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		Design Authority			
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1		Cog.Eng. R.N. Dale [signature] 8/30/99 S7-12			
1		Cog. Mgr. J.S. Schofield [signature] 8/30/99			
		QA			
		Safety			
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EXPERIENCE WITH AEROSOL GENERATION DURING ROTARY MODE CORE SAMPLING IN THE HANFORD SINGLE SHELL WASTE TANKS

J.S. Schofield
Lockheed Martin Hanford Corporation
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract:
This document provides data on aerosol concentrations in tank head spaces, total mass of aerosols in the tank head space and mass of aerosols sent to the exhauster during Rotary Mode Core Sampling from November 1994 through April 1999.

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EXPERIENCE WITH AEROSOL GENERATION DURING ROTARY MODE CORE SAMPLING IN THE HANFORD SINGLE SHELL WASTE TANKS

Prepared for
U. S. Department of Energy
Office of River Protection

By
John Schofield
Lockheed Martin Hanford Company

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Table of Contents

List of Figures

List of Tables

Glossary

ABCASH	Automated Bar Coding of Air Samples at Hanford
acfm	actual cubic feet per minute
CGM	combustible gas monitor
changeout	the replacement of air in a tank head space with a volume of air equal to the head space volume
Ci	curie, equal to 3.7E+10 disintegrations/sec
core	a top to bottom (or until sampling is halted) collection of segments taken from a tank riser
DF	decontamination factor
DOE	Department of Energy
EPA	Environmental Protection Agency
ERS	Environmental Release Summary (database)
exhauster	the exhauster used during RMCS on a tank
g	gram
GEA	gamma energy analysis
head space	the volume of air above the waste surface in a tank
HEPA	high efficiency particulate air
housing	the main body of the exhauster containing the filter media
kg	kilogram
mCi	millicurie, 1E-3 Ci
LFL	lower flammability limit
NDA	non destructive assay
NOC	Notice of Construction
PMCS	push mode core sampling
PTE	Potential to Emit
record sample	stack samples taken during RMCS to measure the radionuclides released to the atmosphere
RMCS	rotary mode core sampling
RMCS core	a core taken from a tank with one or more segments taken in RMCS mode
RPP	River Protection Project
scfm	standard cubic feet per minute
segment	an individual 19 inch long sample, or group of samples, taken which add up to 19 inches
specific activity	the concentration of a radionuclide in the waste on a mass basis, normally in µCi/g or mCi/g
TA	total alpha
TB	total beta
TWINS	Tank Waste Information Network System
TWRS	Tank Waste Remediation System
weighted average	an average which is weighted based upon a given parameter, in this document weighted averages are based upon the number of RMCS segments
WDOH	Washington State Department of Health
µCi	microcurie, 1E-6 Ci

EXPERIENCE WITH AEROSOL GENERATION DURING ROTARY MODE CORE SAMPLING IN THE HANFORD SINGLE SHELL WASTE TANKS

Summary

This document presents information on aerosol formation in tank head spaces during rotary mode core sampling (RMCS) from November 1994 through April 1999 in single shell waste tanks (SST) at the Hanford Site. The average tank head space mass concentration during RMCS has been 2.1E-5 g waste/m^3. The average mass of suspended solids present in a tank head space during RMCS has been 5.6E-2 g waste. The mass of waste sent to an exhauster during RMCS has averaged 5.3E-1 g waste per RMCS core and 8.3E-2 g waste per RMCS segment.

Purpose

The purpose of this document is to present estimates of the concentration and total mass of waste aerosols present in SST head spaces during RMCS, and estimates of the mass of aerosols sent to the exhauster used on the tank, based upon RMCS experience. This document presents all the data available on aerosol formation during RMCS in SSTs from November 1994 to April 1999.

This document is not an evaluation of aerosol formation processes, aerosol dispersion patterns within the tank head space, aerosol settling rates, or factors affecting removal of particulates from a tank. When using the values given in this document to estimate maximum potential quantities released to an exhauster, or to account for peak concentrations when evaluating potential accident scenarios, engineering judgement should be used as deemed necessary to adjust the values given in this document for conservatism.

Introduction

An estimate of the mass of aerosols sent to an exhauster during rotary mode core sampling is needed as a basis for the Potential to Emit (PTE) estimate in future environmental permits for the exhausters employed during RMCS. Estimates of tank head space mass concentrations and total suspended solids during RMCS are also used in certain accident analyses related to RMCS. Since the bit rotation and gas sparging nature of RMCS have a higher potential for aerosol generation than many in-tank activities, aerosols generated during RMCS may also provide an estimate of the upper limit for the concentration of aerosols to be found in a tank head space during these activities.

There are two current Notices of Construction (NOC) approved by the Washington Department of Health (WDOH) and one approved by the Environmental Protection Agency (EPA) for exhauster use during RMCS. The first WDOH permit is for Exhauster Systems 3 and 4 (referred to as Exhauster B and Exhauster C in this document) during RMCS in a tank that is normally passively ventilated (Reference NOC-3). The second WDOH permit (Reference NOC-4) is for RMCS in SX tank farm using the SX exhauster. The current EPA permit is for Exhauster Systems 3 and 4 in passively ventilated tanks (Reference NOC-5).

