA, and one HEGA, even though the filter train consists of one HEPA, then a HEGA, and finally another HEPA. Even though there will be some contribution from the contiguous filters, the conservative and bounding values for exposure will be obtained by considering a full liter of waste on a HEPA or a HEGA separately.

The calculations were done for the HEPA and HEGA utilizing the computer program, Microshield 4 (Grove 1992), and for the HEME using ISO-PC 1.98 (Rittmann 1995) , a PC version of ISOSHLD. Bremsstrahlung was not considered in any of the cases of this report. Its significance is small since heavy shielding is not used, and therefore there is no incidence of "beam hardening". Also, not considering bremsstrahlung, for purposes of this document, is a conservative assumption.

The general approach to the calculations was to first calculate the exposure with already characterized waste. Two characterizations were used, and for each, calculations were done for both the HEPA/HEGA filter train and the HEME, using one liter of the material as the source term. Only isotopes present in significant activities were considered.

For the filter assemblies, configuration, materials, and geometry were obtained from the facility, and from vendor information. Where no information was available, conservative assumptions were made. The approach to modeling the HEPA/HEGA filter train was to model each of a HEPA and a HEGA for exposure rate at contact. Each calculation used 1 L of waste for the source term. For the HEME, the approach was to model the exposure rate measured at an area monitor, the location of which was given by facility operations. In separate cases, calculations were also done for contact exposure rates on HEME.

For the purpose of this analysis, no physical or chemical assumptions are made about the source term or filter material, other than those that would impact the calculation of external exposure from an intact filter. Assumptions made regarding radioactive particle size are beyond the scope of this analysis.

3.0 Calculations

3.1 The AZ-K1-10-1A and 1B HEPA/HEGA Filter Train (see Figure 1).

Microshield 4 was used to do the calculations for the following two models.

3.1.1 HEPA Filter

The HEPA was modeled as a rectangular solid with dimensions of 60.96 cm (24 in.) L x 60.96 cm (24 in.) H x 30.48 cm (12 in) W. The aluminum covering was modeled as an aluminum shield of 0.2 cm (0.08 in.) thickness. Composition of the filter material was the same as in Savino (1996). This consisted of a combination of aluminum (density of 0.03 g/cm^3), and glass (density of 0.02 g/cm^3). In choosing a material in lieu of glass, concrete, which is a material in the Microshield 4 library, was chosen. It is essentially SiO_2, the same as glass. For the purposes of shielding calculations, especially at such low densities, there is little difference.

The exposure rate meter was placed at the side of the filter, at its base, and midway along the width. The front end of the meter was in contact with the shield wall, so the point of measurement was estimated at 15.24 cm (6 in.) from the shield wall (see Figure 2).

The results of these calculations are:

For 90/10 mitigated waste, 1 L of waste will give an exposure rate of 2799 mR/hr in air.

For 90/10 unmitigated waste, 1 L of waste will give an exposure rate of 3011 mR/hr in air.

3.1.2 HEGA Filter

The HEGA filter was also modeled as a rectangular solid, with dimensions coming from vendor data (Flanders). The dimensions of this solid are 60.96 cm (24 in.) L x 60.96 cm (24 in.) H x 40.64 cm (16 in.) W. The covering was modeled as an iron shield of 0.2 cm (0.08 in.) thickness.

The filter material was modeled based on vendor information and assumptions. Vendor data (Flanders) describes the inside of the filter as a series of V shaped beds composed of carbon on a steel mesh. Vendor data (Brown 1998) included the weight of the carbon in the filter, 85 lbs, and the characteristics of the mesh, 60 % free air (40 % steel). Assumptions made are that these V beds comprise 50% of the filter, and the rest of it is air.

To calculate the density of the carbon, the following equation was used:

$$D = (85 \text{ lbs.}) / (1.33 \text{ ft} \times 2 \text{ ft} \times 2 \text{ ft}) \times (3.531\text{E-05 ft}^3/\text{cm}^3) \times (453.5 \text{ g/lbs.}) = 0.256 \text{ g/cm}^3$$

To calculate the density of the steel, the following calculation was used:

$$D = (7.86 \text{ g/cm}^3)(0.40)(0.50) = 1.572 \text{ g/cm}^3$$

where 7.86 g/cm^3 is the nominal density of iron.

The exposure rate meter was placed at the side of the filter, at its base, and midway along the width. The front end of the meter was in contact with the shield wall, so the point of measurement was estimated at 15.24 cm (6 in.) from the shield wall (see Figure 3).

The results of these calculations are:

For 90/10 mitigated waste, 1 L of waste will give an exposure rate of 860 mR/hr in air.

For 90/10 unmitigated waste, 1 L of waste will give an exposure rate of 925 mR/hr in air.

3.2 The AZ-K1-9-1 HEME

ISO-PC 1.98 was used to do the calculations for this model. The dimensions of the shell of the HEME were based on information from a vendor file drawing, VI. 22525 Sup. Sheet. 3420 (see Figure 4). Though the shell of the HEME is a cylinder, it was modeled as a slab shield due to the limitations on the annular source model for ISO-PC. This was considered a 0.635 cm (0.25 in.) slab.

The filter was modeled as an annular source. The internal diameter of the annulus is 64.77 cm (25.5 in.), and the filter part of the annulus is encased in a 0.317 cm (0.125 in) thick cage made of steel. This is based on vendor information (Hause 1998). The internal diameter of the shell of the HEME, taken from the vendor file mentioned above, is 91.44 cm (36 in.). The height of the annulus is taken from the vendor file mentioned above and is 273.68 cm (107.75 in.).

The dimensions of the filter media ring were computed using the following equation:

Outer Radius-Inner Radius = (36 in./2 - 0.125 in) - (25.5 in./2 + 0.125 in.) = 5.0 in = 12.7 cm.

The filter media was assumed to be fiberglass. The density of the material was given by the vendor (Hause 1998), as 17 lbs/ft^3 which equates to 0.272 g/cm^3. In choosing a material in lieu of glass, concrete, which is a material in the ISO-PC library, was chosen.

Both source terms were modeled at the location of the area dosimeter, and at contact. The distance to the dosimeter was based on Drawing H-2-131104, which placed the dosimeter at 76.2 cm (30 in.) from the center of the HEME, and Drawing H-2-131106, which placed it at approximately at the top of the filter portion of the HEME (see Figure 5). The distance from the source was increased by 0.794 cm (0.312 in.) to account for a cover to the portal which houses the dosimeter. The thickness of the portal cover was added to the slab shield which represents the shell of the HEME. For the contact measurements, exposure rate meter was placed at the surface of the HEME, at the top of the annular filter see (Figure 4). The front end of the meter was in contact with the shield wall, so the point of measurement was estimated at 15.24 cm (6 in.) from the shield wall.

The results of these calculations are:

For 90/10 mitigated waste measured at the area meter, 1 L of waste will give an exposure rate of 1810 mR/hr in air.

For 90/10 unmitigated waste measured at the area meter, 1 L of waste will give an exposure rate of 1948 mR/hr in air.

For 90/10 mitigated waste measured at contact, 1 L of waste will give an exposure rate of 3423 mR/hr in air.

For 90/10 unmitigated waste measured at contact, 1 L of waste will give an exposure rate of 3681 mR/hr in air.

4.0 References

Grove, 1992, *Microshield Version 4 User's Manual*, Grove 92-2, Groves Engineering. Inc., Rockville, Maryland.

Rittmann, P.D., 1995, *ISO-PC Version 1.98 - User's Guide*, WHC-SD-UM-030 Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Savino, A.V., 1996, *MICROSHIELD Dose Rate Calculations for HEPA Filters and Prefilters*, WHC-SD-WM-CN-033, Westinghouse Hanford Company, Richland, Washington.

Flanders, *Flanders V-Bed Carbon Adsorbers*, Bulletin No. 894A

Brown, K., 1998, Telephone Conversation with Ken Brown, of Air Commodities, Inc., Seattle, Washington.

Hause, R., 1998, Fax to Jim Kriskovich, from Ray Hause of CECO Filters, Inc., Conshohocken, Pennsylvania, Ref. C246-09223.

Figure 1. 241-AZ-702 HEPA/HEGA/HEPA Train

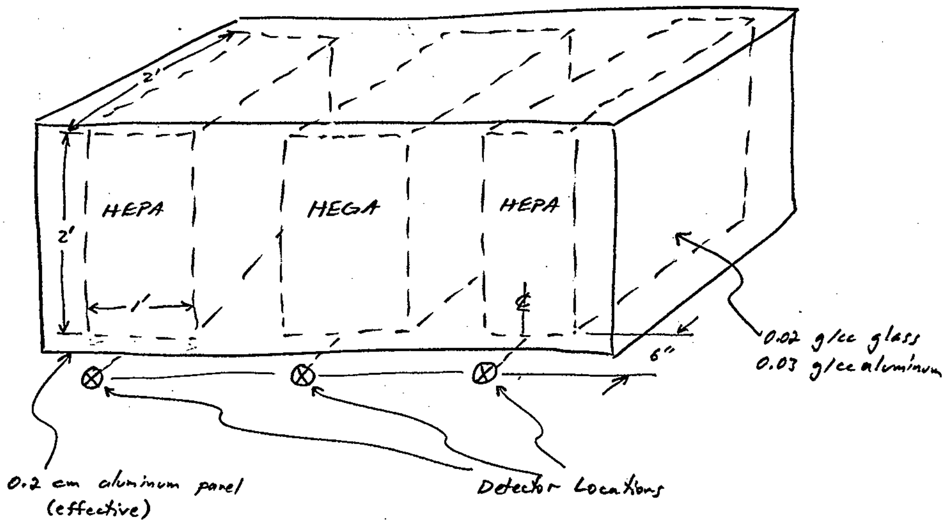


Figure 2. HEPA

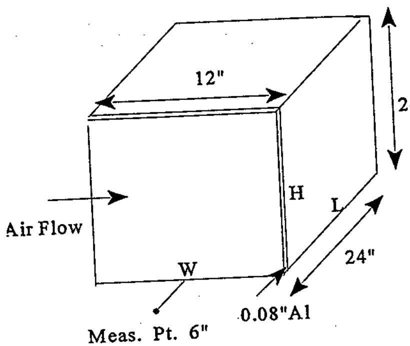


Figure 3. HEGA

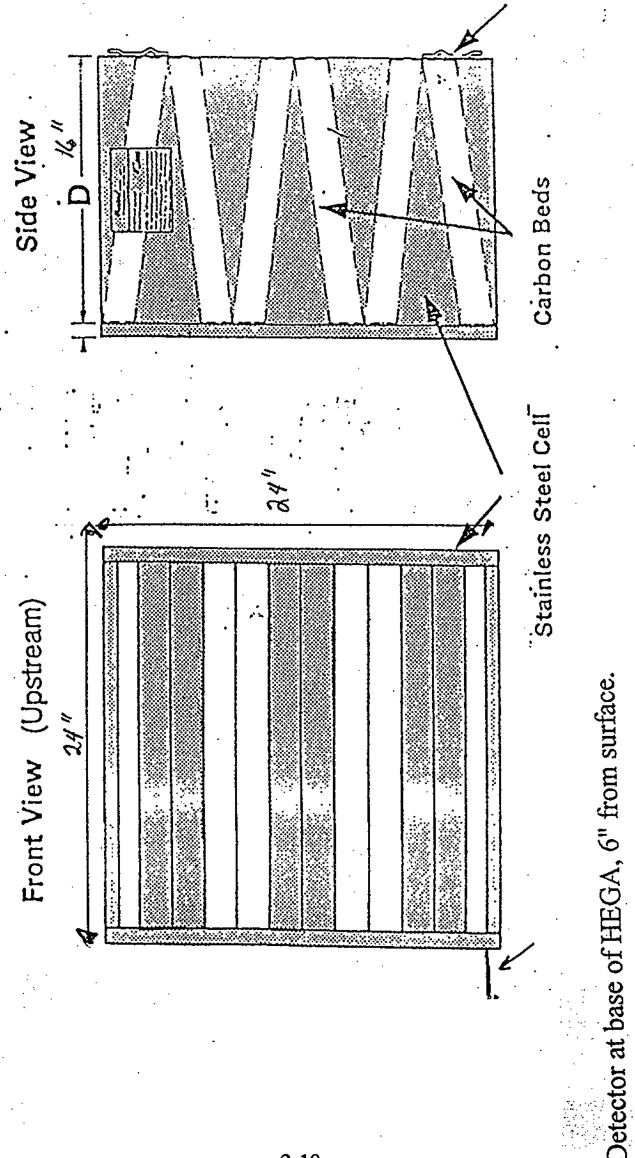
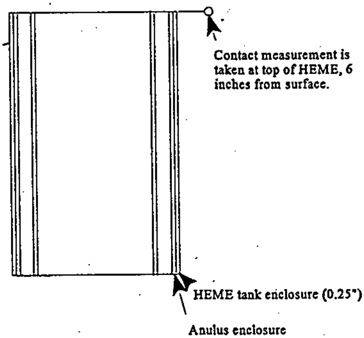


Figure 4. HEME



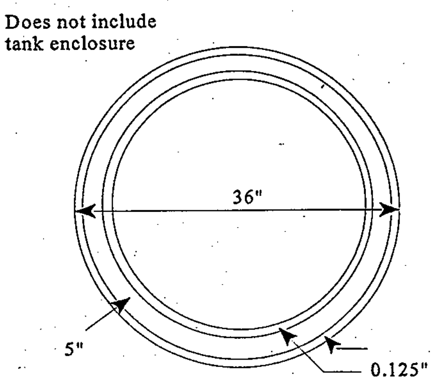
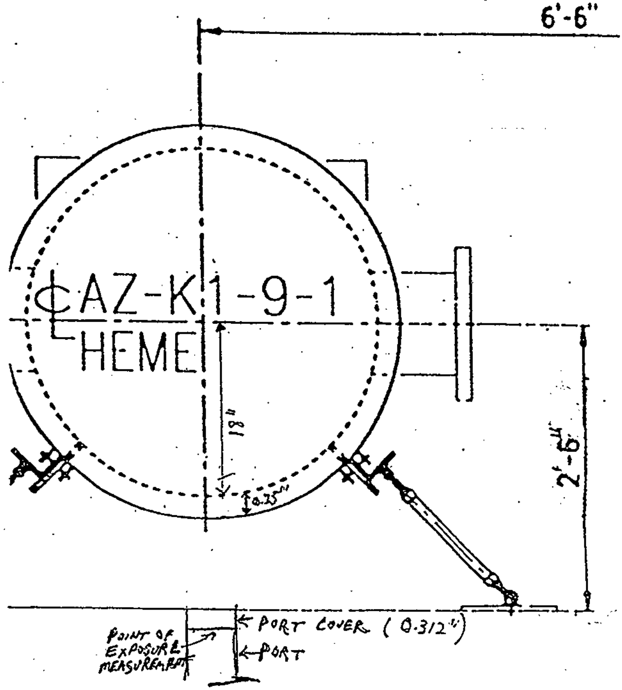


Figure 5. Exposure Measurement at Remote Dosimeter



MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1
DOS File: HEPA1.MS4
Run Date: July 22, 1998
Run Time: 3:38 p.m. Wednesday
Duration: 0:01:07

File Ref: ________
Date: ___/___/___
By: ________
Checked: ________

Case Title: HEPA Mitigated Waste

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	76.4	2.0	6.1
Dose point coordinate Y:	1.0e-001	0.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2	0.0	.1
Air Gap:	15.24	0.0	6.0

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.7	
Concrete	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	16
Y Direction	16
Z Direction	16

SOURCE NUCLIDES

Nuclide	curies	ÌCi/cm^3	Nuclide	curies	ÌCi/cm^3
Ba-137m	2.1400e+000	1.8893e+001	Co-60	1.1900e-003	1.0506e-002
Eu-154	2.2800e-002	2.0129e-001	Sr-90	4.8200e+000	4.2554e+001
Y-90	4.8200e+000	4.2554e+001			

```
Page     : 2
DOS File: HEPA1.MS4
Run Date: July 22, 1998
Run Time:  3:38 p.m. Wednesday
Title    : HEPA Mitigated Waste
```

============================== 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
0.1	3.414e+008	8.355e+002	1.251e+003	1.278e+000	1.914e+000
0.2	5.761e+007	3.052e+002	4.013e+002	5.387e-001	7.082e-001
0.4	6.019e+006	6.726e+001	8.007e+001	1.311e-001	1.560e-001
0.5	1.827e+006	2.592e+001	3.007e+001	5.087e-002	5.903e-002
0.6	7.131e+010	1.229e+006	1.400e+006	2.399e+003	2.732e+003
0.8	3.290e+008	7.701e+003	8.555e+003	1.465e+001	1.627e+001
1.0	3.036e+008	9.003e+003	9.847e+003	1.659e+001	1.815e+001
1.5	3.732e+008	1.698e+004	1.814e+004	2.856e+001	3.052e+001
TOTAL:	7.273e+010	1.264e+006	1.438e+006	2.461e+003	2.799e+003

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1
DOS File: HEPA2.MS4
Run Date: July 22, 1998
Run Time: 3:31 p.m. Wednesday
Duration: 0:01:07

File Ref: ________
Date: ___/___/___
By: ________
Checked: ________

Case Title: HEPA Unmitigated Waste

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	76.4	2.0	6.1
Dose point coordinate Y:	1.0e-001	0.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2	0.0	.1
Air Gap:	15.24	0.0	6.0

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.7	
Concrete	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	16
Y Direction	16
Z Direction	16

SOURCE NUCLIDES

Nuclide	curies	ÌCi/cm^3	Nuclide	curies	ÌCi/cm^3
Ba-137m	2.2900e+000	2.0218e+001	Co-60	1.3400e-003	1.1830e-002
Eu-154	2.9700e-002	2.6221e-001	Sr-90	7.9700e+000	7.0364e+001
Y-90	7.9700e+000	7.0364e+001			

Page : 2
DOS File: HEPA2.MS4
Run Date: July 22, 1998
Run Time: 3:31 p.m. Wednesday
Title : HEPA Unmitigated Waste

================================ 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
0.1	4.447e+008	1.088e+003	1.630e+003	1.665e+000	2.494e+000
0.2	7.505e+007	3.976e+002	5.227e+002	7.017e-001	9.225e-001
0.4	7.840e+006	8.762e+001	1.043e+002	1.707e-001	2.032e-001
0.5	2.379e+006	3.376e+001	3.918e+001	6.627e-002	7.690e-002
0.6	7.633e+010	1.316e+006	1.498e+006	2.568e+003	2.924e+003
0.8	4.285e+008	1.003e+004	1.114e+004	1.908e+001	2.120e+001
1.0	3.876e+008	1.150e+004	1.258e+004	2.119e+001	2.318e+001
1.5	4.784e+008	2.176e+004	2.325e+004	3.661e+001	3.912e+001
TOTAL:	7.815e+010	1.361e+006	1.547e+006	2.648e+003	3.011e+003

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page	: 1	File Ref:	________
DOS File:	HEGA1.MS4	Date:	__/__/__
Run Date:	July 22, 1998	By:	________
Run Time:	3:13 p.m. Wednesday	Checked:	________
Duration:	0:01:37		

Case Title: HEGA Mitigated Waste

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and	inches
Dose point coordinate X:	76.4	2.0	6.1
Dose point coordinate Y:	1.0e-001	0.0	.0
Dose point coordinate Z:	20.32	0.0	8.0
Rectangular volume width :	40.64	1.0	4.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2	0.0	.1
Air Gap:	15.24	0.0	6.0

Source Volume: 151023. cm^3 5.33333 cu ft. 9216 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Carbon	0.258		
Iron	1.572	7.86	

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	16
Y Direction	16
Z Direction	16

SOURCE NUCLIDES

Nuclide	curies	ÎCi/cm^3	Nuclide	curies	ÎCi/cm^3
Ba-137m	2.1400e+000	1.4170e+001	Co-60	1.1900e-003	7.8796e-003
Eu-154	2.2800e-002	1.5097e-001	Sr-90	4.8200e+000	3.1916e+001
Y-90	4.8200e+000	3.1916e+001			

Page : 2
DOS File: HEGA1.MS4
Run Date: July 22, 1998
Run Time: 3:13 p.m. Wednesday
Title : HEGA Mitigated Waste

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	3.414e+008	2.404e+001	3.710e+001	3.678e-002	5.677e-002
0.2	5.761e+007	2.879e+001	5.844e+001	5.081e-002	1.032e-001
0.4	6.019e+006	9.523e+000	2.068e+001	1.856e-002	4.030e-002
0.5	1.827e+006	4.044e+000	8.594e+000	7.937e-003	1.687e-002
0.6	7.131e+010	2.070e+005	4.279e+005	4.041e+002	8.352e+002
0.8	3.290e+008	1.463e+003	2.867e+003	2.782e+000	5.453e+000
1.0	3.036e+008	1.879e+003	3.519e+003	3.463e+000	6.486e+000
1.5	3.732e+008	4.198e+003	7.206e+003	7.062e+000	1.212e+001
TOTAL:	7.273e+010	2.146e+005	4.416e+005	4.175e+002	8.595e+002

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1
DOS File: HEGA2.MS4
Run Date: July 22, 1998
Run Time: 3:36 p.m. Wednesday
Duration: 0:01:40

File Ref: ________
Date: ___/___/___
By: ________
Checked: ________

Case Title: HEGA Unmitigated Waste

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	76.4	2.0	6.1
Dose point coordinate Y:	1.0e-001	0.0	.0
Dose point coordinate Z:	20.32	0.0	8.0
Rectangular volume width :	40.64	1.0	4.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2	0.0	.1
Air Gap:	15.24	0.0	6.0

Source Volume: 151023. cm^3 5.33333 cu ft. 9216 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Carbon	0.258		
Iron	1.572	7.86	

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	16
Y Direction	16
Z Direction	16

SOURCE NUCLIDES

Nuclide	curies	ìCi/cm^3	Nuclide	curies	ìCi/cm^3
Ba-137m	2.2900e+000	1.5163e+001	Co-60	1.3400e-003	8.8728e-003
Eu-154	2.9700e-002	1.9666e-001	Sr-90	7.9700e+000	5.2773e+001
Y-90	7.9700e+000	5.2773e+001			

```
Page     : 2
DOS File: HEGA2.MS4
Run Date: July 22, 1998
Run Time:  3:36 p.m. Wednesday
Title    : HEGA  Unmitigated Waste
```

================================ 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
0.1	4.447e+008	3.132e+001	4.833e+001	4.791e-002	7.394e-002
0.2	7.505e+007	3.750e+001	7.613e+001	6.618e-002	1.344e-001
0.4	7.840e+006	1.241e+001	2.694e+001	2.417e-002	5.250e-002
0.5	2.379e+006	5.267e+000	1.119e+001	1.034e-002	2.197e-002
0.6	7.633e+010	2.216e+005	4.580e+005	4.325e+002	8.939e+002
0.8	4.285e+008	1.905e+003	3.735e+003	3.624e+000	7.104e+000
1.0	3.876e+008	2.399e+003	4.493e+003	4.423e+000	8.282e+000
1.5	4.784e+008	5.380e+003	9.237e+003	9.052e+000	1.554e+001
TOTAL:	7.815e+010	2.314e+005	4.756e+005	4.498e+002	9.252e+002

Run started at 11:48:53 07/24/98

```
ISO-PC  Version 1.98          August 1994
originally ISOSHLD-II;  RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP    509-376-8715
Westinghouse Hanford Company       H6-30
PO Box 1970            Richland, WA  99352
```

Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production 2/14/96 PDR

Run Title: HEME

90/10 mitigated waste as source term measurement at dosimeter

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
CO- 60	1.19E-03	1.190E-03
SR- 90	4.82E+00	4.820E+00
Y - 90	4.82E+00	4.820E+00
BA-137M	2.14E+00	2.140E+00
EU-154	2.28E-02	2.280E-02

Gamma Only -- No Bremsstrahlung !