Very conservative aerosol estimates were used for the existing NOCs and accident analyses, not actual aerosol data. WHC 1993 provided the initial estimate of aerosols sent to the exhauster during RMCS. Based upon assumptions in this document, a value of 1 kg of waste sent to the exhauster per RMCS core taken from the tank was used as the basis for the first RMCS NOC (Reference NOC-1). This number was based upon drilling tests in drums of extremely hard and dry simulated saltcake. This material was intended to present a limiting case for RMCS drill bit testing, and was not physically representative of actual tank wastes. This 1 kg per RMCS core estimate was modified to 77 g waste per RMCS segment for NOC-2, NOC-3, and NOC-5, and 35 g per segment for RMCS in SX farm per Reference NOC-4.

A value of 600 g of waste in the tank head space was assumed in WHC 1997 for certain RMCS accident analyses. This number was based upon earlier conservative assumptions on particulates generated during a large gas release event in Tank 241-101-SY. A value of 100 g waste in the head space was used in an update of this RMCS accident analysis provided in a revision to HNF 1999 that has been submitted to the Department of Energy (DOE) for approval.

After nitrogen-purged RMCS operations commenced in November 1994, it became apparent that the estimates of aerosol generation rates based upon WHC 1993 were very conservative. This was evident from in-tank videos that showed very little dust formation and from the lack of any dose rate buildup on the in-tank prefilter (when used) or the exhauster HEPA filters. An evaluation was begun in 1997 to use RMCS data to estimate actual aerosol generation rates. This document provides the results of that evaluation.

Aerosol Estimation Methods

Dedicated particulate sampling methods such as the use of sticky tapes to capture aerosols for microscopic evaluation or using specially designed samplers was not performed for this evaluation. Funding and personnel were not available for an in-depth study, nor was such a study necessary. Aerosol quantities were estimated using the best data available from existing sources associated with RMCS. Four separate methods were used to provide estimates of the aerosols present in the tank head space or sent to the exhauster. The first method uses non destructive assay (NDA) of an exhauster filter housing to estimate particulates captured on the filters. The second method uses the RMCS exhauster HEPA filter dose rates following completion of a core to estimate the mass of waste on the filters. The third method estimates the tank head space aerosol concentration based upon analytical data from filter papers located upstream of combustible gas meters (CGMs) employed during RMCS. (A CGM draws air out of a tank headspace at a constant flow rate during RMCS to monitor for flammable gases.) The final method uses results from the RMCS exhauster stack record sampler, and HEPA filter decontamination factors (DF), to back-calculate to a head space radionuclide concentration.

It was not possible to utilize any single method of estimating aerosol quantities for all RMCS sampling events. For some sampling events, not all data types were available, or if available were not useful. Reasons for the data not being useful include no RMCS segments taken during the time period evaluated, analytical results not being available as of the release date for this document, analytical data being below background levels or having an analytical variance >±100%, or (for SX tank farm) other tanks being exhausted in parallel or series with the tank being core sampled. Table 1 lists the RMCS sampling events which provided the data for this document, the exhauster that was in service, the aerosol estimate methods used for that event, and the number of RMCS cores and segments obtained during the sampling method. The methods are summarized below.

RMCS Exhauster Housing NDA

Appendix A describes NDA of an exhauster housing after it had been used during RMCS on a number of tanks. Gamma assay of the housing was performed to measure the Cs^{137} on the prefilter, primary HEPA filter and secondary HEPA filter. The quantity of Cs^{137} present on each was estimated by comparison with the Cs^{137} count rate from a known standard measured in an equivalent geometry. The quantity on all three filters was summed to estimate the total sent to the exhauster. The mass of particulates was obtained by dividing the quantity of Cs^{137} present by a weighted average of the Cs^{137} concentration of the wastes in the tanks being exhausted. With this data, tank head space mass concentrations were calculated as well as the mass per core and per segment sent to the exhauster. A summary of the results is given in Table 2. The detailed results are given in Table A-1.

RMCS Exhauster HEPA Dose Rate Data

Appendix B describes using RMCS exhauster dose rate data to estimate aerosol quantities. The dose rate at the edge of the HEPA filter housing is used to estimate a quantity of Cs^{137} on the filter. To obtain an estimate of the waste mass on the filters, this estimated quantity is divided by a weighted average of the Cs^{137} concentration in the wastes of the tanks being exhausted. With this information, tank head space mass concentrations can be calculated as well as the mass per core or per segment sent to the exhauster. The minimum detection ability of the dose rate instruments used is 0.5 mR/hr. All RMCS exhauster dose rates following completion of an RMCS core were less than detectable except for when an exhauster registered slightly above the minimum detectable limit at 0.7 mR/hr after core sampling on TX-113 riser 3 in February, 1999. A summary of the results is given in Table 2. The detailed results are given in Table B-1.

CGM Filter Paper Analyses

Appendix C describes using CGM filter paper analytical data to estimate aerosol quantities. The filter papers are inserted in-line in front of a CGM where they catch the radionuclides in the tank vapors drawn into the CGM. These filter papers were removed and analyzed starting in 1997. For conservatism, only sample results with a variance <100% were used. These analytical data were divided by the specific activity of the radionucides present on the filter paper for the tank on which the CGM was being operated. This provides an estimate of the aerosol concentration in the tank head space since a particulate sample is drawn directly from the tank head space during RMCS. With this data, the mass of waste in the head space and the mass per core and per segment sent to the exhauster can be calculated. A summary of the results is given in Table 2. The detailed results are given in Tables C-1 to C-4.

Record Sample Data

Appendix D describes the method used to calculate aerosol quantities based upon RMCS exhauster record sample data. This method is potentially not as accurate as the other three methods and the results should be viewed as rough estimates only. The potential for less accurate results is due both to the need to assume a decontamination factor (DF) for the HEPA filter housing, and because the record sample data is so low as to be almost negligible. Most of the results had analytical variances of >±100. Some were negative due to the sample count rate being lower than the background count rate. To eliminate unrealistic results, only the positive analyses with a variance <100% were used. These values were divided by the specific activity of the radionuclide in the tank being exhausted to estimate the total mass of waste on the filters. With this data, tank head space mass concentrations were calculated as well as the mass per core or per segment sent to the exhauster. A summary of the results is given in Table 2. The detailed results are given in Tables D-2 to D-5.

One of the RMCS exhauster record sample data points used is suspect. The 1998 composite record sample analytical result for Am^{241} was higher than expected based upon earlier results and the ratio of Am^{241} to total alpha, total beta and Cs^{137} results for the same composite. This record sample data point was not deleted, results are provided both with and without the data point.

All calculations conservatively assumed that the background radionuclide concentration in a tank head space was zero, and that all radionuclides detected by one of these four methods were due solely to RMCS activities.

Discussion of Results

All aerosol estimation methods measured radionuclides present either on the exhauster filters, in the tank head space air, or in the exhauster stack. These radionuclide quantities were divided by the specific activity of waste in the tank to provide mass quantities in the air, on the filters or in the exhaust stream. Appendix E provides the waste specific activities used in this document, along with limitations and potential errors associated with using them.

The calculated average mass concentration in a tank head space during RMCS ranged from a low of 5.5E-6 g/m^3, based upon exhauster housing NDA data, to a high of 4.0E-5 g/m^3, based upon CGM filter paper data. The weighted average of all four methods (based upon numbers of segments obtained during use of that method) was 2.1E-5 g/m^3. The average mass concentration is not the peak concentration, as illustrated by Figure 1. Figure 1 is a representation of relative concentrations only, not a plot of measured concentrations during a specific sampling event. Lines A and B represent aerosol concentrations at points near the drill string and at the tank outlet to the exhauster respectively. Line C represents the calculated average concentration in the tank head space. The peak concentration in the air to the exhauster can exceed the average tank head space concentration for short periods of time. The peak concentration may be higher than the calculated average concentration given in this document, depending upon how long the exhauster or CGM was operating. The longer the run time, the larger the volume of air is that the stack record sampler or CGM filter paper radionuclide quantity is divided by. It is beyond the scope of this document to provide a detailed spatial and time-dependent analysis of tank aerosol concentrations. The methods used in this document provide an estimate of a nominal average mass concentration only.

The average mass of suspended solids in a tank head space was estimated by multiplying the average head space mass concentration by the tank head space volume. The calculated average mass of suspended solids in a tank head space during RMCS ranged from a low of 1.2E-2 g, based upon exhauster housing NDA data, to a high of 1.0E-1 g, based upon CGM filter paper data. The weighted average of all four methods was 5.6E-2 g. Comparing the average to the 600 g and 100 g values used for past accident analysis assumptions it is evident that the accident analyses were conservative by at least three to four orders of magnitude.

Multiplying an average concentration by the tank head space volume to estimate the mass of suspended solids in the tank head space at a given time makes the simplifying assumption that the tank head space concentration is constant with time, and uniform within the head space during RMCS. These simplifying assumptions are not totally correct, as illustrated by Figure 1. With all other variables being equal, the mass concentration and mass of suspended solids in a tank head space will also be affected by the volume of the head space and the exhaust flow rate. The values presented in this document are averages only, based upon the tanks sampled to date.

The calculated mass of waste sent to an exhauster during RMCS ranged from lows of 2.2E-1 g/core and 3.5E-2 g/segment, based upon CGM filter paper data, to highs of 1.0E+0 g/core and 1.7E-1 g/segment, based upon exhauster record sample data. The weighted average of all four methods was 5.3E-1 g/core and 8.3E-2 g/segment. Comparing the average to the 1 kg/core and 35-77 g/segment numbers used for the PTE estimates it is evident that the PTE estimates are conservative by at least three orders of magnitude.

The data in this document were obtained during RMCS in ten separate tanks. A total of 20 RMCS cores containing 106 RMCS segments were obtained. The driest tank sampled was TX-113, which had an interstitial liquid level approximately ten feet below the waste surface. It was expected that this tank would show the highest aerosol generation levels during RMCS. In fact, the levels experienced during RMCS in this tank were among the lowest of any tank. This is discussed under the evaluation of CGM filter paper data in Appendix C.

Results given in this document based upon total beta or individual beta-gamma radionuclides are likely more valid than total alpha or individual alpha based results due to the higher concentrations of beta-gamma radiouclides in the waste and their greater ease of measurement when compared to alpha emitters. Equal weight is given to all results regardless of whether based upon total alpha, total beta or individual radionuclide data. This provides conservative results since the total beta or individual beta-gamma based aerosol values were normally lower than those based upon total alpha or individual alpha emitter results.