90/10 mitigated waste as source term measurement at dosimeter

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5	Shield 6
AIR	1.290E-03	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	2.720E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	0.000E+00	7.860E+00	0.000E+00	7.860E+00	0.000E+00
Totals:	1.290E-03	2.720E-01	7.860E+00	1.290E-03	7.860E+00	1.290E-03

90/10 mitigated waste as source term measurement at dosimeter

```
Source          Shields         Distance to Detector, X = 7.699E+01 cm
 Annular         Cyl. & Slab    Source Volume = 8.529E+05 cc
```

```
                                     Source Mass    = 2.320E+05 grams
 Source Length = 2.737E+02 cm        Distance Along Cylinder, Y = 2.737E+02 cm
 Integration Specs:    NTHETA = 71     NPSI = 71     DELR = 2.117E+00 cm
   Total Intervals:  3.025E+04    (photon source is the 2nd region)
 Shield Thickness: 3.238E+01, 1.270E+01, 3.180E-01, 1.000E+00, 1.429E+00, 2.884
 Distances from Dose Point to the Outside of
   (1) Source Region: 3.159E+01 cm    (2) Next Layer: 3.127E+01 cm
 Dose Buildup Data for Shield 5 with Effective Atomic Number 26.00
 Gamma Only -- No Bremsstrahlung !

        Exposure Rate - Photons in Air    : 1.810E-01 R/hr    = 1.297E-08 amp/kg
```

```
90/10 unmitigated waste as source term  measurement at dosimeter

Table of Source Activity:

        Scale Factor = 1.000E+00

     Isotope     Initial      Final
      Name       Values       Curies
     ------------------------------
     CO- 60     1.34E-03    1.340E-03
     SR- 90     7.97E+00    7.970E+00
     Y - 90     7.97E+00    7.970E+00
     BA-137M    2.29E+00    2.290E+00
     EU-154     2.97E-02    2.970E-02
     ------------------------------

    Gamma Only -- No Bremsstrahlung !
```

```
90/10 unmitigated waste as source term  measurement at dosimeter

Source                Shields        Distance to Detector, X = 7.699E+01 cm
 Annular               Cyl. & Slab   Source Volume = 8.529E+05 cc
                                     Source Mass    = 2.320E+05 grams
 Source Length = 2.737E+02 cm        Distance Along Cylinder, Y = 2.737E+02 cm
 Integration Specs:    NTHETA = 71     NPSI = 71     DELR = 2.117E+00 cm
   Total Intervals:  3.025E+04    (photon source is the 2nd region)
 Shield Thickness: 3.238E+01, 1.270E+01, 3.180E-01, 1.000E+00, 1.429E+00, 2.884
 Distances from Dose Point to the Outside of
   (1) Source Region: 3.159E+01 cm    (2) Next Layer: 3.127E+01 cm
 Dose Buildup Data for Shield 5 with Effective Atomic Number 26.00
 Gamma Only -- No Bremsstrahlung !

        Exposure Rate - Photons in Air    : 1.948E-01 R/hr    = 1.396E-08 amp/kg
```

```
90/10 unmitigated waste as source term  measurement at contact

Source                Shields        Distance to Detector, X = 6.160E+01 cm
 Annular               Cyl. & Slab   Source Volume = 8.529E+05 cc
                                     Source Mass    = 2.320E+05 grams
 Source Length = 2.737E+02 cm        Distance Along Cylinder, Y = 2.737E+02 cm
```

```
Integration Specs:   NTHETA = 71    NPSI = 71    DELR = 2.117E+00 cm
  Total Intervals:  3.025E+04   (photon source is the 2nd region)
Shield Thickness: 3.238E+01, 1.270E+01, 3.180E-01, 1.000E+00, 6.350E-01, 1.424
Distances from Dose Point to the Outside of
  (1) Source Region: 1.619E+01 cm   (2) Next Layer: 1.587E+01 cm
Dose Buildup Data for Shield 5 with Effective Atomic Number 26.00
Gamma Only -- No Bremsstrahlung !

      Exposure Rate - Photons in Air   : 3.681E-01 R/hr   = 2.638E-08 amp/kg
```

90/10 mitigated waste as source term measurement at contact

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
CO- 60	1.19E-03	1.190E-03
SR- 90	4.82E+00	4.820E+00
Y - 90	4.82E+00	4.820E+00
BA-137M	2.14E+00	2.140E+00
EU-154	2.28E-02	2.280E-02

Gamma Only -- No Bremsstrahlung !

90/10 mitigated waste as source term measurement at contact

```
Source              Shields          Distance to Detector, X = 6.160E+01 cm
 Annular             Cyl. & Slab     Source Volume = 8.529E+05 cc
                                     Source Mass   = 2.320E+05 grams
 Source Length = 2.737E+02 cm        Distance Along Cylinder, Y = 2.737E+02 cm
 Integration Specs:   NTHETA = 71    NPSI = 71    DELR = 2.117E+00 cm
   Total Intervals:  3.025E+04   (photon source is the 2nd region)
 Shield Thickness: 3.238E+01, 1.270E+01, 3.180E-01, 1.000E+00, 6.350E-01, 1.424
 Distances from Dose Point to the Outside of
   (1) Source Region: 1.619E+01 cm   (2) Next Layer: 1.587E+01 cm
 Dose Buildup Data for Shield 5 with Effective Atomic Number 26.00
 Gamma Only -- No Bremsstrahlung !

       Exposure Rate - Photons in Air   : 3.423E-01 R/hr   = 2.453E-08 amp/kg
```

Closing: End of cases

Finish run at 11:59:06 07/24/98
Input File (HEME.IN) is shown below:

```
0         2  HEME
90/10 mitigated waste as source term   measurement at dosimeter
 &Input
```

```
          Next =          1,
          IGEOM=         12,
          Ispec=          1,
          X=             76.994,
          T(1)=          32.385,
          T(2)=          12.7,
          T(3)=          .318,
          T(4)=          1
          T(5)=          1.429,
          Y=             273.67,
          SLTH=          273.68,
          NSHLD=          5,
          NTHETA=        70,
          NPSI=          70,
          IPRNT=          1,
          DELR=           2,
          WEIGHT(336)=    2.14E+00,
          WEIGHT(472)=    1.19E-03,
          WEIGHT(415)=    2.28E-02,
          WEIGHT(82)=     4.82E+00,
          WEIGHT(84)=     4.82E+00 &
 iron    9                          7.86                    7.86
 air     3    .00129                          .00129
1glass  16                  .272
90/10 unmitigated waste as source term  measurement at dosimeter
 &Input Next = 4,
          WEIGHT(336)=    2.29E+00,
          WEIGHT(472)=    1.34E-03,
          WEIGHT(415)=    2.97E-02,
          WEIGHT(82)=     7.97E+00,
          WEIGHT(84)=     7.97E+00 &
90/10 unmitigated waste as source term  measurement at contact
 &Input Next = 4,
          T(5) = .635,
          X = 61.595 &
90/10 mitigated waste as source term  measurement at contact
&Input Next = 4,
          WEIGHT(336)=    2.14E+00,
          WEIGHT(472)=    1.19E-03,
          WEIGHT(415)=    2.28E-02,
          WEIGHT(82)=     4.82E+00,
          WEIGHT(84)=     4.82E+00 &
End of cases
  &INPUT NEXT=6 &
```

CHECKLIST FOR PEER REVIEW

Document Reviewed: Calculations of Dose Rate per liter of Characterized Waste Activity with Several Filter Assemblies

Scope of Review: Full report

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 applicable guides or other standards.
[ ]		[X]*	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]	**Document approved.**

Joseph V Nelson Jr *Joseph V Nelson Jr* — 7/24/98
Reviewer (Printed Name and Signature) — 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.

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ATTACHMENT 3
RADIOACTIVE SOURCE INVENTORY DETERMINATION FOR THE 296-P-16 DE-ENTRAINER

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RADIOACTIVE SOURCE INVENTORY DETERMINATION FOR THE 296-P-16 DE-ENTRAINER

Karl Hillesland
Fluor Daniel Northwest, Inc.

1.0 PURPOSE

The radioactive contents of the 296-P-16 de-entrainer must be determined to evaluate the consequence of an over pressurization of the 296-P-16 ventilation system releasing radioactive materials to the atmosphere. This report provides conversion factors to estimate source inventory from exposure rate measurements. Both 67/33 unmitigated and 67/33 mitigated source terms as described in Sections 4.2.7 and 4.2.9 respectively of this calculation note are considered.

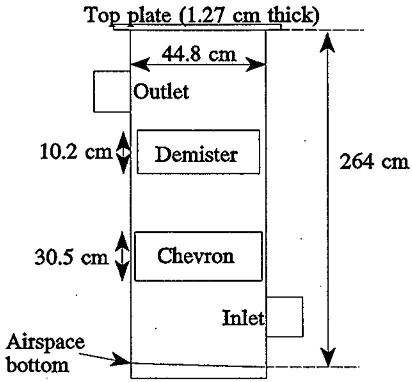
2.0 METHODOLOGY

The source per unit gamma exposure rate is calculated using ISO-PC Version 1.98 (Rittman 1996) for both the 67/33 unmitigated and 67/33 mitigated source terms. This information can then be used to estimate the amount of material in the de-entrainer based on exposure rate measurements.

3.0 ASSUMPTIONS

The 296-P-16 de-entrainer is contained in a cylindrical vessel partially buried in a caisson filled with soil. Air enters the de-entrainer near the bottom, and passes through a chevron (part 9 on drawing H-2-93928 and SK-2-57897) and demister pad (part 18 on drawing H-2-93929 and SK-2-57898) before exiting the de-entrainer near the top of the vessel. Exposure rates are assumed to be measured at contact at the top of the vessel, which has a 1.27 cm (1/2 in.) thick top plate (H-2-93929). Figure 1 is a sketch showing the de-entrainer.

Figure 1. Sketch of 296-P-16 De-entrainer



Most of the material would be expected to accumulate on the demister pad. However, some source material may be in the chevron or on the floor of the vessel. To conservatively bound photon absorption by the waste material, chevron, demister, and other metal parts in the deetrainer, the source is placed on the floor of the vessel such that both the chevron and demister pad provide shielding. The source is assumed to be either the 67/33 unmitigated or 67/33 mitigated source. Bremsstrahlung photons are not included in the calculation, which is conservative for this analysis. Therefore, ^{137}Cs (the parent of ^{137m}Ba) and ^{90}Sr, which are considered beta emitters only, are not included in the analysis.

The chevron is 30.5 cm (12.0 in.) thick (SK-2-57897). The demister pad is 10.2 cm (4 in.) thick (SK-2-57898). Both items are made from 304L SS. Vendor information on density was not available, so a density based on vendor information for similar parts in another de-entrainer was used. As the densities of the demister pads for the 241-A-702, K1-5-2A de-entrainer were found to be as high as 0.19 g/cm^3 (12 lb/ft^3) (CVI-21475), the density of the demister and chevron in the 296-P-16 de-entrainer are assumed to be 0.25 g/cm^3. The total equivalent shielding thickness would therefore be (30.5 cm + 10.2 cm) x (0.25 g/cm^3) / (8.0 g/cm^3) = 1.27 cm of full density (8.0 g/cm^3) steel. 304L SS is modeled as 8.0 g/cm^3 iron, which is a reasonable approximation for calculations of photon exposure rates.

The vessel inner diameter is 89.5 cm (35 1/4 in.) (H-2-93927). The distance from the bottom of the vessel interior to the top surface of the top plate is 265.4 cm (104.5 in.) (H-2-93927 for de-entrainer shell, H-2-93929 for top plate). The source is represented in the calculation by a disk with a diameter equal to the inner diameter of the vessel (89.5 cm).

The exposure rate reported is assumed to be the maximum measured at the top. The exposure rate is calculated at the radial center, even though there is piping in the center that would prevent this. However, at the distance considered, this represents a reasonable approximation for this analysis.

4.0 INPUT DATA

All input data are summarized in Table 1. The input files are included in the output file listings in Section 7.0.

Table 1. Input Data to ISO-PC

Input Parameter	Input Value	
ISO-PC geometry type	6 (Disc Source - Slab Shields)	
Source radius	44.75 cm	
Shield regions	2.54 cm iron @ 8.0 g/cm^3	
Distance from source to exposure receptor	265.43 cm	
Source	<u>Unmitigated</u> ^{137m}Ba 2.34 Ci ^{60}Co 4.38E-3 ^{154}Eu 9.8E-2 90Y 26.0	<u>Mitigated</u> ^{137m}Ba 2.24 Ci ^{60}Co 3.84E-3 ^{154}Eu 6.06E-2 90Y 15.54
Buildup factor	Iron region	

5.0 RESULTS

The exposure rate per liter of the 67/33 unmitigated source calculated by ISO-PC is 72 mR/hr/ℓ. The exposure rate per liter of 67/33 mitigated is 67 mR/hr/ℓ. The output files are included in Section 7.0.

6.0 REFERENCES

CVI-21475, *Mist Eliminators*, 1984, retained by Fluor Daniel Hanford, Inc., Richland, Washington.

H-2-93927, *De-entrainer Shell*, Rev. 1, 1985, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-93928, *De-entrainer Shell Assembly*, Rev. 1, 1985, Kaiser Engineers Hanford Company, Richland, Washington.

H-2-93929, *De-entrainer Cover Pl Assy*, Rev. 1, 1985, Kaiser Engineers Hanford Company, Richland, Washington.

Rittman, P. D., 1996, ISO-PC Version 2.1 is a revision of ISO-PC Version 1.98. Documentation of the revision is included with the Version 2.1 software package. ISO-PC Version 1.98 documentation is contained in *ISO-PC Version 1.98 - User's Guide*, WHC-SD-WM-UM-030, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

SK-2-57897, *Chevron Assy*, Rev. 0, 1984, Kaiser Engineers Hanford Company, Richland, Washington.

SK-2-57898, *Mist Eliminator Assy*, Rev. 0, 1984, Kaiser Engineers Hanford Company, Richland, Washington.

7.0 ISO-PC OUTPUT

7.1 ISO-PC Output for 67/33 Unmitigated Source

```
     Run started at 19:50:50  07/23/98

 ______________________________________________
|                                              |
|    ISO-PC  Version 1.98         August 1994  |
|    originally ISOSHLD-II;  RIBD was removed  |
|                                              |
|    Please send questions or comments to:     |
|    Paul D. Rittmann, PhD CHP   509-376-8715  |
|    Westinghouse Hanford Company       H6-30  |
|    PO Box 1970          Richland, WA  99352  |
|______________________________________________|

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production
2/14/96 PDR

Run Title:  P-16 De-entrainer, unmitigated source

Dose at top of cover plate.  Source at bottom.

Table of Source Activity:

        Scale Factor = 1.000E+00
```

```
Isotope     Initial      Final
 Name       Values       Curies
--------------------------------
CO- 60     4.38E-03    4.380E-03
Y - 90     1.55E+01    1.554E+01
BA-137M    2.34E+00    2.340E+00
EU-154     9.80E-02    9.800E-02
--------------------------------
```

Gamma Only -- No Bremsstrahlung !

Dose at top of cover plate. Source at bottom.

Shield Composition, g/cc

```
           Shield 1    Shield 2
--------------------------------
AIR        0.000E+00   1.290E-03
IRON       8.000E+00   0.000E+00
--------------------------------
 Totals:   8.000E+00   1.290E-03
--------------------------------
```

```
Dose at top of cover plate.  Source at bottom.

Source       Shields        Distance to Detector, X = 2.654E+02 cm
Disc          Slab          Source Radius = 4.475E+01 cm
                            Source Area   = 6.291E+03 sq.cm
Shield Thickness: 2.540E+00, 2.629E+02 cm
Distances from Dose Point to the Outside of
(1) Source Region: 2.654E+02 cm   (2) Next Layer: 2.629E+02 cm
Dose Buildup Data for Shield 1 with Effective Atomic Number 26.00
Gamma Only -- No Bremsstrahlung !

Exposure Rate - Photons in Air: 7.248E-02 R/hr = 5.194E-09 amp/kg


Closing:  &

Finish run at 19:50:51  07/23/98
Input File (P16UNMIT.IN) is shown below:

1          2P-16 De-entrainer, unmitigated source
Dose at top of cover plate.  Source at bottom.
 &INPUT NEXT=1, IGEOM=6, SLTH=44.75,
  NSHLD=1, JBUF=1, DUNIT=0,
  T(1)=2.54,
  X=265.43, ICONC=0, ISPEC=1,
     Weight(84)  = 15.54,
     Weight(336) = 2.34E+00,
     Weight(415) = 9.8E-02,
     Weight(472) = 4.38E-03,
 &
```

```
1IRON     9    8.0
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

7.2 ISO-PC Output for 67/33 Mitigated Source

```
     Run started at 19:50:42  07/23/98

    ISO-PC  Version 1.98          August 1994
    originally ISOSHLD-II;  RIBD was removed

    Please send questions or comments to:
    Paul D. Rittmann, PhD CHP   509-376-8715
    Westinghouse Hanford Company        H6-30
    PO Box 1970            Richland, WA  99352
```

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 2/14/96 PDR

Run Title: P-16 De-entrainer, mitigated source

Dose at top of cover plate. Source at bottom.

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
CO- 60	3.84E-03	3.840E-03
Y - 90	1.55E+01	1.554E+01
BA-137M	2.24E+00	2.240E+00
EU-154	6.08E-02	6.080E-02

Gamma Only -- No Bremsstrahlung !

Dose at top of cover plate. Source at bottom.

Shield Composition, g/cc

	Shield 1	Shield 2
AIR	0.000E+00	1.290E-03
IRON	8.000E+00	0.000E+00

```
  Totals:  8.000E+00  1.290E-03
 --------------------------------

Dose at top of cover plate.  Source at bottom.