The results based upon HEPA filter NDA and CGM filter paper data have a firmer basis than the results based upon HEPA dose rate or RMCS stack record sample data. The NDA method is a direct physical measurement of essentially all the Cs^{137} released to the exhaust stream during RMCS in the tanks on which the filters were present. The CGM filter paper data is a direct measurement of the concentration in the air in a tank head space during RMCS. Aerosol measurements based upon HEPA dose rate are conservative as the filters showed no detectable dose rate for three of the four periods evaluated, and a barely perceptible reading after the fourth period. Back-calculation based upon RMCS stack record sample data is also less reliable due to the majority of the concentration data being at or less than background level, and the need to assume a decontamination factor for the filters. The average results from each method were within reasonable agreement with each other considering all the variables and assumptions involved.

Some of the CGM data points, and more than half of the record sample data points, had negative lab results or $\geq$100% variance in the lab data. These values were not used. If a value of zero had been used for all unused CGM filter paper and stack record sample data points instead of ignoring them, the weighted averages in Table 2 would be reduced by about 23% when excluding the high Am^{241} data point, or by about 40% when it is included.

This document contains seven appendices. Appendices A-D provide particulate results based upon RMCS exhauster housing NDA, RMCS exhauster housing dose rates, CGM filter paper data, and RMCS exhauster stack record sample data respectively. Appendix E provides waste specific activities, and Appendix F provides the raw data used in Appendices A-D. Appendix G provides references for this document.

Conclusions

The results in this document are based upon RMCS experience from startup of nitrogen-purged RMCS in November 1994 through April 1999. Table 2 summarizes the information presented in Appendices A, B, C and D. Based upon this information and the lack of any significant aerosol formation seen in in-tank videos, it can be concluded that past estimates of aerosol concentrations used for regulatory permits and accident analyses were conservative by a nominal three orders of magnitude.

In order to estimate mass releases for regulatory permits, the overall emissions with time are needed as a basis for the PTE estimates. For future permits the mass per core or mass per segment values in Table 2 can be used directly, with conservatism added as desired. When estimating peak concentrations or mass quantities in the tank head space for use in accident analyses, appropriate conservatism should be added to the values in Table 2.

Table 1 Summary Of Aerosol Estimation Methods Used

Tank/Date Sampled		BY-106 1994	BY-106 1995	BY-110 1995	BY-105 1995	SX-101 1997-98	SX-103 1998	SX-105 1998	SX-102 1998	S-110 1998	U-107 1998	BY-105 1998	BY-105 1998	TX-113 1998-99	TX-113 1999	#Cores/ #Segments*
Riser Sampled		10B	10B	12B, 7, 12B, 4	12A	19 / 4	7 / 11	6 / 14	8, 4	6 / 14	7, 2	7	11B	3	5	
Exhauster Used		2 (A)	2 (A)	2 (A)	3 (B)	SX	SX	SX	SX	4 (C)	4 (C)	4 (C)	4 (C)	3 (B), 4 (C)	3(B)	
Aerosol Estimation Method Used	NDA									X (same filters in place, Exhauster C only for TX-113)						7/50
	HEPA Dose Rate	X (same filters in place)			X					X (same filters in place, Exhauster C only for TX-113)					X	13/83
	CGM Filter Paper Data					X / X	X / X	X / X	X	X	X	X	X	X(C)	X	15/74
	RMCS Stack Record Sample Data		X	X	X					X	X	X	X			10/57
										Some composite data used						

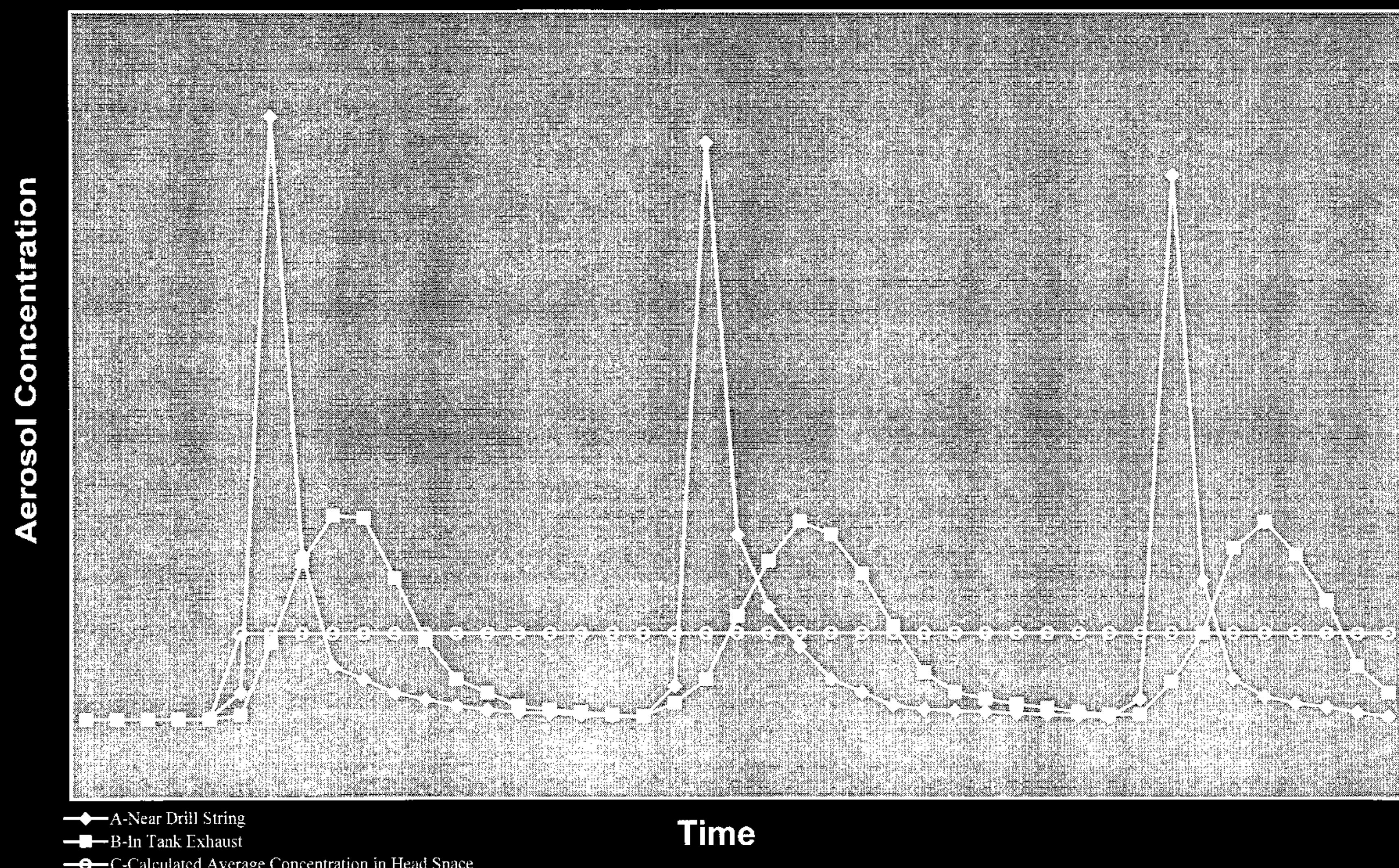
* A total of 20 RMCS cores and 106 RMCS segments were taken between 11/94 and 4/99. Total of cores and segments in last column are >20 and 106 as more than one aerosol estimation method was used when most segments were taken.