Source      Shields       Distance to Detector, X = 2.654E+02 cm
Disc         Slab         Source Radius = 4.475E+01 cm
                          Source Area   = 6.291E+03 sq.cm
Shield Thickness: 2.540E+00, 2.629E+02 cm
Distances from Dose Point to the Outside of
(1) Source Region: 2.654E+02 cm   (2) Next Layer: 2.629E+02 cm
Dose Buildup Data for Shield 1 with Effective Atomic Number 26.00
  Gamma Only -- No Bremsstrahlung !

Exposure Rate - Photons in Air: 6.742E-02 R/hr = 4.832E-09 amp/kg

Closing:  &

Finish run at 19:50:44  07/23/98
Input File (P16MIT.IN) is shown below:

1          2P-16 De-entrainer, mitigated source
Dose at top of cover plate.  Source at bottom.
 &INPUT NEXT=1, IGEOM=6, SLTH=44.75,
  NSHLD=1, JBUF=1, DUNIT=0,
  T(1)=2.54,
  X=265.43, ICONC=0, ISPEC=1,
     Weight(84)  = 15.54,
     Weight(336) = 2.24E+00,
     Weight(415) = 6.08E-02,
     Weight(472) = 3.84E-03,
 &
1IRON    9    8.0
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

CHECKLIST FOR PEER REVIEW

Document Reviewed: Radioactive Source Inventory Determination for the 296-P-16 Deentrainer

Scope of Review: Full report

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 applicable guides or other standards.
[ ]		[X]*	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]	**Document approved.**

Joseph V. Nelson, Jr. *Joseph V. Nelson Jr.* — 7/24/98

Reviewer (Printed Name and Signature) — 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.

ATTACHMENT 4
CALCULATION OF DOSE RATES FOR THE HEMF AND HEME IN THE 296-C-006 VENTILATION SYSTEM OF TANK 241-C-106

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CALCULATION OF DOSE RATES FOR THE HEMF AND HEME IN THE 296-C-006 VENTILATION SYSTEM OF TANK 241-C-106

J. V. Nelson
Fluor Daniel Northwest, Inc.

1.0 Purpose

The 296-C-006 Ventilation system of Tank 241-C-106 includes a high efficiency metal filter (HEMF) and a high efficiency mist eliminator (HEME) in close proximity to each other. Located between the HEMF and HEME is an area radiation monitor (ARM). The purpose of the analysis described in this report was to compute the relationships between the dose rates at the ARM location and the amount of radioactive material held up in the HEME and HEMF. These relationships will be used to infer radionuclide inventories from ARM-measured or postulated worst-case exposure rates.

2.0 Methodology

Shielding calculations were carried out using the computer programs ISO-PC version 1.98 (Rittmann 1995). ISO-PC is based on the ISOSHLD-II code (Simmons et.al. 1967) that uses the point-kernel integration technique to compute gamma-ray attenuation. Bremsstrahlung was not accounted for in the ISO-PC calculations because the contribution was relatively small (about 7 %), and ignoring it in this case is conservative.

The shielding attenuation properties for the bulk materials used in the ISO-PC calculations were obtained from the ISO-PC 1.98 data library. Factors used to convert computed photon fluxes to exposure rates (R/hr) were the default fluence-to-dose conversion factors included in the ISO-PC data library.

3.0 Assumptions

The goal of this analysis was to determine the worst-case (minimum) ratios between exposure rates at the ARM location and radionuclide inventories trapped in the filters. To obtain these ratios, exposure rates at the ARM were assumed to be due to only one source - either the HEME or the HEMF.

Data needed to model the HEMF and HEME in ISO-PC were obtained or estimated from several sources. The location of the ARM relative to the HEMF and HEME were obtained from actual field measurements. Dimensions, materials and weights for the HEME were obtained from drawing A-1759. Dimensions, materials and weights for the HEMF were obtained from drawings D600920Q, D600920C and C102908C.

Both the HEME and HEMF are located in vessels that include annular regions around the filter housing. These regions are filled with steel shot to provide shielding. This shot was assumed to have a density of 8.03 g/cm^3 and a packing fraction of 0.55, as in a previous analysis (Peters 1994). The effective density of the shield is then: $8.03 \times 0.55 = 4.43$ g/cm^3. Full-density steel in other regions was assumed to be at 7.86 g/cm^3, the value suggested in the ISO-PC documentation.

The filter material in the HEME is annular in shape and could be modeled precisely in ISO-PC. However, the HEMF contains five cylindrical filter elements located 72° apart, as shown in Figure 3-1, that could not be modeled with ISO-PC. The filter elements were thus approximated as an annular region with a midpoint radius equal to the distance between the centerline of the filter vessel and the centerline of the filter elements, and a width that conserved total filter volume.

Other specific modeling assumptions are identified in Sections 4.2 and 4.3.

4.0 Input Data

4.1 Source Strength

Two source terms were used in this analysis. The first was an unmitigated 67/33 aerosol composition. The second was the mitigated 67/33 aerosol composition defined in Section 4.2 of the main document. These source terms, listed in Table 4-1, are specified in units of curies per liter of aerosol. Radionuclide inventories corresponding to one liter of source material were assigned to the source region in each model (HEME and HEMF). ^{137}Cs was not included in the source terms because it is not a photon emitter. However, ^{137}Cs was added to the source specifications in the ISO-PC input files so that the photon source from Bremsstrahlung could be computed if need be (even though it was not in the final calculations, as stated earlier). The ^{137}Cs activity for each source term was computed as the given ^{137m}Ba activity divided by 0.946.

4.2 Material Compositions

Material regions in the models contained air, filter media, structural steel and steel shot shielding. Steel was represented as iron in all cases. As given in section 3.0, structural steel was assigned a density of 7.86 g/cm^3 and the smear density of the steel shot was computed to be 4.43 g/cm^3. The air density was 0.0013 g/cm^3 in the ISO-PC models. Smear densities of materials in the HEMF and HEME were computed from weights and dimensions specified for the filters. The data used in the computations and results are shown in Table 4-2.

The filter media in the HEMF was specified in drawing D600920Q to be stainless steel, while the filter media in the HEME is fiberglass. It was assumed for calculational purposes that the HEME contains only fiberglass (i.e., structural materials in the filter were also assumed to be fiberglass). Fiberglass was represented in the ISO-PC models as ordinary concrete, because it appeared to be the most appropriate option available. These approximations had an insignificant effect on the computed dose rates because they are not sensitive to the filter composition - only its dimensions and total material density.

Figure 3-1. Plan View of Filter Elements in the HEMF

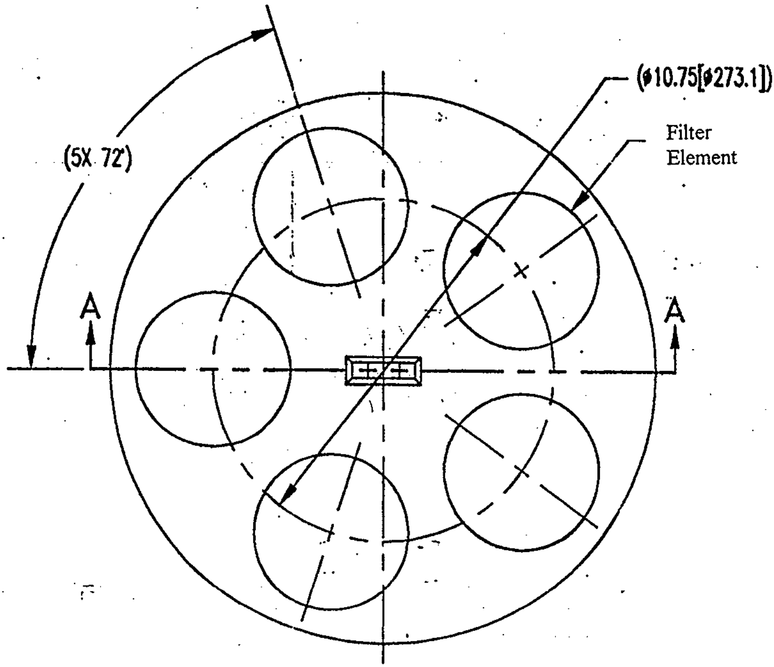


Table 4-1. Source Specification

Radionuclide	Activity (curies per liter of aerosol)	
	67/33 Mitigated Aerosol[a]	67/33 Unmitigated Aerosol[b]
Cs-137	2.37E-00	2.47E-00
Ba-137m	2.24E-00	2.34E-00
Co-60	3.84E-03	4.38E-03
Eu-154	6.06E-02	9.80E-02
Sr-90	1.55E+01	2.60E+01
Y-90	1.55E+01	2.60E+01

[a] Source from Section 4.2, except for Cs-137, which was computed from the Ba-137m activity.
[b] Source from Section 4.2, except for Cs-137, which was computed from the Ba-137m activity.

Table 4-2. HEME and HEMF Filter Specifications

Description	HEME		HEMF	
	Value	Data Source	Value	Data Source
No. of filter elements	1	drwg A-1759	5	drwg C102908C
Filter length, in. (cm)	60 (152.4)	drwg A-1759	35 (88.9)	drwg C102908C
Filter OD, in. (cm)	30 (76.2)	drwg A-1759	6 (15.2)	drwg C102908C
Filter ID, in. (cm)	26 (66.0)	drwg A-1759	0	assumed
Filter volume (total), L	173.0	computed	81.1	computed
Filter mass (total), lbs (kg)	340 (154.5)	drwg A-1759	200 (90.9)	drwg D600920Q
Filter density (g/cm^3)	0.89	computed	1.12	computed
Filter material	fiberglass	TWRS Project	steel	drwg D600920Q

4.3 Description of Calculational Models

As stated in Section 3.0, the HEME contains an annular filter, and the five cylindrical filter elements in the HEMF were approximated as an annulus (see Table 4-3). The geometry of the HEME and HEMF models is then generally similar. The ISO-PC model of the HEME is shown in Figure 4-1, and the model of the HEMF is shown in Figure 4-2. As indicated in these figures, the inner and outer walls of the of the annular space containing the steel shot were combined into one region, outboard of the steel shot region, because of limitations in ISO-PC. Also due to limitations in ISO-PC, the outer boundary of the steel shot shield is straight, not cylindrical, and the outer region simulating the steel walls is a slab, not an annulus (these deviations are not shown in Figures 4-1 and 4-2). The resulting errors in the computed dose rates was not evaluated, but should be small and are in the conservative direction.

The location of the ARM was measured to be 213 cm (7 ft) above the floor and horizontally 19.1 cm (7.5 in.) from the HEME and 30.5 cm (12 in.) from the HEMF. The bottom of the HEME was measured to be 61.0 cm (24 in.) above the floor, and the distance from the bottom of the HEME to the bottom of its filter was estimated from drawing A-1759 to be 92.7 cm (36.5 in.). Thus, the height of the ARM relative to the bottom of the filter is 59.7 cm (23.5 in.), compared to the 152.4 cm (60 in.) height of the filter.

The vertical distance from the floor to the bottom of the filter elements in the HEMF was estimated from drawing D600920Q to be 101.6 cm (40 in.). Thus, the distance from the bottom of the filter to the ARM elevation is 111.8 cm (44 in.), which is greater than the filter length of 88.9 cm (35 in.). Since, in ISO-PC, the dose point must lie within the extent of the source length, this case (the model illustrated in Figure 4-2) could not be computed directly. Instead, two other, very similar models were used to infer the results.

The first model had an extended filter height of 111.8 cm (44 in.), matching the height of the ARM above the bottom of the filter. The one-liter radionuclide inventories were increased by a factor of 111.8/88.9 (= 1.257 cm [0.5 in.]) to keep the source density constant at what it would be for the actual 88.9 cm (35 in.) long filters. Dose rates were then computed at the elevation of the filter top, and 30.5 cm (12 in.) radially from the edge of the HEMF.

The second model had a reduced filter height of 22.9 cm (9 in.)(i.e., 111.8 - 88.9 cm) with the one-liter radionuclide inventories reduced by a factor of 22.9/88.9 (= 0.257 cm [0.1 in.]), again to keep the source density constant. As with the first model, dose rates were computed at the elevation of the filter top, and radially 30.5 cm (12 in.) from the edge of the HEMF. The second model gives the dose rate contribution from the 22.9 cm (9 in.) source length added to the actual 88.9 cm source length in the first model. Thus, the difference in the results obtained using these two models gives the correct result for the actual source length.

Table 4-3. Annular Representation of HEMF Filter Elements

Description	Value	Data Source
Diameter of circle passing through centerlines of the 5 filter elements, cm (in.)	27.31 (10.75)	drwg C102908C
Volume of 5 filter elements, L	81.1	Table 4-2
Filter length, cm (in.)	88.9 (35)	drwg C102908C
Filter area, cm^2 (in^2)	912.3 (141.4)	computed
Width of equivalent annulus, cm (in.)	10.63 (4.2)	computed
Outer radius of filter annulus, cm (in.)	18.97 (7.5)	computed
Inner radius of filter annulus, cm (in.)	8.34 (3.3)	computed

5.0 Calculations

Input Files for the ISO-PC cases run are listed in the Appendix. All cases used the annular source geometry option in ISO-PC (IGEOM = 12). Two cases were run for the HEME, one with the 67/33 mitigated aerosol source (case ID = C6HEMEA), and the other with the 67/33 unmitigated aerosol source (case ID = C6HEMEB).

Four cases were run for the HEMF. These cases are identified, and the differences between them are characterized in Table 5-1. Two cases were required for each source because the elevation of the ARM was above the top of the HEMF filter elements. As discussed in Section 4.3, ISO-PC can compute dose rates at the side of a cylindrical model only within the axial extent of the source region. This complication did not exist for the HEME.

Table 5-1. Identification of ISO-PC Runs for the HEMF (Case IDs)

Source Term	Source Length	
	111.8 cm	22.9 cm
67/33 Mitigated	C6HEMF1A	C6HEMF2A
67/33 Unmitigated	C6HEMF1B	C6HEMF2B

Figure 4-1. Calculational Model of the HEME

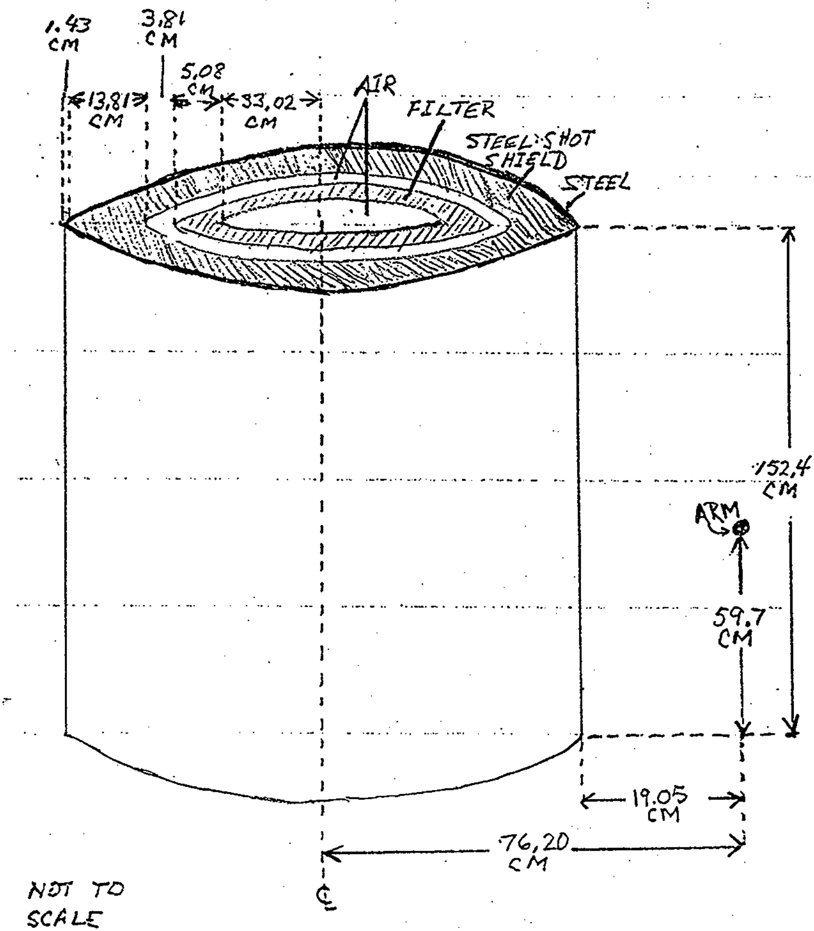
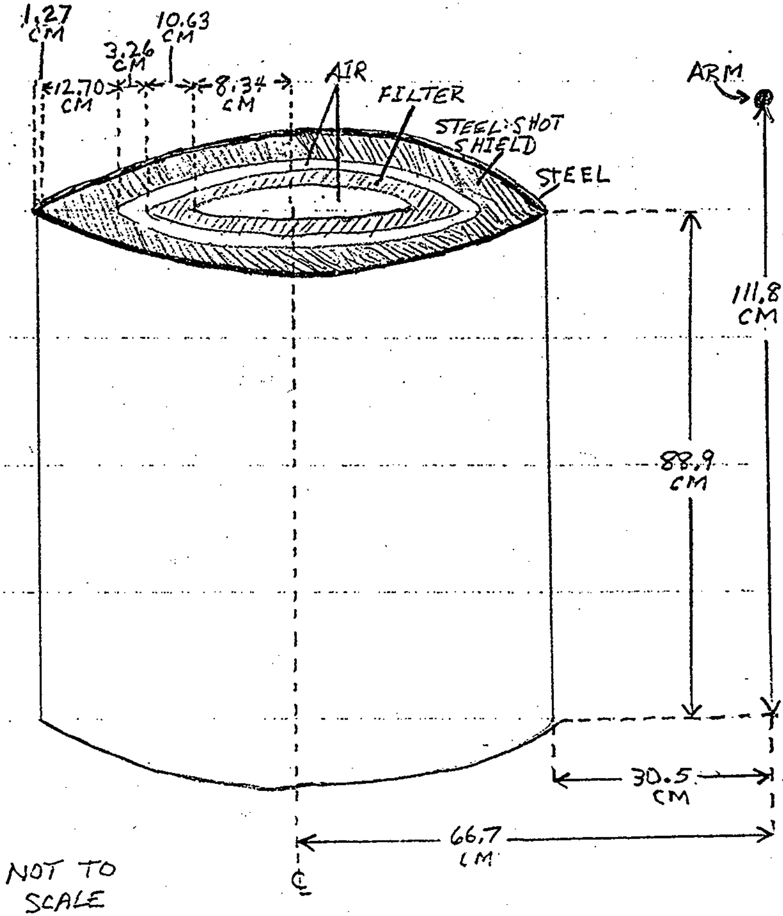


Figure 4-2. Calculational Model of the HEMF



6.0 Results and Conclusion

Output files for the six ISO-PC calculation made are listed in the appendix along with the input files. Results of the calculations for the HEME are summarized in Table 6-1, and results of the calculations for the HEMF are summarized in Table 6-2. These results are in units of exposure rate (mR/hr) per liter of aerosol (mitigated and unmitigated). For the HEMF, the difference between the two calculations for each source (listed in the right-hand column of Table 6-2) gives the result for the actual source (filter) length.

The reciprocal of the results in Tables 6-1 and 6-2 can be used as worst-case factors to convert dose rates measured by the ARM to liters of radioactive aerosol held up in the HEME or HEMF.

Table 6-1. Results of ISO-PC Calculations for the HEME

Source	Exposure Rate (mR/hr per liter of aerosol)
67/33 Mitigated	10.0
67/33 Unmitigated	11.1

Table 6-2. Results of ISO-PC Calculations for the HEMF

Source	Exposure Rate (mR/hr per liter of aerosol)		
	Model 1: source length = 111.8 cm	Model 2: source length =22.9 cm	Difference: source length = 88.9 cm
67/33 Mitigated	14.40	9.14	5.26
67/33 Unmitigated	16.03	10.13	5.90

7.0 References

Peters, G. J., 1994, *Individual Shielding Thickness for HEMF or HEME*, Calc. No. W320-33-006, Rev. 0, Kaiser Engineers Hanford, Richland, Washington.

Rittmann, P. D., 1995, *ISO-PC Version 1.98 - User's Guide*, WHC-SD-WM-UM-030, Rev 0, Westinghouse Hanford Company, Richland, Washington.

Simmons, G. L., et al., 1967, *ISOSHLD-II: Code Revision to Include Calculation of Dose Rate from Shielded Bremsstrahlung Sources*, BNWL-236 SUP1, Pacific Northwest Laboratories, Richland, Washington.

Drawing A-1759, Rev. 4, *High Efficiency Mist Eliminator*, CECO Filters, Inc., Conshohocken, Pennsylvania, August 1995.

Drawing C102908C, *Assembly, Tubesheet*, Pall Trinity Micro, Cortland, New York, October 1995.