Table 2 Summary Of RMCS Aerosol Data

Aerosol Estimation Method	Average Tank Head Space Mass Concentration during RMCS (g waste/m³)	Average Mass of Suspended Solids in Tank Head Space During RMCS (g waste)	Average Mass per RMCS Core to Exhauster (g waste)	Average Mass per RMCS Segment to Exhauster (g waste)
NDA of Exhauster Filter Housing	5.5E-6	1.2E-2	3.4E-1	4.7E-2
Dose Rate Increase on RMCS Exhauster HEPA Filter Housing	1.4E-5	4.8E-2	5.8E-1	9.1E-2
Combustible Gas Meter Filter Paper Data	4.0E-5	1.0E-1	2.2E-1	3.5E-2
RMCS Exhauster Record Sample Data	2.2E-5 (1.0E-4)[1]	4.5E-2 (2.2E-1)[1]	1.0E+0 (4.8E+0)[1]	1.7E-1 (7.8E-1)[1]
Weighted Average of All Methods[2]	2.1E-5 (3.8E-5)[1]	5.6E-2 (9.3E-2)[1]	5.3E-1 (1.3E+0)[1]	8.3E-2 (2.2E-1)[1]

[1] Numbers in parenthesis include suspect Am^{241} 1998 composite record sample result
[2] Weighted average based upon number of RMCS segments taken with each method

Figure 1 Relative Waste Aerosol Concentrations In Tank Head Space[1]



[1] Figure is conceptual model only showing relative concentrations in tank head space, not actual measurements

APPENDIX A

ESTIMATION OF AEROSOLS GENERATED DURING RMCS BASED UPON RMCS EXHAUSTER HOUSING NON-DESTRUCTIVE ASSAY

APPENDIX A - Estimation Of Aerosols Generated During RMCS Based Upon RMCS Exhauster Housing Non-Destructive Assay

Summary of Method

This method of estimating RMCS aerosol generation quantities uses non-destructive assay (NDA) of the exhauster housing to determine the Cs^{137} quantity (mci) on the filters inside. This Cs^{137} quantity is then divided by a weighted average of the waste specific activities (mci/g) for the tanks on which the exhauster (and the same filters) was present during sampling. The resulting mass on the filters divided by the volume of air flowing through the exhauster provides an estimate of the average aerosol mass concentration in the air to the exhauster. This value was multiplied by the tank head space volume to obtain the average mass of particulates present in the tank head space during RMCS. The mass of waste on the filters divided by the number of rotary cores or segments taken provides the mass per core or per segment sent to the exhauster.

Description

Particulates in the exhaust stream are removed by the HEPA filter(s) upstream of the exhaust fan. The captured particulates contain radionuclides, with Cs^{137} being the predominant gamma emitter. By performing an NDA of the exhauster housing, the quantity of Cs^{137} on the HEPA can be estimated. This Cs^{137} value is then used to back-calculate to a waste mass quantity on the filter using the Cs^{137} concentration in the tank waste. This filter waste mass quantity is used to calculate the concentration of particulates in the tank exhaust stream, the total suspended solids in the tank head space, and the mass of waste sent to the exhauster for each RMCS core or segment taken.

Dividing the Cs^{137} content of the HEPA by the specific activity of Cs^{137} in the waste gives the estimated mass of waste sent to the exhauster. The specific activity value used for the waste in each tank sampled is given in Table E-1. Since RMCS was performed on more than one tank prior to the NDA, a weighted average specific activity was used. The weighted average specific activity was calculated based upon the number of RMCS segments taken from each tank sampled.