Drawing D600920C, Rev. 3, *Assembly, Filter*, Pall Trinity Micro, Cortland, New York.

Drawing D600920Q, Rev. 2, *Assembly, Filter*, Pall Trinity Micro, Cortland, New York, April 1995.

APPENDIX

ISO-PC Input and Output Files

Input Files

C6HEMEA

```
0       2TNK C106 C006 HEME,MIT.SRC,NOBREM.,PF=0.55 #C6HEMEA
DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=152.4, Y=59.7, IPRNT=1,
 NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
 T(1)=29.21, T(2)=5.08, T(3)=3.81, T(4)=13.81, T(5)=1.43,
 X=76.2, ICONC=0, ISPEC=1,
    Weight(472) = 3.84E-03,
    Weight( 82) = 1.55E+01,
    Weight( 84) = 1.55E+01,
    Weight(335) = 2.37E+00,
    Weight(336) = 2.24E+00,
    Weight(415) = 6.06E-02,
 &
 AIR    3   0.0013          0.0013
 ORD.CON16          0.89
1IRON   9                         4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMEB

```
0       2TNK C106 C006 HEME,UNMIT.SRC,NOBREM.,PF=0.55#C6HEMEB
DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=152.4, Y=59.7, IPRNT=1,
 NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
 T(1)=29.21, T(2)=5.08, T(3)=3.81, T(4)=13.81, T(5)=1.43,
 X=76.2, ICONC=0, ISPEC=1,
    Weight(472) = 4.38E-03,
    Weight( 82) = 2.60E+01,
    Weight( 84) = 2.60E+01,
    Weight(335) = 2.47E+00,
    Weight(336) = 2.34E+00,
    Weight(415) = 9.80E-02,
 &
 AIR    3   0.0013          0.0013
 ORD.CON16          0.89
1IRON   9                         4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF1A

```
0       2TNK C106 C006 HEMF,MIT.SRC,NOBR. FILT. LEN. INCR. #C6HEMF1A
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=111.8, Y=111.8, IPRNT=1,
 NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
 T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
 X=66.7, ICONC=0, ISPEC=1, SFACT=1.257
    Weight(472) = 3.84E-03,
    Weight( 82) = 1.55E+01,
    Weight( 84) = 1.55E+01,
    Weight(335) = 2.37E+00,
    Weight(336) = 2.24E+00,
    Weight(415) = 6.06E-02,
 &
 AIR    3   0.0013          0.0013
1IRON   9          1.12           4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF1B

```
0       2TNK C106 C006 HEMF,UNMIT.SRC,NOBR. FILT. LEN. INCR. #C6HEMF1B
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=111.8, Y=111.8, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=1.257
    Weight(472) = 4.38E-03,
    Weight( 82) = 2.60E+01,
    Weight( 84) = 2.60E+01,
    Weight(335) = 2.47E+00,
    Weight(336) = 2.34E+00,
    Weight(415) = 9.80E-02,
 &
 AIR    3   0.0013          0.0013
1IRON   9           1.12            4.43    7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF2A

```
0       2TNK C106 C006 HEMF,MIT.SRC,NOBR. SHORT FILT. LEN. #C6HEMF2A
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP
 &INPUT NEXT=1, IGEOM=12, SLTH=22.9, Y=22.9, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=0.257
    Weight(472) = 3.84E-03,
    Weight( 82) = 1.55E+01,
    Weight( 84) = 1.55E+01,
    Weight(335) = 2.37E+00,
    Weight(336) = 2.24E+00,
    Weight(415) = 6.06E-02,
 &
 AIR    3   0.0013          0.0013
1IRON   9           1.12            4.43    7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF2B

```
0       2TNK C106 C006 HEMF,UNMIT.SRC,NOBR. SHORT FILT. LEN. #C6HEMF2B
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP
 &INPUT NEXT=1, IGEOM=12, SLTH=22.9, Y=22.9, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=0.257
    Weight(472) = 4.38E-03,
    Weight( 82) = 2.60E+01,
    Weight( 84) = 2.60E+01,
    Weight(335) = 2.47E+00,
    Weight(336) = 2.34E+00,
    Weight(415) = 9.80E-02,
 &
 AIR    3   0.0013          0.0013
1IRON   9           1.12            4.43    7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

Output Files

C6HEMEA

Run started at 18:24:13 07/23/98

```
 ________________________________________
|                                        |
| ISO-PC Version 1.98      August 1994   |
| originally ISOSHLD-II; RIBD was removed |
|                                        |
| Please send questions or comments to:  |
| Paul D. Rittmann, PhD CHP  509-376-8715 |
| Westinghouse Hanford Company     HO-36 |
| PO Box 1970       Richland, WA 99352   |
|________________________________________|
```

Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: TNK C106 C006 HEME,MIT.SRC,NOBREM.,PF=0.55 #C6HEMEA

DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
CO- 60	3.84E-03	3.840E-03
SR- 90	1.55E+01	1.550E+01
Y - 90	1.55E+01	1.550E+01
CS-137	2.37E+00	2.370E+00
BA-137M	2.24E+00	2.240E+00
EU-154	6.06E-02	6.060E-02

Gamma Only -- No Bremsstrahlung !

DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5	Shield 6
AIR	1.300E-03	0.000E+00	1.300E-03	0.000E+00	0.000E+00	1.290E-03
ORD CONC	0.000E+00	8.900E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	0.000E+00	0.000E+00	4.430E+00	7.860E+00	0.000E+00
Totals:	1.300E-03	8.900E-01	1.300E-03	4.430E+00	7.860E+00	1.290E-03

DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP

```
Source       Shields      Distance to Detector, X = 7.620E+01 cm
 Annular      Cyl. & Slab  Source Volume = 1.730E+05 cc
                           Source Mass   = 1.540E+05 grams
 Source Length = 1.524E+02 cm   Distance Along Cylinder, Y = 5.970E+01 cm
 Integration Specs:  NTHETA = 19   NPSI = 31   DELR = 1.016E+00 cm
  Total Intervals: 2.945E+03  (photon source is the 2nd region)
 Shield Thickness: 2.921E+01, 5.080E+00, 3.810E+00, 1.381E+01, 1.430E+00, 1.905E+01 cm
 Distances from Dose Point to the Outside of
  (1) Source Region: 3.810E+01 cm  (2) Next Layer: 3.429E+01 cm
```

Dose Buildup Data for Shield 4 with Effective Atomic Number 26.00
Gamma Only -- No Bremsstrahlung !

Exposure Rate - Photons in Air : 9.992E-03 R/hr = 7.161E-10 amp/kg

Closing: &

Finish run at 18:24:36 07/23/98
Input File (C6HEMEA.IN) is shown below:

```
0       2TNK C106 C006 HEME,MIT.SRC,NOBREM.,PF=0.55 #C6HEMEA
DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=152.4, Y=59.7, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=29.21, T(2)=5.08, T(3)=3.81, T(4)=13.81, T(5)=1.43,
  X=76.2, ICONC=0, ISPEC=1,
    Weight(472) = 3.84E-03,
    Weight( 82) = 1.55E+01,
    Weight( 84) = 1.55E+01,
    Weight(335) = 2.37E+00,
    Weight(336) = 2.24E+00,
    Weight(415) = 6.06E-02,
 &
 AIR    3   0.0013          0.0013
 ORD.CON16           0.89
1IRON   9                          4.43      7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMEB

Run started at 18:16:01 07/23/98

```
 ___________________________________________
|                                 |
|  ISO-PC  Version 1.98      August 1994  |
|  originally ISOSHLD-II;  RIBD was removed  |
|                                 |
|  Please send questions or comments to:   |
|  Paul D. Rittmann, PhD CHP   509-376-8715  |
|  Westinghouse Hanford Company     HO-36   |
|  PO Box 1970        Richland, WA  99352  |
|___________________________________________|
```

Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: TNK C106 C006 HEME,UNMIT.SRC,NOBREM.,PF=0.55 #C6HEMEB

DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
CO- 60	4.38E-03	4.380E-03
SR- 90	2.60E+01	2.600E+01
Y - 90	2.60E+01	2.600E+01
CS-137	2.47E+00	2.470E+00
BA-137M	2.34E+00	2.340E+00
EU-154	9.80E-02	9.800E-02

Gamma Only -- No Bremsstrahlung !

```
DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP

 Shield Composition, g/cc

        Shield 1  Shield 2  Shield 3  Shield 4  Shield 5  Shield 6
------------------------------------------------------------------------
AIR       1.300E-03 0.000E+00 1.300E-03 0.000E+00 0.000E+00 1.290E-03
ORD CONC  0.000E+00 8.900E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00
IRON      0.000E+00 0.000E+00 0.000E+00 4.430E+00 7.860E+00 0.000E+00
------------------------------------------------------------------------
 Totals:  1.300E-03 8.900E-01 1.300E-03 4.430E+00 7.860E+00 1.290E-03
------------------------------------------------------------------------


DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP

Source        Shields       Distance to Detector, X = 7.620E+01 cm
 Annular      Cyl. & Slab   Source Volume = 1.730E+05 cc
                            Source Mass   = 1.540E+05 grams
 Source Length = 1.524E+02 cm   Distance Along Cylinder, Y = 5.970E+01 cm
 Integration Specs:  NTHETA = 19   NPSI = 31   DELR = 1.016E+00 cm
  Total Intervals:  2.945E+03  (photon source is the 2nd region)
 Shield Thickness: 2.921E+01, 5.080E+00, 3.810E+00, 1.381E+01, 1.430E+00, 1.905E+01 cm
 Distances from Dose Point to the Outside of
  (1) Source Region: 3.810E+01 cm  (2) Next Layer: 3.429E+01 cm
 Dose Buildup Data for Shield 4 with Effective Atomic Number 26.00
 Gamma Only -- No Bremsstrahlung !

    Exposure Rate - Photons in Air  : 1.114E-02 R/hr  = 7.986E-10 amp/kg

Closing: &

Finish run at 18:16:24 07/23/98
Input File (C6HEMEB.IN) is shown below:

0       2TNK C106 C006 HEME,UNMIT.SRC,NOBREM.,PF=0.55#C6HEMEB
DOSE RATE AT AREA RAD MONITOR 19.1 CM FROM SIDE OF HEME, 59.7 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=152.4, Y=59.7, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=29.21, T(2)=5.08, T(3)=3.81, T(4)=13.81, T(5)=1.43,
  X=76.2, ICONC=0, ISPEC=1,
    Weight(472) = 4.38E-03,
    Weight( 82) = 2.60E+01,
    Weight( 84) = 2.60E+01,
    Weight(335) = 2.47E+00,
    Weight(336) = 2.34E+00,
    Weight(415) = 9.80E-02,
 &
 AIR    3   0.0013          0.0013
 ORD.CON16             0.89
1IRON    9                         4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF1A

```
   Run started at 19:05:12 07/23/98

 _________________________________________
|                                         |
|  ISO-PC  Version 1.98      August 1994  |
|  originally ISOSHLD-II;  RIBD was removed |
|                                         |
|  Please send questions or comments to:  |
|  Paul D. Rittmann, PhD CHP  509-376-8715 |
|  Westinghouse Hanford Company     HO-36 |
|  PO Box 1970        Richland, WA  99352 |
|_________________________________________|


Title Line from Library File (ISO-PC.LIB):
```

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: TNK C106 C006 HEMF,MIT.SRC,NOBR. FILT. LEN. INCR. #C6HEMF1A

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP

Table of Source Activity:

Scale Factor = 1.257E+00

Isotope Name	Initial Values	Final Curies
CO- 60	3.84E-03	4.827E-03
SR- 90	1.55E+01	1.948E+01
Y - 90	1.55E+01	1.948E+01
CS-137	2.37E+00	2.979E+00
BA-137M	2.24E+00	2.816E+00
EU-154	6.06E-02	7.617E-02

Gamma Only -- No Bremsstrahlung !

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5	Shield 6
AIR	1.300E-03	0.000E+00	1.300E-03	0.000E+00	0.000E+00	1.290E-03
IRON	0.000E+00	1.120E+00	0.000E+00	4.430E+00	7.860E+00	0.000E+00
Totals:	1.300E-03	1.120E+00	1.300E-03	4.430E+00	7.860E+00	1.290E-03

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP

```
Source        Shields       Distance to Detector, X = 6.670E+01 cm
 Annular        Cyl. & Slab  Source Volume = 1.020E+05 cc
                             Source Mass   = 1.142E+05 grams
 Source Length = 1.118E+02 cm   Distance Along Cylinder, Y = 1.118E+02 cm
 Integration Specs:  NTHETA = 19   NPSI = 31   DELR = 1.063E+00 cm
   Total Intervals: 5.890E+03  (photon source is the 2nd region)
 Shield Thickness: 5.080E+00, 1.063E+01, 3.260E+00, 1.270E+01, 1.270E+00, 3.050E+01 cm
 Distances from Dose Point to the Outside of
   (1) Source Region: 4.773E+01 cm  (2) Next Layer: 4.447E+01 cm
 Dose Buildup Data for Shield 4 with Effective Atomic Number 26.00
 Source Scale Factor was 1.257E+00
 Gamma Only -- No Bremsstrahlung !

       Exposure Rate - Photons in Air  : 1.440E-02 R/hr  = 1.032E-09 amp/kg
```

Closing: &

Finish run at 19:05:51 07/23/98
Input File (C6HEMF1A.IN) is shown below:

```
0       2TNK C106 C006 HEMF,MIT.SRC,NOBR. FILT. LEN. INCR. #C6HEMF1A
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=111.8, Y=111.8, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=1.257
```

```
   Weight(472) = 3.84E-03,
   Weight( 82) = 1.55E+01,
   Weight( 84) = 1.55E+01,
   Weight(335) = 2.37E+00,
   Weight(336) = 2.24E+00,
   Weight(415) = 6.06E-02,
&
AIR    3   0.0013          0.0013
1IRON   9          1.12          4.43     7.86
&
END OF RUN
&INPUT NEXT=6 & END
```

C6HEMF1B

Run started at 19:05:53 07/23/98

```
 _______________________________________________
|                                               |
| ISO-PC Version 1.98         August 1994       |
| originally ISOSHLD-II; RIBD was removed       |
|                                               |
| Please send questions or comments to:         |
| Paul D. Rittmann, PhD CHP   509-376-8715      |
| Westinghouse Hanford Company      HO-36       |
| PO Box 1970         Richland, WA  99352       |
|_______________________________________________|
```

Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: TNK C106 C006 HEMF,UNMIT.SRC,NOBR. FILT. LEN. INCR. #C6HEMF1B

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP

Table of Source Activity:

Scale Factor = 1.257E+00

Isotope Name	Initial Values	Final Curies
CO- 60	4.38E-03	5.506E-03
SR- 90	2.60E+01	3.268E+01
Y - 90	2.60E+01	3.268E+01
CS-137	2.47E+00	3.105E+00
BA-137M	2.34E+00	2.941E+00
EU-154	9.80E-02	1.232E-01

Gamma Only -- No Bremsstrahlung !

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5	Shield 6
AIR	1.300E-03	0.000E+00	1.300E-03	0.000E+00	0.000E+00	1.290E-03
IRON	0.000E+00	1.120E+00	0.000E+00	4.430E+00	7.860E+00	0.000E+00
Totals:	1.300E-03	1.120E+00	1.300E-03	4.430E+00	7.860E+00	1.290E-03

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP

```
Source          Shields       Distance to Detector, X = 6.670E+01 cm
 Annular          Cyl. & Slab  Source Volume = 1.020E+05 cc
                              Source Mass    = 1.142E+05 grams
 Source Length = 1.118E+02 cm   Distance Along Cylinder, Y = 1.118E+02 cm
 Integration Specs:  NTHETA = 19   NPSI = 31   DELR = 1.063E+00 cm
   Total Intervals: 5.890E+03  (photon source is the 2nd region)
 Shield Thickness: 5.080E+00, 1.063E+01, 3.260E+00, 1.270E+01, 1.270E+00, 3.050E+01 cm
 Distances from Dose Point to the Outside of
   (1) Source Region: 4.773E+01 cm   (2) Next Layer: 4.447E+01 cm
 Dose Buildup Data for Shield 4 with Effective Atomic Number 26.00
 Source Scale Factor was 1.257E+00
 Gamma Only -- No Bremsstrahlung !

       Exposure Rate - Photons in Air   : 1.603E-02 R/hr   = 1.149E-09 amp/kg

Closing:  &

Finish run at 19:06:33  07/23/98
Input File (C6HEMF1B.IN) is shown below:

0        2TNK C106 C006 HEMF,UNMIT.SRC,NOBR. FILT. LEN. INCR. #C6HEMF1B
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF, 111.8 CM UP
 &INPUT NEXT=1, IGEOM=12, SLTH=111.8, Y=111.8, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=1.257
    Weight(472) = 4.38E-03,
    Weight( 82) = 2.60E+01,
    Weight( 84) = 2.60E+01,
    Weight(335) = 2.47E+00,
    Weight(336) = 2.34E+00,
    Weight(415) = 9.80E-02,
 &
 AIR    3   0.0013            0.0013
1IRON   9             1.12               4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF2A

```
Run started at 19:06:35  07/23/98

 ________________________________________
|                                        |
|  ISO-PC  Version 1.98       August 1994  |
|  originally ISOSHLD-II;  RIBD was removed  |
|                                        |
|  Please send questions or comments to:    |
|  Paul D. Rittmann, PhD CHP   509-376-8715  |
|  Westinghouse Hanford Company      HO-36  |
|  PO Box 1970          Richland, WA  99352  |
|________________________________________|


Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production   7/6/94 PDR


Run Title:  TNK C106 C006 HEMF,MIT.SRC,NOBR. SHORT FILT. LEN. #C6HEMF2A


DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP

Table of Source Activity:

      Scale Factor = 2.570E-01

   Isotope   Initial   Final
    Name     Values    Curies
   ------------------------------
   CO- 60   3.84E-03  9.869E-04
   SR- 90   1.55E+01  3.984E+00
```

```
Y - 90    1.55E+01  3.984E+00
CS-137    2.37E+00  6.091E-01
BA-137M   2.24E+00  5.757E-01
EU-154    6.06E-02  1.557E-02
-----------------------------

Gamma Only -- No Bremsstrahlung !


DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP

 Shield Composition,  g/cc

        Shield 1  Shield 2  Shield 3  Shield 4  Shield 5  Shield 6
-------------------------------------------------------------------------
AIR      1.300E-03 0.000E+00 1.300E-03 0.000E+00 0.000E+00 1.290E-03
IRON     0.000E+00 1.120E+00 0.000E+00 4.430E+00 7.860E+00 0.000E+00
-------------------------------------------------------------------------
 Totals: 1.300E-03 1.120E+00 1.300E-03 4.430E+00 7.860E+00 1.290E-03
-------------------------------------------------------------------------

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP

Source        Shields       Distance to Detector, X = 6.670E+01 cm
 Annular       Cyl. & Slab   Source Volume = 2.089E+04 cc
                             Source Mass   = 2.339E+04 grams
 Source Length = 2.290E+01 cm   Distance Along Cylinder, Y = 2.290E+01 cm
 Integration Specs:  NTHETA = 19   NPSI = 31   DELR = 1.063E+00 cm
   Total Intervals:  5.890E+03  (photon source is the 2nd region)
 Shield Thickness: 5.080E+00, 1.063E+01, 3.260E+00, 1.270E+01, 1.270E+00, 3.050E+01 cm
 Distances from Dose Point to the Outside of
   (1) Source Region: 4.773E+01 cm   (2) Next Layer: 4.447E+01 cm
 Dose Buildup Data for Shield 4 with Effective Atomic Number 26.00
 Source Scale Factor was 2.570E-01
 Gamma Only -- No Bremsstrahlung !

      Exposure Rate - Photons in Air   : 9.141E-03 R/hr   = 6.551E-10 amp/kg

Closing: &

Finish run at 19:07:05 07/23/98
Input File (C6HEMF2A.IN) is shown below:

0       2TNK C106 C006 HEMF,MIT.SRC,NOBR. SHORT FILT. LEN. #C6HEMF2A
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP
 &INPUT NEXT=1, IGEOM=12, SLTH=22.9, Y=22.9, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=0.257
    Weight(472) = 3.84E-03,
    Weight( 82) = 1.55E+01,
    Weight( 84) = 1.55E+01,
    Weight(335) = 2.37E+00,
    Weight(336) = 2.24E+00,
    Weight(415) = 6.06E-02,
 &
 AIR    3   0.0013             0.0013
1IRON   9             1.12              4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

C6HEMF2B

Run started at 19:07:07 07/23/98

```
 ________________________________________________
|                                                |
| ISO-PC  Version 1.98          August 1994      |
| originally ISOSHLD-II;  RIBD was removed       |
|                                                |
| Please send questions or comments to:          |
| Paul D. Rittmann, PhD CHP   509-376-8715       |
| Westinghouse Hanford Company       HO-36       |
| PO Box 1970          Richland, WA  99352       |
|________________________________________________|
```

Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: TNK C106 C006 HEMF,UNMIT.SRC,NOBR. SHORT FILT. LEN. #C6HEMF2B

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP

Table of Source Activity:

Scale Factor = 2.570E-01

Isotope Name	Initial Values	Final Curies
CO- 60	4.38E-03	1.126E-03
SR- 90	2.60E+01	6.682E+00
Y - 90	2.60E+01	6.682E+00
CS-137	2.47E+00	6.348E-01
BA-137M	2.34E+00	6.014E-01
EU-154	9.80E-02	2.519E-02

Gamma Only -- No Bremsstrahlung !