The average mass of aerosols in the tank head space was obtained by multiplying the average tank head space particulate concentration by the tank head space volume.

The mass sent to the exhauster per RMCS core or per RMCS segment was obtained by dividing the mass of waste sent to the exhaust stream by the numbers of RMCS cores or RMCS segments obtained during the exhauster operating time. The number of RMCS cores and segments is provided in Table F-1-1.

Exhauster C had the same filters present during RMCS in tanks S-110, U-107, BY-105, and the first core in TX-113. Following this usage, an NDA was performed on the exhauster housing to determine the Cs^{137} content of the prefilter, first HEPA filter and second HEPA filter. The results are presented in Appendix F, Section 2.0. The NDA was performed as described in Greager 1999. A gamma energy analysis was done of the housing at a number of points adjacent to the prefilter, first HEPA and second HEPA. Cs^{137} was the only radionuclide reported as present. The Cs^{137} count rate at these locations was compared to the count rate with a mock-up of a similar housing geometry with a known Cs^{137} source located in the middle of the filter.

Table E-1 lists the specific activities of the wastes in S-110, U-107, BY-105 and TX-113. A weighted average specific activity for the waste on the filters was obtained by:

[[0.227 mCi/g][10 seg]+[0.121mCi/g][10 seg]+[0.225 mCi/g][18 seg]+[0.130 mCi/g][12 seg]]÷[10+10+18+12 segments] = 0.182 mCi/g

Calculating a weighted average based upon the number of segments assumes aerosol generation is roughly the same per segment and the specific activity of a radionuclide is constant throughout a tank. These assumptions are adequate for the purpose of this document. Aerosol generation can vary with water content, waste hardness, depth of sample taken, nitrogen flow rate and porosity of the waste, but an in-depth evaluation of all these parameters is beyond the scope of this document. The impact of these variables should average out over the 106 RMCS segments taken. The specific activities used do not vary greatly from tank to tank, and any variations will not have a significant impact on the final aerosol results. See Appendix E for further discussion of limitations on specific activities used in this document.

Per Appendix F, Table F-2, the total quantity of Cs^{137} present in the housing was 0.430 mCi. The total mass of waste on the filters was thus:

0.430 mCi ÷ 0.182 mCi/g waste = 2.37 g waste in exhauster

The tank head space particulate concentration was obtained by dividing the mass of waste sent to the exhaust stream by the volume of air sent to the exhauster. This latter value was obtained by multiplying the exhauster flow rate by the exhauster run times for each tank from Table F-1-1. The recorded exhauster flow is not the actual cfm flow rate. The RMCS exhauster flow rate is controlled to a nominal 200 "scfm". This "scfm" is based upon 29.921 in. Hg (760 mm Hg) and 69°F (21°C). The indicated RMCS exhauster flow rate is thus what the flow rate would be for the same mass flow if the temperature and pressure in the exhauster inlet were 29.921 in. Hg and 69°F. A correction factor is built into the equipment logic that assumes an atmospheric pressure of 29.27 in Hg, the average atmospheric pressure at Hanford. The temperature of the gas is sensed and the measured flow rate automatically corrected to what it would be at 69°F.

The exhauster will operate at about 1-2 in. H_2O negative pressure, resulting in about a 29.16 in. Hg pressure in a waste tank. To revise the indicated 200 scfm exhauster reading to an actual cfm value for this document, the 200 scfm value was multiplied by (29.92/29.16)(T+459)/528. Tank vapor space temperature data were obtained from Table F-1-1. The calculated flow rates during RMCS for these tanks were 207 acfm (S-110), 206 acfm (U-107), 208-209 acfm (BY-105) and 203 acfm (TX-113).

The total volume of tank air through the exhauster during core sampling of these tanks was thus:

[[207 cfm][159.78 hr]+[206][273.85]+[208][135.77]+[209][307.92]+[203][358.28]][60 min/h]= 1.55 E+7 ft^3

The average tank head space mass concentration during RMCS in the above tanks when Exhauster C was being employed was:

[2.37 g ÷ 1.55 E+7 ft^3] x [35.315 ft^3/m^3] = 5.5 E-6 average g waste per m^3 in exhauster inlet

The average mass of waste in a tank head space was calculated by multiplying the tank head space mass concentration by the tank head space volume from Table F-1-2, as shown below for S-110:

[2.37 g ÷ 1.55 E+7 ft^3] x [89100 ft^3] = 1.38E-3 g waste in S-110 head space

The particulate quantities in the other three tank head spaces were calculated in a similar manner. The weighted average mass in a tank head space was based upon the number of segments taken in each tank.

Table F-1-1 shows the number of rotary cores (7) and rotary segments (50) taken when this exhauster and these filters were present. The average mass of waste sent to the exhauster is thus:

2.37 g waste ÷ 7 rotary cores = 3.4E-1 g waste/rotary core

or

2.37 g waste ÷ 50 rotary segments = 4.7E-2 g waste/rotary segment

All data were input to a spreadsheet to perform the calculations. Results are provided in Table A-1.

Summary of Calculations

Non Destructive Assay was performed on an RMCS exhauster used on four tanks during which seven RMCS cores and 50 RMCS segments were obtained. The results indicate:

- The average tank head space mass concentration during RMCS was 5.5E-6 g waste/m^3.
- The average mass of suspended solids in the tank head space during RMCS was 1.2E-2 g waste.
- The average mass sent to the exhauster during RMCS was 3.4E-1 g waste/core.
- The average mass sent to the exhauster during RMCS was 4.7E-2 g waste/segment.

Table A-1 Concentrations And Aerosol Mass Quantities During RMCS Based Upon NDA of Exhauster C Filter Housing

Tank and Risers Sampled	Average Aerosol Concentration in Air to Exhauster (g waste/m^3)	Average Mass of Particulates in Tank Head Space During RMCS (g waste)		g waste/RMCS Core	g waste/RMCS segment
S-110 R6, R14		1.4E-2			
U-107 R7, R2		9.2E-3			
BY-105 R7 1998	5.5E-6	1.3E-2	1.2E-2	3.4E-1	4.7E-2
BY-105 R11B 1998		1.3E-2			
TX-113 R3		1.1E-2			

APPENDIX B

ESTIMATION OF AEROSOLS GENERATED DURING RMCS BASED UPON RMCS EXHAUSTER HEPA FILTER DOSE RATES

APPENDIX B - Estimation Of Aerosols Generated During RMCS Based Upon RMCS Exhauster HEPA Filter Dose Rates

Summary of Method

This method of estimating RMCS aerosol generation quantities multiplies the dose rate increase (mR/hr) at the side of the RMCS HEPA filter housing by a calculated dose conversion factor (mCi/mR/hr) to obtain an approximation of the radionuclide quantity (mCi) on the HEPA filter. This radionuclide quantity is divided by the waste specific activity (mCi/g) to determine the mass of waste on the HEPA filter. Dividing the HEPA filter waste mass by the volume of air passing through the filter provides an estimate of the average tank head space particulate concentration during RMCS. Multiplying the average tank head space particulate concentration by the tank head space volume gives an estimate of the average mass of suspended particulates in the tank head space during RMCS. Dividing the HEPA filter waste mass by the number of RMCS cores or RMCS segments provides the mass per RMCS core or per RMCS segment sent to the exhauster.

Description

Particulates in the exhaust stream are removed by the HEPA filter(s) upstream of the exhaust fan. The captured particulates contain radionuclides, with Cs^{137} being the predominant gamma emitter. As the particulate quantity on the HEPA filter increases, the dose rate at the side of the filter housing will increase proportionately. By monitoring the HEPA dose rate at the side of the filter housing, the quantity of Cs^{137} on the HEPA can be estimated. This Cs^{137} value is then used to back-calculate to a waste mass quantity on the filter using the Cs^{137} concentration in the tank waste. This filter waste mass quantity is used to calculate the concentration of particulates in the tank exhaust stream, the total suspended solids in the tank head space, and the mass of waste sent to the exhauster for each RMCS core or segment taken.

During RMCS exhauster operation, the dose rate, in mR/hr, at the side of the HEPA filter housing is periodically measured with an Eberline RO-3B per procedure to indicate when radioactive particulates are building up on the filter. The data from all tanks on which an RMCS exhauster was present during RMCS sampling (BY-105 (1995&1998), BY-106, BY-110, S-110, TX-113, and U-107) were used.

The dose rate at the side of the SX exhauster HEPA filter housing was measured during RMCS of SX farm tanks (for sampling of tanks SX-101, SX-102, SX-103 and SX-105) but the data is not useful for this document because the SX exhauster draws on 13 tanks in parallel or in series with the tank being core sampled. Many of the tanks have a much higher off gas flow rate than the sampled tank. In addition, there is background radiation in the area of the SX exhauster filter housing, making a small increase in the housing dose rate due to RMCS difficult to detect.

Table F-1-1 in Appendix F lists the RMCS exhauster run times, core and segment numbers, and HEPA filter dose rates following RMCS on a tank. The exhauster operations were grouped into four distinct periods for analysis in Appendix B. Table B-1 summarizes the data for each period.

No dose rates above minimum detectable limits were evident at the sides of any RMCS exhauster until mid 1998-early 1999. The limit of detection of the RO-3B is 0.5 mR/hr. All dose rate measurements were less than detectable until sampling on BY-105 in 1998 with Exhauster C. During RMCS on this tank, there were a few readings of 0.7 mR/hr, but most were <0.5 mR/hr. The variation in readings is to be expected as the specific instrument, person using the instrument, and location at which the dose rate is checked can vary with time. Following completion of the first core in TX-113, Exhauster C was listed as having a 0.7 mR/hr dose rate. For exhauster periods 1, 2, and 4 listed in Table B-1 it was conservatively assumed that the dose rate at the side of the housing at the beginning of the period was zero, and the final dose rate was equal to 0.5 mR/hr. For period 3 it was conservatively assumed that the dose rate at the side of the housing at the beginning of the period was zero, and the final dose rate was equal to 0.7 mR/hr.

The dose rate was converted into a Cs^{137} content on the primary filter. Dose rate calculations (O'Conner 1997) performed using Microshield for an RMCS exhauster HEPA filter housing give a dose conversion factor of 2.38 mR/hr/mCi Cs^{137} at the side of the housing, assuming even dispersal of waste material on the first HEPA filter.

The assumption that radionuclides are evenly distributed on the HEPA is a reasonable assumption based upon the exhauster design and the method used to measure the radiation dose rate. A similar dose calculation using ISOSHLD (Crocker 1998) estimated 2.82 mR/hr/mCi Cs^{137} in the filter housing. The lower value of 2.38 mR/hr/mCi Cs^{137} was used as it will give a higher (more conservative) mass on the filters.