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5	Shield 6
AIR	1.300E-03	0.000E+00	1.300E-03	0.000E+00	0.000E+00	1.290E-03
IRON	0.000E+00	1.120E+00	0.000E+00	4.430E+00	7.860E+00	0.000E+00
Totals:	1.300E-03	1.120E+00	1.300E-03	4.430E+00	7.860E+00	1.290E-03

DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP

```
Source       Shields      Distance to Detector, X = 6.670E+01 cm
 Annular      Cyl. & Slab  Source Volume = 2.089E+04 cc
                           Source Mass   = 2.339E+04 grams
 Source Length = 2.290E+01 cm   Distance Along Cylinder, Y = 2.290E+01 cm
 Integration Specs:  NTHETA = 19   NPSI = 31   DELR = 1.063E+00 cm
   Total Intervals:  5.890E+03  (photon source is the 2nd region)
 Shield Thickness: 5.080E+00, 1.063E+01, 3.260E+00, 1.270E+01, 1.270E+00, 3.050E+01 cm
 Distances from Dose Point to the Outside of
   (1) Source Region: 4.773E+01 cm   (2) Next Layer: 4.447E+01 cm
 Dose Buildup Data for Shield 4 with Effective Atomic Number 26.00
 Source Scale Factor was 2.570E-01
 Gamma Only -- No Bremsstrahlung !
```

Exposure Rate - Photons in Air : 1.013E-02 R/hr = 7.257E-10 amp/kg

Closing: &

Finish run at 19:07:37 07/23/98
Input File (C6HEMF2B.IN) is shown below:

```
0       .2TNK C106 C006 HEMF,UNMIT.SRC,NOBR. SHORT FILT. LEN. #C6HEMF2B
DOSE RATE AT AREA RAD MONITOR 30.5 CM FROM SIDE OF HEMF AT TOP
 &INPUT NEXT=1, IGEOM=12, SLTH=22.9, Y=22.9, IPRNT=1,
  NTHETA=19, NPSI=31, DELR=1, NSHLD=5, JBUF=4,
  T(1)=5.08, T(2)=10.63, T(3)=3.26, T(4)=12.70, T(5)=1.27,
  X=66.7, ICONC=0, ISPEC=1, SFACT=0.257
    Weight(472) = 4.38E-03,
    Weight( 82) = 2.60E+01,
    Weight( 84) = 2.60E+01,
    Weight(335) = 2.47E+00,
    Weight(336) = 2.34E+00,
    Weight(415) = 9.80E-02,
 &
 AIR    3   0.0013          0.0013
1IRON   9            1.12            4.43     7.86
 &
END OF RUN
 &INPUT NEXT=6 &  END
```

CHECKLIST FOR PEER REVIEW

Document Reviewed: Calculation of Dose Rates for the HEMF and HEME in the C-006 Ventilation System of Tank 241-C-106

Scope of Review: Full Report

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

Karl E. Hillesland   *Karl E Hillesland*   7/24/98
Reviewer (Printed Name and Signature)   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.

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ATTACHMENT 5

SUPPLEMENTAL CALCULATIONS TO HNF-SD-WM-CN-099 REV. 1

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Supplemental Calculations to HNF-SD-WM-CN-099 Rev. 1

B. E. Hey
Fluor Daniel Northwest, Inc.

Purpose

This attachment contains supplemental calculations to the main body of the calculation note to cover active ventilation system releases exhausting from TWRS underground waste tanks in the performance of their storage mission. Specifically, the calculations estimate bounding onsite and offsite radiological and toxicological consequences for the upset conditions of high temperature (i.e., fire in or around the ventilation system), over-pressure, and continuous unfiltered release. The ventilation systems and waste materials evaluated here are as follows:

1.241-A-702 ventilation system with AWF Liquid
HEPA inventory = 0.0492 L (ref. Attached MICROSHIELD)
De-entrainer inventory = 1.5 L (ref. CN-099 Rev. 1, Section 2)
Maximum exhaust flow rate = 1890 L/s
PF = 10^{-8}

2. 296-P-16 ventilation system with SST Solids
HEPA stage inventory = 0.146 L (ref. Attached MICROSHIELD)
De-entrainer inventory = 1.5 L (ref. CN-099 Rev. 1, Section 2)
Maximum exhaust flow rate = 3300 L/s
PF = 10^{-10}

3. 296-S-15 ventilation system with SST Solids
HEPA stage inventory = 0.146 L (ref. Attached MICROSHIELD)
Maximum exhaust flow rate = 3300 L/s
PF = 10^{-10}

The waste types of aging waste feed (AWF) liquid and single shell tank (SST) solids are characterized as follows:

AWF Liquid

Cs-137 = 8.8E+10 Bq/L (ref. SARR-016 Rev. 2 Table 1b)
ULD = 1.4E+3 Sv/L (ref. SARR-016 Rev. 2 Table 2b)
SOF Multipliers:
continuous, anticipated, onsite = 1.0E+4 s/L (ref. SARR-011 Rev. 2 Table E-12C)
continuous, anticipated, offsite = 8.4E+0 s/L (ref. SARR-011 Rev. 2 Table E-12C)
puff, anticipated, onsite = 2.9E+3 1/L (ref. SARR-011 Rev. 2 Table E-12D)
puff, anticipated, offsite = 3.4E-2 1/L (ref. SARR-011 Rev. 2 Table E-12D)

SST Solids

Cs-137 = 1.0E+11 Bq/L (ref. SARR-016 Rev. 2 Table 1a)
ULD = 2.2E+5 Sv/L (ref. SARR-016 Rev. 2 Table 2b)
SOF Multipliers:
continuous, anticipated, onsite = 4.0E+4 s/L (ref. SARR-011 Rev. 2 Table E-12A)
continuous, anticipated, offsite = 9.4E+1 s/L (ref. SARR-011 Rev. 2 Table E-12A)
puff, anticipated, onsite = 1.2E+4 s/L (ref. SARR-011 Rev. 2 Table E-12A)
puff, anticipated, offsite = 3.8E-1 s/L (ref. SARR-011 Rev. 2 Table E-12A)

241-A-702 and 296-P-16 Exhaust Systems

The 241-A-702 and 296-P-16 exhaust systems are as described in the main body of this calculation note. The HEPA filter inventory is calculated in the same way and with the same control point, but with the source material as specified above. The MICROSHIELD output files below were used to estimate inventories of 4.92E-2 L and 0.146 L for the 241-A-702 and 296-P-16 HEPA filter stages respectively. Note that for the 296-P-16 HEPA filter, the MICROSHIELD calculated dose rate represents 1 L on 1 stage, or 1/2 L on 2 stages.

The main body of this calculation note estimated de-entrainer inventories for both systems at 1.5 L of equivalent waste holdup. This was based on a single radiation survey of the 296-P-16 de-entrainer. Due to the lack of data associated with these components, and the fact that the Cs-137 concentration for the waste compositions being considered are not greatly different, the same 1.5 L of equivalent waste holdup is also assumed in this attachment.

296-S-15 Exhaust System

The 296-S-15 exhaust ventilation system in use on the 241-SX tank farm is assumed to take head space gas from approximately 12 single shell tanks via a common header. There exists a single out-of-service heater and two parallel HEPA filter banks of identical construction to the single HEPA filter bank in use on the 296-P-16 exhauster. Unfiltered releases are calculated on the basis of 3,300 L/s (7,000 scfm) maximum flow. As in the case of the 296-P-16 HEPA, the dose rate control point is assumed to be a single location centered on the bottom side of the filter housing. A single stage HEPA filter inventory is calculated based on a detector reading of 200 mR/hr. The estimated inventory for the HEPA filter stage is the same as for the 296-P-16 HEPA filter (i.e., 0.146 L). There are 4 HEPA filter stage equivalents assumed to be contained in the two filter banks and another 5th stage assumed for the holdup of the ducting, heater, etc.

All Three Exhaust Systems

The continuous release calculations for simple filter failure (due to wetting), and for the continuous release adder to the high temperature (fire) scenario, assumed a tank head space partition fraction of 10^{-10} (unagitated conditions). The overpressure release scenario, however, implies a considerable amount of tank agitation. For the continuous release associated with the overpressure event, therefore, the agitated partition fraction (10^{-8}) corresponding to approximately 20 mg/m^3 in the head space was assumed for the 10 minute, 12 hour, and 24 hour releases. Also, for the 241-A-702 system, a partition fraction of 10^{-8} is used for simple filter failure to account for waste transfer during storage.

Calculations and Results

The radiological and toxicological consequence calculations for each of the three systems are performed below using the same methodology as in the main body of this calculation note. Results are shown in Tables 1 through 6.

241-A-702 with AWF Liquid - Radiological

Fire - Onsite

$$D = \frac{6.4E\text{-}5\ L}{(0.0492\ L)(13)(1E\text{-}4)(1.4E{+}3\ Sv/L)(3.41\ E\text{-}2\ s/m^3)(3.3E\text{-}4\ m^3/s)}$$

D = **1.0E-6 Sv onsite**

Fire - Offsite

D = (6.4E-5 L)(1.4E+3 Sv/L)(2.83E-5 S/m^3)(3.3E-4 m^3/s) = **8.4E-10 Sv offsite**

Overpressure - Onsite

$$D = \frac{3.6E\text{-}2\ L}{[(0.0492\ L)(13)+(1.5\ L)(2)](0.01)(1.4E{+}3\ Sv/L)(3.41E\text{-}2\ s/m^3)(3.3E\text{-}4\ m^3/s)}$$

D = **5.7E-4 Sv onsite**

Overpressure - Offsite

D = (3.6E-2 L)(1.4E+3 Sv/L)(2.83E-5 s/m^3)(3.3E-4 m^3/s) = **4.7E-7 Sv offsite**

241-A-702 with AWF Liquid - Toxicological, continuous, anticipated

Fire - Onsite

D = (6.4E-5 L/120 s)(1.0E+4 s/L) = **5.3E-3 onsite**

Fire - Offsite

D = (6.4E-5 L/120 s)(8.4E+0 s/L) = **4.5E-6 offsite**

Overpressure - Onsite

D = (3.6E-2 L/120 s)(1.0E+4 s/L) = **3.0E+0 onsite**

Overpressure - Offsite

D = (3.6E-2 L/120 s)(8.4E+0 s/L) = **2.5E-3 offsite**

241-A-702 with AWF Liquid - Toxicological, puff, anticipated

Fire - Onsite

D = (6.4E-5 L)(2.9E+3 1/L) = **1.9E-1 onsite**

Fire - Offsite

D = (6.4E-5 L)(3.4E-2 1/L) = **2.2E-6 offsite**

Overpressure - Onsite

D = (3.6E-2 L)(2.9E+3 1/L) = **1.0E+2 onsite**

Overpressure - Offsite

D = (3.6E-2 L)(3.4E-2 1/L) = **1.2E-3 offsite**

296-P-16 with SST Solids - Radiological

Fire - Onsite

$$D = \frac{4.4E\text{-}5\ L}{(0.146\ L)(3)(1E\text{-}4)(2.2E{+}5\ Sv/L)(3.41E\text{-}2\ s/m^3)(3.3E\text{-}4\ m^3/s)}$$

D = **1.1E-4 Sv onsite**

Fire - Offsite

D = (4.4E-5 L)(2.2E+5 Sv/L)(2.83E-5 s/m^3)(3.3E-4 m^3/s) = **9.0E-8 Sv offsite**

Overpressure - Onsite

$$D = \frac{1.9E\text{-}2\ L}{[(0.146\ L)(3)+(1.5\ L)](1E\text{-}2)(2.2E{+}5\ Sv/L)(3.41E\text{-}2\ s/m^3)(3.3E\text{-}4\ m^3/s)}$$

D = **4.7E-2 Sv onsite**

Overpressure - Offsite

D = (1.9E-2 L)(2.2E+5 Sv/L)(2.83E-5 s/m^3)(3.3E-4 m^3/s) = **3.9E-5 Sv offsite**

296-P-16 with SST Solids - Toxicological, continuous, anticipated

Fire - Onsite

D = (4.4E-5 L/120 s)(4.0E+4 s/L) = **1.5E-2 onsite**

Fire - Offsite

D = (4.4E-5 L/120 s)(9.4E+1 s/L) = **3.4E-5 offsite**

Overpressure - Onsite

D = (1.9E-2 L/120 s)(4.0E+4 s/L) = **6.3E+0 onsite**

Overpressure - Offsite

D = (1.9E-2 L/120 s)(9.4E+1 s/L) = **1.5E-2 offsite**

296-P-16 with SST Solids - Toxicological, puff, anticipated

Fire - Onsite

D = (4.4E-5 L)(1.2E+4 1/L) = **5.3E-1 onsite**

Fire - Offsite

D = (4.4E-5 L)(3.8E-1 1/L) = **1.7E-5 offsite**

Overpressure - Onsite

D = (1.9E-2 L)(1.2E+4 1/L) = **2.3E+2 onsite**

Overpressure - Offsite

D = (1.9E-2 L)(3.8E-1 1/L) = **7.2E-3 offsite**

296-S-15 with SST Solids - Radiological

Fire - Onsite

$$D = \frac{7.3E\text{-}5\ L}{(0.146\ L)(5)(1E\text{-}4)(2.2E{+}5\ Sv/L)(3.41E\text{-}2\ s/m^3)(3.3E\text{-}4\ m^3/s)}$$

D = **1.8E-4 Sv onsite**

Fire - Offsite

D = $(7.3E\text{-}5\ L)(2.2E{+}5\ Sv/L)(2.83E\text{-}5\ s/m^3)(3.3E\text{-}4\ m^3/s)$ = **1.5E-7 Sv offsite**

Overpressure - Onsite

$$D = \frac{7.3E\text{-}3\ L}{(0.146\ L)(5)(1E\text{-}2)(2.2E{+}5\ Sv/L)(3.41E\text{-}2\ s/m^3)(3.3E\text{-}4\ m^3/s)}$$

D = **1.8E-2 Sv onsite**

Overpressure - Offsite

D = $(7.3E\text{-}3\ L)(2.2E{+}5\ Sv/L)(2.83E\text{-}5\ s/m^3)(3.3E\text{-}4\ m^3/s)$ = **1.5E-5 Sv offsite**

<u>296-S-15 with SST Solids - Toxicological, continuous, anticipated</u>

Fire - Onsite

D = (7.3E-5 L/120 s)(4.0E+4 s/L) = **2.4E-2 onsite**

Fire - Offsite

D = (7.3E-5 L/120 s)(9.4E+1 s/L) = **5.7E-5 offsite**

Overpressure - Onsite

D = (7.3E-3 L/120 s)(4.0E+4 s/L) = **2.4E+0 onsite**

Overpressure - Offsite

D = (7.3E-3 L/120 s)(9.4E+1 s/L) = **5.7E-3 offsite**

296-S-15 with SST Solids - Toxicological, puff, anticipated

Fire - Onsite

D = (7.3E-5 L)(1.2E+4 1/L) = **8.8E-1 onsite**

Fire - Offsite

D = (7.3E-5 L)(3.8E-1 1/L) = **2.8E-5 offsite**

Overpressure - Onsite

D = (7.3E-3 L)(1.2E+4 1/L) = **8.8E+1 onsite**

Overpressure - Offsite

D = (7.3E-3 L)(3.8E-1 1/L) = **2.8E-3 offsite**

References

References in this attachment are found in the Section 6.0 of the main body of this document.

Table 1. Radiological and Toxicological Consequences for Airborne Releases of AWF Liquid from the 241-A-702 Ventilation System. (ULD = 1.4E+3 Sv/L)

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	6.4E-5	--	3.30E-4	3.41E-2	--	1.0E-6
Overpressure Instantaneous Release, Onsite	3.6E-2	--	3.30E-4	3.41E-2	--	5.7E-4
Continuous Unfiltered Release, 10 Minutes, Onsite	--	1.89E-5	3.30E-4	3.41E-2	6.00E+2	1.8E-4
Continuous Unfiltered Release, 12 Hours, Onsite	--	1.89E-5	3.30E-4	5.54E-3	4.32E+4	2.1E-3
High Temperature Instantaneous Release, Offsite	6.4E-5	--	3.30E-4	2.83E-5	--	8.4E-10
Overpressure Instantaneous Release, Offsite	3.6E-2	--	3.30E-4	2.83E-5	--	4.7E-7
Continuous Unfiltered Release, 10 Minutes, Offsite	--	1.89E-5	3.30E-4	2.83E-5	6.00E+2	1.5E-7
Continuous Unfiltered Release, 24 Hours, Offsite	--	1.89E-5	2.70E-4	4.62E-6	8.64E+4	2.9E-6

Toxicological, Continuous, Anticipated					
Item (USOF = 1.0E+4)	dQ/dt (L/s)	SOF	Item (USOF = 8.4E+0)	dQ/dt (L/s)	SOF
High Temp., Onsite	5.3E-7	5.3E-3	High Temp., Offsite	5.3E-7	4.5E-6
Over Press., Onsite	3.0E-4	3.0E+0	Over Press., Offsite	3.0E-4	2.5E-3
Continuous, Onsite	1.89E-5	1.9E-1	Continuous, Offsite	1.89E-5	1.6E-4

Table 2. Summary Radiological and Toxicological Consequences for Airborne Releases of AWF Liquids Aerosols from the 241-A-702 Ventilation System.

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxic SOF
Onsite	High Temperature (Fire)	2.1E-3 (12 hr)	1.8E-4 (10 min)	2.0E-1
	Overpressure[1] (Steam Bump)	2.7E-3 (12 hr)[2]	7.5E-4 (10 min)[2]	3.2E+0[2]
	Filter Failure (Wetting)	2.1E-3 (12 hr)[3]	1.8E-4 (10 min)	1.9E-1
Offsite	High Temperature (Fire)	2.9E-6 (24 hr)	1.5E-7 (10 min)	1.6E-4
	Overpressure[1] (Steam Bump)	3.3E-6 (24 hr)[2]	6.2E-7 (10 min)[2]	2.7E-3[2]
	Filter Failure (Wetting)	2.9E-6 (24 hr)[3]	1.5E-7 (10 min)	1.6E-4

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

Table 3. Radiological and Toxicological Consequences for Airborne Releases of SST Solids Aerosols from the 296-P-16 Ventilation System. (ULD = 2.2E+5 Sv/L)

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	4.4E-5	--	3.30E-4	3.41E-2	--	1.1E-4
Overpressure Instantaneous Release, Onsite	1.9E-2	--	3.30E-4	3.41E-2	--	4.7E-2
Continuous Unfiltered Release, 10 Minutes, Onsite	--	3.30E-7	3.30E-4	3.41E-2	6.00E+2	4.9E-4
Continuous Unfiltered Release, 12 Hours, Onsite	--	3.30E-7	3.30E-4	5.54E-3	4.32E+4	5.7E-3
High Temperature Instantaneous Release, Offsite	4.4E-5	--	3.30E-4	2.83E-5	--	9.0E-8
Overpressure Instantaneous Release, Offsite	1.9E-2	--	3.30E-4	2.83E-5	--	3.9E-5
Continuous Unfiltered Release, 10 Minutes, Offsite	--	3.30E-7	3.30E-4	2.83E-5	6.00E+2	4.1E-7
Continuous Unfiltered Release, 24 Hours, Offsite	--	3.30E-7	2.70E-4	4.62E-6	8.64E+4	7.8E-6
Toxicological, Continuous, Anticipated						
Item (USOF = 4.0E+4 s/L)	dQ/dt (L/s)	SOF	Item (USOF = 9.4E+1 s/L)	dQ/dt (L/s)	SOF	
High Temp., Onsite	3.7E-7	1.5E-2	High Temp., Offsite	3.7E-7	3.4E-5	
Over Press., Onsite	1.6E-4	6.3E+0	Over Press., Offsite	1.6E-4	1.5E-2	
Continuous, Onsite	3.30E-7	1.3E-2	Continuous, Offsite	3.30E-7	3.1E-5	

Table 4. Summary Radiological and Toxicological Consequences for Airborne Releases of SST Solids Aerosols from the 296-P-16 Ventilation System.

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxic SOF
Onsite	High Temperature (Fire)	5.8E-3 (12 hr)	6.0E-4 (10 min)	2.8E-2
	Overpressure[1] (Steam Bump)	6.2E-1 (12 hr)[2]	9.6E-2 (10 min)[2]	7.6E+0[2]
	Filter Failure (Wetting)	5.7E-3 (12 hr)[3]	4.9E-4 (10 min)	1.3E-2
Offsite	High Temperature (Fire)	7.9E-6 (24 hr)	5.0E-7 (10 min)	6.5E-5
	Overpressure[1] (Steam Bump)	8.2E-4 (24 hr)[2]	8.0E-5 (10 min)[2]	1.8E-2[2]
	Filter Failure (Wetting)	7.8E-6 (24 hr)[3]	4.1E-7 (10 min)	3.1E-5

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

Table 5. Radiological and Toxicological Consequences for Airborne Releases of SST Solids from the 296-S-15 Ventilation System. (ULD = 2.2E+5 Sv/L)

Radiological						
Item	Q (L)	dQ/dt (L/s)	R (m^3/s)	χ/Q (s/m^3)	t (s)	CEDE (Sv)
High Temperature Instantaneous Release, Onsite	7.3E-5	--	3.30E-4	3.41E-2	--	1.8E-4
Overpressure Instantaneous Release, Onsite	7.3E-3	--	3.30E-4	3.41E-2	--	1.8E-2
Continuous Unfiltered Release, 10 Minutes, Onsite	--	3.30E-7	3.30E-4	3.41E-2	6.00E+2	4.9E-4
Continuous Unfiltered Release, 12 Hours, Onsite	--	3.30E-7	3.30E-4	5.54E-3	4.32E+4	5.7E-3
High Temperature Instantaneous Release, Offsite	7.3E-5	--	3.30E-4	2.83E-5	--	1.5E-7
Overpressure Instantaneous Release, Offsite	7.3E-3	--	3.30E-4	2.83E-5	--	1.5E-5
Continuous Unfiltered Release, 10 Minutes, Offsite	--	3.30E-7	3.30E-4	2.83E-5	6.00E+2	4.1E-7
Continuous Unfiltered Release, 24 Hours, Offsite	--	3.30E-7	2.70E-4	4.62E-6	8.64E+4	7.8E-6
Toxicological, Continuous, Anticipated						
Item (USOF = 4.0E+4 s/L)	dQ/dt (L/s)	SOF	Item (USOF = 9.4E+1 s/L)	dQ/dt (L/s)	SOF	
High Temp., Onsite	6.1E-7	2.4E-2	High Temp., Offsite	6.1E-7	5.7E-5	
Over Press., Onsite	6.1E-5	2.4E+0	Over Press., Offsite	6.1E-5	5.7E-3	
Continuous, Onsite	3.30E-7	1.3E-2	Continuous, Offsite	3.30E-7	3.1E-5	

Table 6. Summary Radiological and Toxicological Consequences for Airborne Releases of SST Solids Aerosols from the 296-S-15 Ventilation System.

Receptor	Event	Radiological Dose (Sv CEDE) No CAM-Fan Interlock	Radiological Dose (Sv CEDE) With CAM-Fan Interlock	Toxic SOF
Onsite	High Temperature (Fire)	5.9E-3 (12 hr)	6.7E-4 (10 min)	3.7E-2
	Overpressure[1] (Steam Bump)	5.9E-1 (12 hr)[2]	6.7E-2 (10 min)[2]	3.7E+0[2]
	Filter Failure (Wetting)	5.7E-3 (12 hr)[3]	4.9E-4 (10 min)	1.3E-2
Offsite	High Temperature (Fire)	8.0E-6 (24 hr)	5.6E-7 (10 min)	8.8E-5
	Overpressure[1] (Steam Bump)	8.0E-4 (24 hr)[2]	5.6E-5 (10 min)[2]	8.8E-3[2]
	Filter Failure (Wetting)	7.8E-6 (24 hr)[3]	4.1E-7 (10 min)	3.1E-5

[1] Accident will be prevented by overpressure event controls.

[2] Includes only effects due to releases from ventilation system followed by unfiltered release from headspace through failed filters. Effects due to initiating event must be added to obtain total consequence.

[3] Continuous release doses (uniform over 12 h onsite and 24 h offsite) can be extrapolated to annual average doses by multiplying by 15.2 and 9.80 for the onsite and offsite receptors, respectively (see section 5.1.1).

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1 File Ref: __________
DOS File: 702A-AWF.MS4 Date: ___/___/___
Run Date: August 5, 1998 By: __________
Run Time: 4:55 p.m. Wednesday Checked: __________
Duration: 0:00:04

Case Title: 702-A HEPA with AWF Liquid

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	76.2	2.0	6.0
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	15.0368	0.0	5.9

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	2.2703e+000	2.0043e+001	Co-60	0.0000e+000	0.0000e+000
Eu-154	0.0000e+000	0.0000e+000			

Page : 2
DOS File: 702A-AWF.MS4
Run Date: August 5, 1998
Run Time: 4:55 p.m. Wednesday
Title : 702-A HEPA with AWF Liquid

================================ RESULTS ===================

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.6	7.558e+010	1.866e+006	2.084e+006	3.642e+003	4.068e+003
TOTAL:	7.558e+010	1.866e+006	2.084e+006	3.642e+003	4.068e+003

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1 File Ref: ________
DOS File: P16-SST.MS4 Date: __/__/__
Run Date: August 5, 1998 By: ________
Run Time: 4:52 p.m. Wednesday Checked: ________
Duration: 0:00:04

Case Title: P-16 HEPA with SST Solids

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	198.12	6.0	6.0
Dose point coordinate Y:	60.96	2.0	.0
Dose point coordinate Z:	91.44	3.0	.0
Rectangular volume width :	182.88	6.0	.0
Rectangular volume length:	182.88	6.0	.0
Rectangular volume height:	30.48	1.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	15.0368	0.0	5.9

Source Volume: 1.01941e+6 cm^3 36 cu ft. 62208. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap	Immersion Shield
Air			0.00122	0.00122
Aluminum	0.03	2.702		
glass	0.02			

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	2.5676e+000	2.5187e+000	Co-60	0.0000e+000	0.0000e+000
Eu-154	0.0000e+000	0.0000e+000			

Page : 2
DOS File: P16-SST.MS4
Run Date: August 5, 1998
Run Time: 4:52 p.m. Wednesday
Title : P-16 HEPA with SST Solids

================================ RESULTS ======================

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.6	8.548e+010	2.977e+005	3.502e+005	5.811e+002	6.836e+002
TOTAL:	8.548e+010	2.977e+005	3.502e+005	5.811e+002	6.836e+002

PEER REVIEW CHECKLIST

Document Reviewed: Attachment 5 to HNF-SD-WM-CN-099 Rev. 1
Author: Brit Hey
Date: August 7, 1998
Scope of Review: Entire Attachment 5

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.**

D.A. Himes [signature] 8/11/98

Reviewer (Printed Name and Signature) Date

HEDOP REVIEW CHECKLIST

Document Reviewed: Attachment 5 to HNF-SD-WM-CN-099 Rev. 1
Author: Brit Hey
Date: August 7, 1998
Scope of Review: Entire Attachment 5

YES	NO*	N/A		
[X]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[X]	[ ]	[ ]	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[ ]	[ ]	[X]	3.	HEDOP-approved code(s) were used.
[ ]	[ ]	[X]	4.	Receptor locations were selected according to HEDOP recommendations.
[X]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[X]	[ ]	[ ]	6.	Hanford site data were used.
[ ]	[ ]	[X]	7.	Model adjustments external to the computer program were justified and performed correctly.
[X]	[ ]	[ ]	8.	The analysis is consistent with HEDOP recommendations.
[ ]		[X]	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.)
[X]	[ ]		**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. Himes [signature] 8/11/98 HEDOP-Approved
Reviewer (Printed Name and Signature) Date

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

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ATTACHMENT 6

REVISIONS TO THE CALCULATIONS FOR THE ORGANIC SOLVENT FIRE ACCIDENT

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ATTACHMENT 6

1.0 Purpose

The purpose of this attachment is to update the bounding onsite and offsite single-shell tanks (SSTs) and double-shell tanks (DSTs) radiological and toxicological calculations for the organic solvent fire accident scenarios analyzed in WHC-SD-WM-CN-032, *Analysis of Consequences of Postulated Solvent Fires in Hanford Site Waste Tanks,* Revision 0. This attachment contains supplemental calculations to the main body of the calculation note HNF-SD-WM-CN-099, Revision 1. Specifically, this attachment revises organic solvent fire cases G, H, K, and L calculations in WHC-SD-WM-CN-032 with the revised HEPA filter source term calculated in the Attachment 5 to HNF-SD-WM-CN-099. In addition, Attachment 6 presents calculations for the bounding cases (G, H, K, and L) for sluicing condition per Project W-320 using the appropriate source term information derived in the main text of this calculation note.

2.0 Methodology

The revised calculations for the quiescent cases G, H, K, and L from WHC-SD-WM-CN-032 were done using the assumptions and the overall calculation methodology presented in WHC-SD-WM-CN-032 with the updated HEPA filter rupture source term and consequences for the over pressurization scenarios for the 296-P-16 and 241-702-A ventilation systems, as calculated in the Attachment 5 to HNF-SD-WM-CN-099, Revision 1. The sluicing condition organic solvent fire accident analysis calculations for cases G, H, K, and L were evaluated using the HEPA source term values from HNF-SD-WM-CN-099, Revision 1, and from previously unpublished worksheet documenting the toxicological and radiological calculations presented in Addendum 1 of HNF-SD-WM-BIO-001, Section 3.4.2.9. The following describes the methodology used to calculate the bounding consequence for each case:

Cases G and K

Cases G and K represent the bounding onsite radiological consequences for SSTs and DSTs from WHC-SD-WM-CN-032 for the organic solvent fire accident. For the total onsite radiological consequences, the HEPA rupture dose calculated in WHC-SD-WM-CN-032 for cases G and K were substituted by the HEPA rupture over pressurization dose for 296-P-16 with SST solids and 241-702-A with AWF liquids calculated in Attachment 5. For the total offsite radiological consequences, the methodology presented in Section 6.2, "Worksheet 2. Dose Summary," of WHC-SD-WM-CN-032 was used with the revised total onsite dose calculated in this attachment.

Cases H and L

Cases H and L represent the bounding toxicological consequences for SSTs and DSTs from WHC-SD-WM-CN-032 for the organic solvent fire accident. The revised onsite and offsite toxicological sum-of-fractions (SOF) calculations were done using the over pressurization event HEPA inventory calculated for 296-P-16 with SST solids and 241-702-A with AWF liquids in

Attachment 5. The methodology used to calculate the total SOFs in Section 6.3, "Worksheet 3. Toxicological," was used with the revised HEPA inventory calculated in Attachment 5.

Project W-320 Cases G, H, K, and L

The methodology used for computing bounding toxicological and radiological calculations for Project W-320 cases G, H, K, and L is same as described previously for the organic solvent fire accident analysis Cases G, K , H, and L for the BIO quiescent scenario. That is, the calculation follows the methodology of WHC-SD-WM-CN-032. However, the input parameters such as unit liter doses (ULDs) and sum-of-fraction (SOF) multipliers were changed to appropriately reflect the conditions for the W-320 accident scenario. The derivation worksheet for the consequences presented in HNF-SD-WM-BIO-001, Addendum 1, has not been published in a calculation note to date. A mathematical error was found in the derivation worksheet pertaining to the density adjustment to ULDs to account for the sluicing conditions. Therefore, the previously published figures for radiological consequences were reported higher then actual. The toxicological consequences derivation worksheet (included as Appendix A to Attachment 6) has not been validated. The toxicological consequences derivation worksheet was used for identifying HEPA fractions and total SOF for cases H and L. The old HEPA fraction was subtracted from the reported total SOF and the revised HEPA fraction calculated herein was added in.

3.0 Assumptions

The revised calculations were completed using the same assumptions and input parameters identified in WHC-SD-WM-CN-032 with the exception of the HEPA rupture dose for radiological consequences and HEPA inventory for toxicological consequences. It is also assumed that the toxicological consequences worksheet (Appendix A) for Project W-320 organic solvent fire accident is correct as presented.

4.0 Input Data

All input data used in the calculations for cases G, H, K, and L are summarized in Table 4.1.

Table 4.1 Key Input Data

Input Parameter	Input Value	Source
296-P-16 HEPA Inventory for onsite over pressure event	1.9 E-02 L	Attachment 5, HNF-SD-WM-CN-099, for 296-P-16 ventilation with SST Solids
296-P-16 HEPA rupture dose for onsite over pressure event	4.7 E-02 Sv	Attachment 5, HNF-SD-WM-CN-099, for 296-P-16 ventilation with SST Solids
241-702-A HEPA Inventory for onsite over pressure event	3.6 E-02 L	Attachment 5, HNF-SD-WM-CN-099, for 241-702-A ventilation with AWF Liquids
241-702-A HEPA rupture dose for onsite over pressure event	5.7 E-04 Sv	Attachment 5, HNF-SD-WM-CN-099, for 241-702-A ventilation with AWF Liquids
Onsite Solvent Smoke Dose for Case G	1.39 E-04 Sv	WHC-SD-WM-CN-032, Worksheet 6.2, Case G, Column H
Onsite Aqueous Boil-off Dose for Case G	4.55 E-02 Sv	WHC-SD-WM-CN-032, Worksheet 6.2, Case G, Column I
Onsite Solvent Smoke Dose for Case K	4.2 E-04 Sv	WHC-SD-WM-CN-032, Worksheet 6.2, Case K, Column H
Onsite Solvent Boil-off Dose for Case K	2.28 E-02 Sv	WHC-SD-WM-CN-032, Worksheet 6.2, Case K, Column I
Onsite Breathing Rate	3.3 E -04 m^3/s	WHC-SD-WM-CN-032, Table 5.1
Offsite Breathing Rate	3.3 E-04 m^3/s	WHC-SD-WM-CN-032, Table 5.1
ULD, Ingestion, SST Solids	4.1 Svm^3/sL	WHC-SD-WM-CN-032, Table 5.1
ULD, Inhalation, SST Solids	2.2 E-05 Sv/L	WHC-SD-WM-CN-032, Table 5.1

Input Parameter	Input Value	Source
ULD, Ingestion, AWF Liquids	0.092 Svm^3/sL	WHC-SD-WM-CN-032, Table 5.1
ULD, Inhalation, AWF Liquids	1.4 E+03 Sv/L	WHC-SD-WM-CN-032, Table 5.1
Atm. Dispersion Factor, Onsite	3.41 E-02 s/m^3	WHC-SD-WM-CN-032, Table 5.1
Atm. Dispersion Factor, Offsite	2.83 E-05 s/m^3	WHC-SD-WM-CN-032, Table 5.1
Pool Fire Maximum Ventilation Rate for Case H	6.70 E+01 s	WHC-SD-WM-CN-032, Worksheet 6.3, Case H, Column I
Pool Fire Maximum Ventilation Rate for Case L	7.00 E+01 s	WHC-SD-WM-CN-032, Worksheet 6.3, Case L, Column I
Onsite SST (Passive) Solids SOF Multiplier for "Unlikely"	2.1 E+04 s/L	WHC-SD-WM-CN-032, Table 5-4
Offsite SST (Passive) Solids SOF Multiplier for "Unlikely"	3.3 E+01 s/L	WHC-SD-WM-CN-032, Table 5-4.
Onsite DST (Active) Liquids SOF Multiplier for "Unlikely"	7.5 E+02 s/L	WHC-SD-WM-CN-032, Table 5-4
Offsite DST (Active) Liquids SOF Multiplier for "Unlikely"	8.4 s/L	WHC-SD-WM-CN-032, Table 5-4
Onsite "Unlikely" Total SOF, Case H	3.86 E+01	WHC-SD-WM-CN-032, Worksheet 6.3, Case H, Column DI
Offsite "Unlikely" Total SOF, Case H	2.66 E-01	WHC-SD-WM-CN-032, Worksheet 6.3, Case H, Column DJ
Onsite "Unlikely" HEPA Fraction (SOF), Case H	4.45 E-02	WHC-SD-WM-CN-032, Worksheet 6.3, Case H, Column DC
Offsite "Unlikely" HEPA Fraction (SOF), Case H	7.00 E-05	WHC-SD-WM-CN-032, Worksheet 6.3, Case H, Column DD

Input Parameter	Input Value	Source
Onsite "Unlikely" Total SOF, Case L	4.02 E+01	WHC-SD-WM-CN-032, Worksheet 6.3, Case L, Column DI
Offsite "Unlikely" Total SOF, Case L	2.89 E+01	WHC-SD-WM-CN-032, Worksheet 6.3, Case L, Column DJ
Onsite "Unlikely" HEPA Fraction, Case L	7.03 E-02	WHC-SD-WM-CN-032, Worksheet 6.3, Case L, Column DC
Offsite "Unlikely" HEPA Fraction, Case L	7.87 E-04	WHC-SD-WM-CN-032, Worksheet 6.3, Case L, Column DD

5.0 Calculations for Cases G, H, K, and L for Quiescent Condition

This section presents the calculations for the organic solvent fire accident scenarios cases G, H, K, and L for the quiescent condition.

5.1 CASE G – Bounding Radiological for SSTs

This Section presents radiological dose calculations for Case G using 296-P-16 Ventilation System Information.

5.1.1 Onsite Radiological Consequences

The total onsite dose is computed by summing doses due to solvent smoke, aqueous boiloff, and HEPA rupture (WHC-SD-WM-CN-0

total dose = Solvent smoke + aqueous boiloff + HEPA rupture

Where:

$D_{(onsite), G}$ = total dose for Case G, Sv

1.39 E-04 Sv = Onsite solvent smoke dose, Case G (Table 4.1)

4.55 E-02 Sv = Onsite Aqueous Boiloff dose, Case G (Table 4.1

4.7 E-02 Sv = 296-P-16 HEPA rupture dose for onsite overpressurization event, Case G (Table 4

Therefore;

$$D_{(onsite), G} = 1.39E-04 + 4.55E-02 + 4.7E-02$$

$$\boxed{D_{(onsite), G} = 9.3\ E-02\ Sv}$$

5.1.2 Offsite Radiological Consequences

The total offsite dose is calculated using the following equatio[n]
from WHC-SD-WM-CN-032:

$$\text{total dose} = \left(\begin{matrix}\text{onsite inhalation}\\ \text{dose}\end{matrix}\right)\left(\frac{\chi/Q_{\text{offsite}}}{\chi/Q_{\text{onsite}}}\right)\left(1 + \frac{ULD_G}{R \times ULD_I}\right) \quad (5\text{-}1)$$

—(refer to Pg 42, WHC-SD-WM-CN-032, Re[v]

where:

$D_{(\text{offsite}),G}$ = total dose for case G

ULD_G = Unit Liter ingestion dose, Sv m³/sL

R = breathing rate, m³/s

ULD_I = Unit liter Inhalation dose, Sv/L

$D_{(\text{onsite}),G}$ = Onsite Inhalation dose, Sv

χ/Q = Atmospheric dispersion factor, s/m³

Now:

ULD_G = 4.1 Sv m³/sL = ULD, Ingestion SST solids (Tabl[e]

R = 3.3 E-04 m³/s = offsite breathing rate (Table 4.1)

ULD_I = 2.2 E-05 Sv/L = ULD, Inhalation SST solids (Table 4[

$D_{(\text{onsite}),G}$ = 6.93 E-02 Sv = onsite Inhalation dose (Section 5.1

$$\chi/Q \text{ offsite} = 2.83\text{E-05 s/m}^3 \quad \text{(Table 4.1)}$$

$$\chi/Q \text{ onsite} = 3.41\text{E-02 s/m}^3 \quad \text{(Table 4.1)}$$

Therefore:

$$D_{(offsite),G} = (1.93\text{E-02 Sv})\left(\frac{2.83\text{E-05 s/m}^3}{3.41\text{E-02 s/m}^3}\right)\left(1 + \frac{4.1 \text{ Sv m}^3/\text{sL}}{3.3\text{E-04 m}^3/\text{s} \cdot 2.2\text{E-05}}\right.$$

$$D_{(offsite),G} = 8.2\text{E-05 Sv}$$

5.2 Case K - Bounding Radiological for DSTs

This section presents radiological dose calculations for Case K using 241-702-A ventilation system information.

5.2.1 Onsite Radiological Consequences

The total onsite dose is computed by summing doses due to solvent smoke, aqueous boiloff, and HEPA rupture (WHC-SD-WM-CN-032):

total dose = solvent smoke + aqueous boiloff + HEPA rupture

Where:

$D_{(onsite),K}$ = total dose for case K, Sv

Onsite Solvent smoke dose for case K = 4.2 E-04 Sv (Table 4.1)

Onsite solvent boiloff dose for case K = 2.28 E-02 Sv (Table 4.1)

241-702-A HEPA rupture dose for onsite for overpressurization = 5.7 E-04 Sv (Table 4.1)

Therefore:

$$D_{(onsite),K} = 4.2\text{E-}04 + 2.28\text{E-}02 + 5.7\text{E-}04$$

$$\boxed{D_{(onsite),K} = 2.38\text{E-}02 \text{ Sv}}$$

5.2.2 Offsite Radiological Consequences

The total offsite dose is calculated using Equation (5-1).

$$\text{total dose} = (\text{onsite inhalation dose})\left(\frac{\chi/Q \text{ offsite}}{\chi/Q \text{ onsite}}\right)\left(1 + \frac{ULD_G}{R \times ULD_I}\right)$$

where:

ULD_G = 0.092 Sv m³/s L = ULD, Ingestion AWF Liquids (Table 4.1)

R = 3.3 E-04 m³/s = offsite breathing rate (Table 4.1)

ULD_I = 1.4 E+03 Sv/L = ULD, Inhalation, AWF Liquids (Table 4.1)

$D_{(onsite),K}$ = 2.38 E-02 Sv = onsite Inhalation dose (Section 5.2.1)

χ/Q offsite = 2.83 E-05 s/m³ (Table 4.1)

χ/Q onsite = 3.41 E-02 s/m³ (Table 4.1)

$D_{(offsite),K}$ = total offsite dose for case K, Sv

Therefore:

$$D_{(offsite),K} = (2.38\ E\text{-}02\ Sv)\left(\frac{2.83\ E\text{-}05\ s/m^3}{3.41\ E\text{-}02\ s/m^3}\right)\left(1 + \frac{0.092\ Sv\ m^3/s\ L}{3.3\ E\text{-}04\ m^3/s \cdot 1.4\ E\text{+}03\ Sv/L}\right)$$

$$\boxed{D_{(offsite),K} = 2.37\ E\text{-}05\ Sv}$$

5.3 Case H – Bounding Toxicological for SSTs

This section presents toxicological dose calculations for case H using 296-P-16 ventilation system information.

5.3.1 Onsite Toxicological Consequences

To calculate total sum of fractions for onsite dose, revised HEPA fraction is calculated using methodology presented in WHC-SD-WM-CN-032; Section 3.2.

Now:

Release rate = HEPA inventory / release duration (5-2)

where

HEPA Inventory = 1.9 E-02 L = for 296-P-16 for onsite overpressure event (Table 4.1)

Release duration = 6.7 E+01 s = for pool fire max ventilation duration for Case H (Table 4.

Therefore:

Release rate = 1.9 E-02/6.7 E+01 = 2.84 E-04 L/s

The revised SOF for HEPA is calculated as:

Revised SOF_{HEPA} = Release rate × SOF multiplier (5-3)

Where :

$$\text{SOF multiplier} = 2.1\text{E+04 s/L} = $$ onsite SST (Passive) solids SOF multiplier for "Unlikely" event

Hence :

$$\text{Revised SOF}_{(\text{onsite})_{\text{HEPA},H}} = 2.84\text{E-04 L/s} \times 2.1\text{E+04 s/L} = 5.7$$

Now revised total SOF for onsite is calculated by subtracting the WHC-SD-WM-CN-032 HEPA fraction and adding in revised HEPA fractio[n] calculated above

Now

$$\text{Revised total SOF}_{(\text{onsite})} = (\text{total SOF})_{\text{CN-032}} - (\text{HEPA fraction})_{\text{CN-032}} + \begin{pmatrix}\text{Revised} \\ \text{SOF}\end{pmatrix}_{\text{onsite}}$$

— (5-4

Where :

$(\text{Total SOF})_{\text{CN-032}}$ = 3.86 E+01 = onsite "unlikely" total SOF, Case H (Table 4.1

$(\text{HEPA Fraction})_{\text{CN-032}}$ = 4.45 E-02 = Onsite "Unlikely" HEPA fraction (Table 4. for Case H

Therefore :

$$\text{Revised total SOF}_{(\text{onsite}),H} = 3.86\text{E+01} - 4.45\text{E-02} + 5.7$$

$$\boxed{(\text{Revised total SOF})_{\text{onsite},H} = 44.3}$$

5.3.2 offsite Toxicological Consequences

Using Equations (5-2), (5-3), and (5-4) the total revised offsite SOF is calculated using methodology presented in Section 5.3.1 with input parameters from Table 4.1.

(5-2) Release rate $= 1.9\text{E-}02\,\text{L} / 6.7\text{E+}01\,\text{s} = 2.84\text{E-}04\,\text{L/s}$

SOF multiplier = SOF multiplier offsite SST solids = $3.3\text{E+}01\,\text{s/L}$ (Table 4.1)

(5-3) $\text{Revised SOF}_{(\text{offsite})_{HEPA,H}} = 2.84\text{E-}04\,\text{L/s} \times 3.3\text{E+}01\,\text{s/L} = 9.4\text{E-}03$

$(\text{Total SOF})_{CN\text{-}032} = 2.66\text{E+}01$ = offsite "Unlikely" total SOF, case H (Table 4.

$(\text{HEPA Fraction})_{CN\text{-}032} = 7.00\text{E-}05$ = offsite "Unlikely" HEPA fraction for Case H (Table 4.1)

Therefore, equation (5-4) for offsite total SOF, case H:

$\text{Revised total SOF}_{(\text{offsite}),H} = 2.66\text{E-}01 - 7.00\text{E-}05 + 9.4\text{E-}03$

$$(\text{Revised total SOF})_{\text{offsite},H} = 2.8\text{E-}01$$

5.4 Case L - Bounding Toxicological for DSTs

This section presents toxicological dose calculations for Case L using 241-702-A Ventilation System information.

5.4.1 Onsite Toxicological Consequences

Using Equations (5-2), (5-3), and (5-4) the total revised onsite SOF is calculated using methodology presented in Section 5.3.1 with appropriate input parameters from Table 4.1.

Now:

HEPA inventory = 3.6 E-02 L = for 241-702-A onsite overpressurization event (Table 4.1)

Release duration = 7.00 E+01 s = for Pad fire max Ventilation duration for Case L (Table 4.1)

Therefore computing Equation (5-2) for Case L onsite:

Release rate = 3.6 E-02 L / 7.00 E+01 s = 5.14 E-04 L/s

Now

SOF multiplier = 7.50 E+02 s/L = AWF Liquids for "Unlikely" onsite (Table 4.

Computing Equation (5-3) for Case L onsite:

$$\text{Revised SOF}_{(onsite)\,HEPA,\,L} = 5.14\,E\text{-}04 \times 7.50\,E\text{+}02 = 3.9\,E\text{-}01$$

Now

$(\text{Total SOF})_{CN-032} = 4.02E+01$ = Onsite "Unlikely" total SOF for case L (Table 4.1)

$(\text{HEPA Fraction})_{CN-032} = 7.03E-02$ = Onsite "Unlikely" HEPA Fraction for Case L (Table 4.

Therefore Equation (5-4) for onsite total SOF, case L:

$$\text{Revised total SOF}_{(onsite),L} = 4.02E+01 - 7.03E-02 + 3.9E-01$$

$$\boxed{(\text{Revised total SOF})_{onsite,L} = 40.5}$$

5.4.2 Offsite Toxicological Consequences

Using Equations (5-2), (5-3), and (5-4) the total revised offsite SOF is calculated using methodology presented in Section 5-3.1 with appropriate input parameters from Table 4-1

The release rate is the same as computed in Section 5.4.1
Therefore Release rate = 5.14E-04 L/s

Now

SOF multiplier = 8.40 = AWF Liquids for "Unlikely" offsite (Table 4-

Computing Equation (5-3) for Case L offsite:

$$\text{Revised SOF}_{(\text{offsite})_{HEPA,L}} = 5.14\text{E-}04 \times 8.40 = 4.32\text{E-}03$$

Now

$(\text{Total SOF})_{CN\text{-}032}$ = 2.89 E-01 = offsite "Unlikely" total SOF for case L (Table 4-

$(\text{HEPA Fraction})_{CN\text{-}032}$ = 7.87 E-04 = offsite "Unlikely" HEPA Fraction for Case L (Table 4-

Therefore Equation (5-4) for offsite total SOF, Case L:

$$\text{Revised total SOF}_{(\text{offsite}),L} = 2.89\text{E-}01 - 7.87\text{E-}04 + 4.32\text{E-}03$$

$$\boxed{(\text{Revised total SOF})_{\text{offsite},L} = 2.93\text{E-}01}$$

6.0 Sluicing Organic Solvent Fire Bounding Calculations

This section presents radiological and toxicological dose calculations for the organic solvent fire accident scenario for the sluicing conditions for the Project W-320.

6.1 Case G - Bounding Radiological for Tank 241-C-106 Sluicing Condition

This section presents the calculations for the radiological consequences for the sluicing condition per Project W-320 for Tank 241-C-106 for 296-C-006 ventilation system.

Table 6.1.1 presents the onsite radiological dose calculations using the HEPA filter source term of 1.91 E-01 liters. Table 6.1.2 presents the offsite radiological dose calculations. The values for solvent atmospheric release inventory, solvent ULD, aqueous atmospheric release inventory, density, aqueous ULD, atmospheric dispersion coefficient, and breathing rate are from calculation note WHC-SD-WM-CN-032.

6.2 Case K - Bounding Radiological for Tank 241-AY-102 Sluicing Condition

This section presents the calculations for the radiological consequences for the sluicing condition per Project W-320 for Tank 241-AY-102 for 241-702-A ventilation system.

Table 6.1.1 presents the onsite radiological dose calculations using the HEPA filter source term of 3.66 E-02 liters. Table 6.1.2 presents the offsite radiological dose calculations. The values for solvent atmospheric release inventory, solvent ULD, aqueous atmospheric release inventory, density, aqueous ULD, atmospheric dispersion coefficient, and breathing rate are from calculation note WHC-SD-WM-CN-032.

Table 6.1.1 Onsite Radiological Dose Calculations for Sluicing Conditions (Project W-320) Organic Solvent Fire Accident with Controls

CASE	Solvent Atm. Release Basis (kg) [a]	x/Q * R	Solvent ULD (sv/L) [a]	Onsite Solvent Smoke Dose (Sv)	Aqueous Atm. Releases (kg) [a]	Density (kg/L) [b]	Aqueous ULD (Sv/L) [c]	x/Q * R	Onsite Aqueous Boiloff Dose (Sv)	HEPA Filter Source term (L) [c]	HEPA ULD [c]	x/Q * R	Onsite HEPA Rupture Dose (Sv)	Total Onsite Dose (Sv)
G	4.38E+00	1.13E-05	2.83	1.39E-04	3.68E-01	1.41	1.20E+05	1.13E-05	3.52E-01	1.91E-01	1.20E+05	1.13E-05	2.59E-01	6.11E-01
K	1.32E+01	1.13E-05	2.83	4.20E-04	3.33E-01	1.27	3.90E+04	1.13E-05	1.15E-01	3.66E-02	3.90E+04	1.13E-05	1.61E-02	1.32E-01

x/Q = 3.41 E-02 s / m ^3 [a]; R = 3.3 E-04 m ^3 /s [a]; x/Q * R = 1.125E-05

a. from WHC-SD-WM-CN-032, 1996, *Calculation Notes for Tank Farm Deflagration Frequencies due to various Ignition Sources*, Rev 0-A, Westinghouse Hanford Company, Richland
b. from HNF-SD-WM-BIO-001, *Tank Waste Remediation System Basis for Interim Operation,* Addendum 1, Section 3.4.2.9
c. from HNF-SD-WM-CN-099, 1998, *Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems,* Rev. 1, Fluor Daniel Northwest, Inc., Richland, Washington.

Table 6.1.2 Offsite Radiological Dose Calculations for Sluicing Conditions (Project W-320) Organic Solvent Fire Accident with Controls

CASE	Solvent Atm. Release Basis (kg) [a]	x/Q * R	Solvent ULD (sv/L) [a]	Offsite Solvent Smoke Dose (Sv)	Aqueous Atm. Releases (kg) [a]	Density (kg/L) [b]	Aqueous ULD (Sv/L) [c]	x/Q * R	Offsite Aqueous Boiloff Dose (Sv)	HEPA Filter Source term (L) [c]	HEPA ULD [c]	x/Q * R	Offsite HEPA Rupture Dose (Sv)	Total Offsite Dose (Sv)
G	4.38E+00	9.34E-09	2.83	1.16E-07	3.68E-01	1.41	1.20E+05	9.34E-09	2.93E-04	1.91E-01	1.20E+05	9.34E-09	2.14E-04	5.07E-04
K	1.32E+01	9.34E-09	2.83	3.49E-07	3.33E-01	1.27	3.90E+04	9.34E-09	9.55E-05	3.66E-02	3.90E+04	9.34E-09	1.33E-05	1.09E-04

x/Q = 2.83 E-05 s / m ^3 ; R = 3.3 E-04 m ^3 /s; x/Q * R = 9.34E-09

a from WHC-SD-WM-CN-032, 1996, *Calculation Notes for Tank Farm Deflagration Frequencies due to various Ignition Sources*, Rev 0-A, Westinghouse Hanford Company, Richland
b. from HNF-SD-WM-BIO-001, *Tank Waste Remediation System Basis for Interim Operation,* Addendum 1, Section 3.4.2.9
c. from HNF-SD-WM-CN-099, 1998, *Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems,* Rev. 1, Fluor Daniel Northwest, Inc., Richland, Washington.

6.3 Case H - Bounding Toxicological for 241-C-106

This section presents toxicological consequences for Case H recalculated using methodology presented in Section 5.3 for Tank 241-C-106 for Project W-320 with appropriate input parameters.

6.3.1 Onsite Toxicological Consequences, case H

Using Equations (5-2), (5-3), and (5-4) the total onsite revised SOF is calculated using methodology presented in Section 5.3.1 with appropriate input parameters for Project W-320.

Now:

HEPA Inventory = 1.91E-01 L (HNF-SD-WM-CN-099, Rev 1

Release duration = 6.7 E+01 s = for Pool Fire max Ventilation duration for Case H (Table 4.1)

Therefore computing Equation (5-2) for Case H, onsite

Release rate = 1.91 E-01 L / 6.7 E+01 s = 2.9 E-03 L/s

Now

SOF Multiplier = 4.5 E+02 S/L = SST Solids for "Extremely Unlikely" (Addendum 1, HNF-SD-WM-BIO-001, Table 3.4.1-7, 67/33 "extremely unlikely" reasonable case

Computing Equation (5-3) for Case H Onsite:

$$\left(\text{Revised SOF}_{(\text{onsite})\ HEPA,H}\right)_{W-320} = 1.31$$

NOW

$$(\text{Total SOF})_{\text{Project W320, H}} = 1.91\text{E+01}$$

(Column D from Unpublished Proj. W320 Org. Sol. Fire accident Worksheet)

$$(\text{HEPA Fraction})_{\text{Project W320, H}} = 2.12\text{E-03}$$

(Column D1 from Unpublished Proj W320 Org. Sol. Fire accident Worksheet)

Therefore Equation (5-4) for onsite total SOF, Case H:

$$\left(\text{Revised total SOF}_{(\text{onsite}),\,H}\right)_{W320} = 1.91\text{E+01} - 2.12\text{E-03} + 1.31$$

$$\boxed{\left(\text{Revised total SOF}_{(\text{onsite}),\,H}\right)_{W320} = 2.04\text{E+01}}$$

6.3.2 Offsite Toxicological Consequences, Case H

Using Equations (5-2), (5-3), and (5-4) the total revised offsite SOF is calculated using methodology presented in Section 5.3.1 with appropriate input parameters for Project W320

The release rate is the same as computed in Section 6.3.1

Therefore release rate = 2.9 E-03 L/s

Now

SOF multiplier = 5.6 S/L = SST Solids offsite for "Extremely Unlikely" (Addendum 1, HNF-SD-WM-... Table 3.4.1-... 67/33 "extremely unlikely" reasonable c...)

Computing Equation (5-3) for Case H, offsite:

$$\left(\text{Revised SOF}_{(\text{offsite}),\ \text{HEPA},\ H}\right)_{W\text{-}320} = 2.9E\text{-}03\ L/s \times 5.6\ S/L = 1.62E\text{-}02$$

Now

$$\left(\text{Total SOF}\right)_{(\text{offsite}),\ H,\ W320} = 1.99E\text{-}01$$ (Column DR, from Unpublished Proj W320 org. sol. fire accident worksheet)

$$\left(\text{HEPA Fraction}\right)_{(\text{offsite}),\ H,\ W320} = 3.60E\text{-}05$$ (Column DJ, from Unpublished Proj W320 Org. Sol. fire accident Worksheet)

Therefore Equation (5-4) for offsite total SOF, Case H:

$$\left(\text{Revised total SOF}_{(\text{offsite}),\ H}\right)_{W320} = 1.99E\text{-}01 - 3.6E\text{-}05 + 1.62E\text{-}02$$

$$\boxed{\left(\text{Revised total SOF}_{(\text{offsite}),\ H}\right)_{W320} = 2.2E\text{-}01}$$

6.4 Case L – Bounding Toxicological for 241-AY-102

This section presents toxicological consequences for Case L recalculated using methodology presented in Section 5.3 for Tank 241-AY-102 for Project W-320 with appropriate input parameters.

6.4.1 Onsite Toxicological Consequences, Case L

Using Equations (5-2), (5-3), and (5-4) the total onsite revised SOF is calculated using methodology presented in Sections 5.3.1 with appropriate input parameters for Project W-320.

Now:

HEPA inventory = 3.66 E-02 L (HNF-SD-WM-CN-099, Re...

Release duration = 7.00 E+01 s = for pool fire max ventilation duration for Case L (Table 4.1)

Therefore Computing Equation (5-2) for Case L, Onsite

Release rate = 3.66 E-02 L / 7.00 E+01 s = 5.23 E-04 L/s

Now SOF multiplier = 2.8 E+02 S/L (Addendum 1, HNF-SD-WM-BIO-001 Table 3.4.1-7, 90/10 mix Onsite reasonable Case Ext. Unlikely)

Computing Equation (5-3) for Case L, onsite

$$\left(\text{Revised SOF}_{(\text{onsite})\,HEPA,\,L}\right)_{W-320} = 1.5\text{ E-01}$$

Now

$$(\text{Total SOF})_{\text{Project W320, L}} = 1.99\text{E+01}$$

(Column DQ from Unpublished Proj W320 Org-Sol. fire accident Worksheet)

$$(\text{HEPA Fraction})_{\text{Project W320, L}} = 1.97\text{E-02}$$

(Column DI from Unpublished Proj. W320 Org. Sol. fire accident Worksheet)

Therefore Equation (5-4) for onsite total SOF, case L:

$$\left(\text{Revised total SOF}_{(\text{onsite}),\,L}\right)_{W-320} = 1.99\text{E+01} - 1.97\text{E-02} + 1.5\text{E-01}$$

$$\boxed{\left(\text{Revised total SOF}_{(\text{onsite}),\,L}\right)_{W-320} = 2.0\text{E+01}}$$

6.4.2 offsite Toxicological Consequences, Case L

Using Equations (5-2), (5-3), and (5-4) the total revised offsite SOF is calculated using methodology presented in Section 5.3.1 with appropriate input parameters for Project W-320.

The release rate is the same as computed in Section 6.4.1

Therefore release rate = 5.23 E-04 L/s

Now

$$\text{SOF multiplier} = 2.1\ \text{s/L}$$

(Addendum 1, HNF-SD-WM-BIO-001 Table 3.4.1-7, 90/10 mix offsite reasonable case "extremely unlikely")

Computing Equation (5-3) for Case L, offsite

$$\left(\text{Revised SOF}_{(\text{offsite}),\text{HEPA},L}\right)_{W-320} = 5.23E{-}04\ \text{L/s} \times 2.1\ \text{s/L} = 1.1E{-}03$$

Now

$$(\text{Total SOF})_{(\text{offsite}),L,W320} = 2.16\ E{-}01$$

(Column DR, from Unpublished Proj W320 orig. sol fire accident worksheet)

$$(\text{HEPA Fraction})_{(\text{offsite}),L,W320} = 5.81\ E{-}05$$

(Column DJ, from Unpublished Proj W320 orig sol fire accident worksheet.)

Therefore equation (5-4) for offsite total SOF, Case L:

$$\left(\text{Revised total SOF}_{(\text{offsite}),H}\right)_{W320} = 2.16E{-}01 - 5.81E{-}05 + 1.1E{-}03$$

$$\boxed{\left(\text{Revised total SOF}_{(\text{offsite}),L}\right)_{W320} = 2.2\ E{-}01}$$

7.0 References

HNF-SD-WM-BIO-001, 1998, *Tank Waste Remediation System Basis for Interim Operation,* Rev 0-J, Fluor Daniel Hanford Company, Richland, Washington.

HNF-SD-WM-CN-099, 1998, *Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems*, Rev. 1, Fluor Daniel Northwest, Inc., Richland, Washington.

WHC-SD-WM-CN-032, 1996, *Calculation Notes for Tank Farm Deflagration Frequencies due to various Ignition Sources,* Rev. 0-A, Westinghouse Hanford Company, Richland.

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APPENDIX A

Organic Solvent Fire Toxicological Consequences Derivation Worksheet

for

Cases H and L

Organic Solvent Fire Toxicological Consequences Derivation Worksheet.* (3 Sheets)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Case	Tank type	Solvent pool description	Pool area m²	Bounding parameters	Ventilation flow	Vent description	Tank gas volume, m^3	Pool fire.4 maximum vent durations	Pool fire.4 solvent burned in vent, kg	Pool fire.4 reaction gas fraction	Pool fire.4 headspace gas fraction	Source conc. P_2O_5, mg/m^3	Source conc. CO, mg/m^3	Source conc. NO_2, mg/m^3
H	SST	large	2.10 E+02	toxicological	passive	HEPA/flapper	4.82 E+03	6.70 E+01	8.40 E+01	3.00 E-01	6.00 E-01	1.92 E+03	1.88 E+03	2.44 E+02
L	DST	large	2.10 E+02	toxicological	100 cfm (0.047 m^3/s)	flapper/vent pipe	5.30 E+03	7.00 E+01	9.21 E+01	3.10 E-01	6.10 E-01	1.94 E+03	1.90 E+03	2.47 E+02

A	P	Q	R	S	T	U	V	W	X	Y	Z
Case	Aqueous vent rate, L/s	Van's onsite limit, ex. unlikely, s/L	Van's offsite limit, ex. unlikely, s/L	Van's onsite limit, unlikely, s/L	Van's offsite limit, unlikely, s/L	Onsite SOF aqueous boil-off	Offsite SOF aqueous boil-off	Vent rate of gas, m^3/s	Onsite conc. P_2O_5, mg/m^3	Onsite conc. CO, mg/m^3	Onsite conc. NO_2, mg/m^3
H	9.48 E-04	2.00 E+02	6.20 E-01	7.50 E+02	8.00 E+00	1.90 E-01	5.88 E-04	4.31 E+01	1.14 E+03	1.12 E+03	1.45 E+02
L	1.03 E-03	2.10 E+02	6.20 E-01	7.50 E+02	8.40 E+00	2.16 E-01	6.37 E-04	4.62 E+01	1.19 E+03	1.16 E+03	1.51 E+02

A	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
Case	Onsite normalized conc., mg/m^3	Source soot conc., mg/m^3	Onsite total particulate, mg/m^3	Offsite total particulate, mg/m^3	Particulate limit ERPG-3, mg/m^3	Particulate limit ERPG-2 mg/m^3	Particulate limit ERPG-1 mg/m^3	Ex. un. onsite total particulate fraction	Ex. un. offsite total particulate fraction	Offsite normalized conc., mg/m^3	Ammonia headspace conc., mg/m^3
H	5.95 E-01	1.74 E+03	2.18 E+03	4.47 E+00	5.00 E+02	5.00 E+01	3.00 E+01	4.36 E+00	8.93 E-02	1.22 E-03	1.99 E+02
L	6.12 E-01	1.77 E+03	2.27 E+03	4.84 E+00	5.00 E+02	5.00 E+01	3.00 E+01	4.54 E+00	9.68 E-02	1.31 E-03	1.99 E+02

	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV
Case	Ammonia ERPG-3, mg/m^3	Ammonia ERPG-2, mg/m^3	Ammonia ERPG-1, mg/m^3	1,3 Buta headspace Conc., mg/m^3	1,3 Buta ERPG-3, mg/m^3	1,3 Buta ERPG-2, mg/m^3	1,3 Buta ERPG-1, mg/m^3	meth. chl. Headspace conc., mg/m^3	meth. chl. ERPG-3, mg/m^3	meth. chl. ERPG-2, mg/m^3	meth. chl. ERPG-1, mg/m^3
H	6.80 E+02	1.40 E+02	1.70 E+01	1.90 E-01	1.10 E+04	1.10 E+02	2.20 E+01	2.18 E+01	1.74 E+04	3.48 E+03	7.00 E+02
L	6.80 E+02	1.40 E+02	1.70 E+01	1.90 E-01	1.10 E+04	1.10 E+02	2.20 E+01	2.18 E+01	1.74 E+04	3.48 E+03	7.00 E+02

Table 3.4.2.9-2. Organic Solvent Fire Toxicological Consequences. (3 Sheets)

	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG
Case	TBP headspace conc., mg/m^3	TBP ERPG-3, mg/m^3	TBP ERPG-2, mg/m^3	TBP ERPG-1, mg/m^3	P_2O_5 headspace conc., mg/m^3	P_2O_5 ERPG-3, mg/m^3	P_2O_5 ERPG-2, mg/m^3	P_2O_5 ERPG-1, mg/m^3	NO_2 headspace Conc., mg/m^3	NO_2 ERPG-3, mg/m^3	NO_2 ERPG-2, mg/m^3
H	1.16 E+01	5.00 E+01	1.50 E+01	3.00 E+00	1.92 E+03	1.00 E+02	2.50 E+01	5.00 E+00	2.44 E+02	9.40 E+01	4.70 E+01
L	1.16 E+01	5.00 E+01	1.50 E+01	3.00 E+00	1.94 E+03	1.00 E+02	2.50 E+01	5.00 E+00	2.47 E+02	9.40 E+01	4.70 E+01

* This worksheet has not been Validated.

	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR
Case	NO_2 ERPG-1, mg/m^3	Acetonit Headspace conc., mg/m^3	Acetonit ERPG-3, mg/m^3	Acetonit ERPG-2, mg/m^3	Acetonit ERPG-1, mg/m^3	Prop. nit. headspace conc., mg/m^3	Prop. nit. ERPG-3, mg/m^3	Prop. nit. ERPG-2, mg/m^3	Prop. nit. ERPG-1, mg/m^3	CO headspace conc., mg/m^3	CO ERPG-3, mg/m^3
H	3.80 E+00	2.18 E+01	6.00 E+01	2.00 E+01	3.00 E+00	1.05 E+01	6.00 E+01	2.00 E+01	3.00 E+00	1.88 E+03	1.36 E+03
L	3.80 E+00	2.18 E+01	6.00 E+01	2.00 E+01	3.00 E+00	1.05 E+01	6.00 E+01	2.00 E+01	3.00 E+00	1.90 E+03	1.36 E+03

	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC
Case	CO ERPG-2, mg/m^3	CO ERPG-1, mg/m^3	Benzene headspace conc., mg/m^3	Benzene ERPG-3, mg/m^3	benzene ERPG-2, mg/m^3	Benzene ERPG-1, mg/m^3 (_/ft^3)	Butanol headspace conc., mg/m^3	Butanol ERPG-3, mg/m^3	Butanol ERPG-2, mg/m^3	Butanol ERPG-1, mg/m^3	Dodecane headspace conc., mg/m^3
H	6.90 E+02	2.30 E+02	1.32 E+00	3.13 E+03	1.57 E+03	7.80 E+01	1.64 E+02	7.50 E+03	7.50 E+02	7.50 E+01	2.96 E+02
L	6.90 E+02	2.30 E+02	1.32 E+00	3.13 E+03	1.57 E+03	7.80 E+01	1.64 E+02	7.50 E+03	7.50 E+02	7.50 E+01	2.96 E+02

	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN
Case	Dodecane ERPG-3, mg/m^3	Dodecane ERPG-2, mg/m^3	Dodecane ERPG-1, mg/m^3	2-hexano headspace conc., mg/m^3	2-hexano ERPG-3, mg/m^3	2-hexano ERPG-2, mg/m^3	2-hexano ERPG-1, mg/m^3	N_2O headspace conc., mg/m^3	N_2O ERPG-3, mg/m^3	N_2O ERPG-2, mg/m^3	N_2O ERPG-1, mg/m^3
H	7.33 E+03	1.45 E+03	3.70 E+01	2.68 E+00	5.00 E+03	5.00 E+02	5.00 E+01	1.29 E+03	3.60 E+04	1.80 E+04	2.70 E+02
L	7.33 E+03	1.45 E+03	3.70 E+01	2.68 E+00	5.00 E+03	5.00 E+02	5.00 E+01	1.29 E+03	3.60 E+04	1.80 E+04	2.70 E+02

Organic Solvent Fire Toxicological Consequences. (3 Sheets)

	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY
Case	Tridecan headspace conc., mg/m^3	Tridecan ERPG-3, mg/m^3	Tridecan ERPG-2, mg/m^3	Tridecan ERPG-1, mg/m^3	Ex. un. onsite corrosives and irritant fraction	Ex. un. offsite corrosives and irritant fraction	Unlikely onsite corrosives and irritant fraction	Unlikely offsite corrosives and irritant fraction	Ex. un. onsite systemic poisons fraction	Ex. un. offsite systemic poisons fraction	Unlikely onsite systemic poisons fraction
H	3.88 E+02	7.33 E+03	1.45 E+03	3.70 E+01	1.33 E+01	1.03 E-01	5.01 E+01	5.65 E-01	1.14 E+00	5.91 E-03	2.58 E+00
L	3.88 E+02	7.33 E+03	1.45 E+03	3.70 E+01	1.38 E+01	1.11 E-01	5.21 E+01	6.12 E-01	1.19 E+00	6.40 E-03	2.67 E+00

	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ
Case	Unlikely offsite systemic poisons fraction	Ex. un. onsite nervous system fraction	Ex. un. offsite nervous system fraction	Unlikely onsite nervous system fraction	Unlikely offsite nervous system fraction	Ex. un. onsite particulate fraction	Ex. un. offsite particulate fraction	Unlikely onsite particulate fraction	Unlikely offsite particulate fraction	Ex. un. onsite HEPA fraction	Ex. un. offsite HEPA fraction
H	2.31 E-02	9.05 E-02	9.37 E-04	4.57 E-01	3.11 E-02	4.36 E+00	8.93 E-02	4.36 E+01	1.49 E-01	2.12 E-03	3.60 E-05
L	2.49 E-02	9.30 E-02	1.00 E-03	4.70 E-01	3.33 E-02	4.54 E+00	9.68 E-02	4.54 E+01	1.61 E-01	1.97 E-02	5.81 E-05

	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	
Case	Unlikely onsite HEPA fraction	Unlikely offsite HEPA fraction	Ex. un. onsite SOF aqueous boil-off	Ex. un. offsite SOF aqueous boil-off	Unlikely onsite SOF aqueous boil-off	Unlikely offsite SOF aqueous boil-off	Ex. un. onsite total SOF	Ex. Un. offsite total SOF	Unlikely onsite total SOF	Unlikely offsite total SOF	
H	4.45 E-02	7.00 E-05	1.90 E-01	5.88 E-04	7.11 E-01	7.58 E-03	1.91 E+01	1.99 E-01	9.75 E+01	7.76 E-01	
L	7.03 E-02	7.87 E-05	2.16 E-01	6.37 E-04	7.71 E-01	8.63 E-03	1.99 E+01	2.16 E-01	1.01 E+02	9.41 E-01	

ERPG = Emergency Response Planning Guideline.
HEPA = high-efficiency particulate air (filter).
SOF = sum of fractions.
TBP = tri-butyl phosphate.

CHECKLIST FOR PEER REVIEW

Document Reviewed: HNF-SD-WM-CN-099, *Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems*, Rev. 1.

Scope of Review: Attachment 6 only.

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.
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[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.

DONAVAN A. FOSS [signature] 8/11/98
Reviewer (Printed Name and Signature) 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.

Note: A HEDOP review is not required for this Attachment since all values related to dose consequences have been referenced from sources that have already received a HEDOP review.

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ATTACHMENT 7

DEVELOPMENT OF INGESTION DOSE CONSEQUENCES

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Development of Ingestion Dose Consequences

Grant W. Ryan
DE&S, Inc.

Development of Ingestion Dose Consequences

Ingestion ULDs

Using the following ingestion unit liter dose (ULD) information that is found in WHC-SD-WM-SARR-037, the W-320 specific ingestion ULDs are calculated in manner similar to the W-320 specific inhalation ULDs documented in Section 4.2 of the main body of this calculation note.

Waste Material	Ingestion ULD (Sv-m3)/(s-L)
SST Liquids	0.052
SST Solids	4.1
AWF Liquids	0.092
AWF Solids	8.1

For the 90/10 mix for Tank 241-AY-102, the following equation is used:

90/10 mix = 90%[(10%)(SST Liquids) + (90%)(AWF Liquids)] + 10%[(90%)(SST Solids) + (10%)(AWF Solids)]
90/10 mix = 0.53 (Sv-m3)/(s-L)

For the 67/33 mix for Tank 241-C-106, the following equation is used:

67/33 mix = 67%[(10%)(SST Liquids) + (90%)(AWF Liquids)] + 33%[(90%)(SST Solids) + (10%)(AWF Solids)]
67/33 mix = 1.54 (Sv-m3)/(s-L)

Dispersion Coefficients (X/Q's)

The following dispersion coefficients are used:

	offsite (s/m3)
acute	2.83E-05
24 hour	4.62E-06
Annual	1.24E-07

(Values derived from WHC-SD-WM-SARR-016)

Release Period (s)

600	10-min release
86400	24-hr release
31536000	Annual release

Ingestion Dose Calculation Methods

Ingestion doses are calculated only for the offsite receptor by using either of the following equations:

Ingestion Dose (Sv) = Q (L) x X/Q (s/m3) x ULD (Sv-m3/s-L)
or
Ingestion Dose (Sv) = Q (L/s) x X/Q (s/m3) x ULD (Sv-m3/s-L) x t (s)

where,

Q = source term amount (L)
Q = source term release rate (L/s)
X/Q = appropriate atmospheric dispersion coefficient from above (s/m3)
ULD = ingestion unit liter dose from above (Sv-m3/s-L)
t = release duration (s)

Ingestion Dose Calculations

Table 1. Ingestion Dose Calculations

Vent System	Type of Release	ULD	Amount of Waste Released from Vent System (L)	Unfiltered Particulate Release Rate (L/s)	Ingestion Dose from Vent System Release (Sv)	Ingestion Dose From 24-hr Unfiltered Release (Sv)	Ingestion Dose From Annual Unfiltered Release (Sv)	Total 24-hr Ingestion Dose (Sv)	Total Annual Ingestion Dose (Sv)	Ingestion Dose from 10-min Unfiltered Release (Sv)	Total 10-min Ingestion Dose (Sv)
241-702-A	Fire	90/10 mix	6.63E-05	1.9E-05	9.93E-10	4.0E-06	3.9E-05	4.0E-06	3.9E-05	1.7E-07	1.7E-07
241-702-A	Overpressure	90/10 mix	3.66E-02	1.9E-05	5.48E-07	4.0E-06	3.9E-05	4.5E-06	4.0E-05	1.7E-07	7.2E-07
241-702-A	Fire	AWF Liquids	6.40E-05	1.9E-05	1.67E-10	6.9E-07	6.8E-06	6.9E-07	6.8E-06	3.0E-08	3.0E-08
241-702-A	Overpressure	AWF Liquids	3.60E-02	1.9E-05	9.37E-08	6.9E-07	6.8E-06	7.9E-07	6.9E-06	3.0E-08	1.2E-07
241-702-AZ	Fire	90/10 mix	2.32E-03	9.4E-06	3.47E-08	2.0E-06	2.0E-05	2.0E-06	2.0E-05	8.5E-08	1.2E-07
241-702-AZ	Overpressure	90/10 mix	5.90E-03	9.4E-06	8.84E-08	2.0E-06	2.0E-05	2.1E-06	2.0E-05	8.5E-08	1.7E-07
296-P-16	Fire	67/33 mix	4.80E-05	3.3E-07	2.10E-09	2.0E-07	2.0E-06	2.1E-07	2.0E-06	8.7E-09	1.1E-08
296-P-16	Overpressure	67/33 mix	1.98E-02	3.3E-07	8.65E-07	2.0E-07	2.0E-06	1.1E-06	2.9E-06	8.7E-09	8.7E-07
296-P-16	Fire	SST Solids	4.40E-05	3.3E-07	5.11E-09	5.4E-07	5.3E-06	5.5E-07	5.3E-06	2.3E-08	2.8E-08
296-P-16	Overpressure	SST Solids	1.90E-02	3.3E-07	2.20E-06	5.4E-07	5.3E-06	2.7E-06	7.5E-06	2.3E-08	2.2E-06
296-C-006	Fire	67/33 mix	1.15E-03	1.7E-06	5.02E-08	1.0E-06	1.0E-05	1.1E-06	1.0E-05	4.5E-08	9.5E-08
296-C-006	Overpressure	67/33 mix	1.91E-01	1.7E-06	8.35E-06	1.0E-06	1.0E-05	9.4E-06	1.9E-05	4.5E-08	8.4E-06
296-S-15	Fire	SST Solids	7.30E-05	3.3E-07	8.47E-09	5.4E-07	5.3E-06	5.5E-07	5.3E-06	2.3E-08	3.1E-08
296-S-15	Overpressure	SST Solids	7.30E-03	3.3E-07	8.47E-07	5.4E-07	5.3E-06	1.4E-06	6.1E-06	2.3E-08	8.7E-07

The following table (i. e., Table 2) has been developed to supplement information that is documented in the main calculation note text. This table provides the total offsite radiological dose consequences (inhalation and ingestion) for the with CAM-fan interlock and without CAM-fan interlock cases for each ventilation system evaluated in the main text of this calculation note.

Table 2. Total Offsite Radiological Dose Calculations (Main Body Values Plus Ingestion from Table 1).

		A	B	C	D	E	F	G
Vent System	Type of Release	Inhalation Dose - No CAM-Fan Interlock (Sv)	Inhalation Dose With CAM-Fan Interlock (Sv)	Column A and B Values Found in Table X of Main CN-099 Text	Total 24-hr Ingestion Dose (Sv) From Table 1 Above	Total 10-min Ingestion Dose (Sv) From Table 1 Above	Total Radiological Offsite Dose No CAM-Fan Interlock (Sv) [A + D]	Total Offsite Radiological Dose With CAM-Fan Interlock (Sv) [B + E]
241-702-A	Fire	7.9E-05	4.1E-06	2	4.0E-06	1.7E-07	8.3E-05	4.3E-06
241-702-A	Overpressure	9.3E-05	1.7E-05	2	4.5E-06	7.2E-07	9.8E-05	1.8E-05
241-702-A	Wetting	7.9E-05	4.1E-06	2	4.0E-06	1.7E-07	8.3E-05	4.3E-06
241-702-AZ	Fire	4.1E-05	2.9E-06	4	2.0E-06	1.2E-07	4.3E-05	3.0E-06
241-702-AZ	Overpressure	4.2E-05	4.2E-06	4	2.1E-06	1.7E-07	4.4E-05	4.4E-06
241-702-AZ	Wetting	4.0E-05	2.1E-06	4	2.0E-06	8.5E-08	4.2E-05	2.2E-06
296-P-16	Fire	4.3E-06	2.8E-07	6	2.1E-07	1.1E-08	4.5E-06	2.9E-07
296-P-16	Overpressure	4.5E-04	4.4E-05	6	1.1E-06	8.7E-07	4.5E-04	4.5E-05
296-P-16	Wetting	4.3E-06	2.2E-07	6	2.0E-07	8.7E-09	4.5E-06	2.3E-07
296-C-006	Fire	2.3E-05	2.4E-06	8	1.1E-06	9.5E-08	2.4E-05	2.5E-06
296-C-006	Overpressure	2.4E-04	2.1E-04	8	9.4E-06	8.4E-06	2.5E-04	2.2E-04
296-C-006	Wetting	2.2E-05	1.1E-06	8	1.0E-06	4.5E-08	2.3E-05	1.1E-06

Note: For the "wetting" type of release for each ventilation system, the column D and E values reflect only the unfiltered release ingestion dose consequences from Table 1 (this attachment) and do not include any ingestion dose contribution from the ventilation system failure (e.g., HEPA release). This is consistent with the calculations performed in the main text of this calculation note.

References

WHC-SD-WM-SARR-016, 1996, Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SARR-037, 1996, Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

CHECKLIST FOR PEER REVIEW

Document Reviewed: HNF-SD-WM-CN-099, *Radiological and Toxicological Analyses of Tank 241-AY-102 and Tank 241-C-106 Ventilation Systems*, Rev. 1.

Scope of Review: Attachment 7 only.

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.

Janet S. Davis Janet S. Davis 8/9/98

Reviewer (Printed Name and Signature) 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.

Note: A HEDOP review is not required for this Attachment since all values related to dose consequences have been referenced from sources that have already received a HEDOP review.

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