Gamma emitting Cs^{137} is the predominant radionuclide contributor to filter dose rates. Beta emitting Sr^{90} can contribute to the dose rate due to bremsstrahlung radiation, and other nuclides may provide some small additional dose, but the major dose rate contributor in aged SST waste is Cs^{137}. Ignoring the presence of all radionuclides (including Sr^{90}) except Cs^{137} in calculating a HEPA filter waste mass will provide a conservative result. This is because assuming all radiation present is due to Cs^{137} will result in overestimating the Cs^{137}content of the filter housing, which in turn will result in overestimating the waste mass on the HEPA filter.

Dividing the HEPA dose rate for each exhauster installation by the dose conversion factor of 2.38 mR/hr/mCi results in a maximum increase of 0.21 mCi Cs^{137} on the RMCS exhauster HEPA for operation periods 1, 2 and 4 and 0.29 mCi for period 3, of Table B-1.

Dividing the Cs^{137} content of the HEPA by the specific activity of Cs^{137} in the waste gives the estimated mass of waste sent to the exhauster. The specific activity value used for the waste in each tank sampled is given in Table E-1. Since RMCS was performed on more than one tank in operating periods 1 and 3, a weighted average specific activity was used for these periods. The weighted average specific activity was calculated based upon the number of RMCS segments taken from each tank sampled during that period. Calculations to estimate the specific activity of waste mixtures were performed in the same manner as shown in Appendix A. The specific activities used for each operating period are shown in Table B-1.

For all installations excluding BY-106 in 1994 and 1995 the RMCS exhausters were hooked directly to the waste tank, so the mass of waste sent to the exhauster was assumed equal to the mass of waste entering the bottom of the tank riser. When sampling BY-106 a prefilter was installed in the tank riser between the tank and the exhauster. For BY-106 the mass of waste sent to the exhauster was multiplied by a factor of 5 to account for a decontamination factor (DF) across the in-tank prefilters (see Appendix D for basis of DF for BY-106 prefilter).

The mass sent to the exhauster per RMCS core or per RMCS segment was obtained by dividing the mass of waste entering the riser by the number of RMCS cores or RMCS segments obtained during the exhauster operating period. The numbers of RMCS cores and segments are provided in Table F-1-1.

The tank head space particulate concentration was obtained by dividing the mass of waste entering the riser by the volume of gas sent to the exhauster. This volume of gas sent to the exhauster was obtained by multiplying the exhauster flow rate by the exhauster run time from Table F-1-1. The calculations for aerosols generated based upon HEPA dose rates use actual cfm while the exhauster flow is based upon standard cfm. The spreadsheet file used for the calculations converted scfm to acfm. See Appendix A for the method used to convert scfm to acfm.

The average mass of aerosols in the tank head space was obtained by multiplying the average tank head space particulate concentration by the tank head space volume from Table F-1-2.

Following is an example of how the mass of waste on a filter, mass per RMCS core, mass per RMCS segment, average tank head space mass concentration and average mass of aerosols in the tank head space were calculated for exhauster operating period #1. Data used are from Tables E-1, F-1-1, and F-1-2.

[0.21 mCi] [1000 μCi/mCi] = 210 μCi Cs^{137} on HEPA

[210 μCi Cs^{137} on HEPA] ÷ [177 μCi Cs^{137}/g waste] = 1.19 g waste on HEPA

[1.19 g][[DF of 5 for BY-106 prefilter][11 seg] + [DF of 1 for BY-110][13 seg]] ÷ [11+13 seg] = 3.37 g waste from tank

(Note the DF of 5 to account for the prefilter is only applicable to the RMCS of BY-106 in 1994 and 1995, for all other exhauster periods the mass of waste on the HEPA was equal to the mass leaving the tank)

[200 scfm] x [29.92÷29.16] x [83+459] ÷528 = 211 acfm to exhauster from BY-106 in 11-12/94

using same formula results in 210 acfm for BY-106 in 1/95, and 209 acfm for BY-110.

3.77 g waste÷[((211 acfm)(48.78 hr)+(210)(18.67)+(209)(112.5))(60 min/hr)]= 1.49E-6 average g waste/ft^3 in head space

[1.49E-6 g/ft^3] [35.315 ft^3/m^3] = 5.3 E-5 average g waste per m^3 in tank head space

[1.49E-6 g/ft^3] [53,700 ft^3 in BY-106 head space] = 8.0E-2 average g waste in BY-106 head space during RMCS

[1.49E-6 g/ft^3] [92,000 ft^3 in BY-110 head space] = 0.14 average g waste in BY-110 head space during RMCS

[3.37 g waste] ÷ [4 RMCS cores] = 0.84 g waste per core to exhaust stream

[3.77 g waste] ÷ [24 RMCS segments] = 0.14 g waste per segment to exhaust stream

All data were input to a spreadsheet and the mass to exhauster per RMCS core, mass to exhauster per RMCS segment, average tank head space mass concentration, and average mass of aerosols in the tank head space were calculated for each of the RMCS exhauster operating periods shown in Table B-1 in the same manner as shown above. Results are given in Table B-2.

Summary of Calculations

RMCS exhauster operations were segregated into four operating periods during which RMCS was performed. The exhauster data for BY-108 was not used in these calculations as no RMCS was performed in this tank. Exhausters were operated in six tanks during which 13 RMCS cores and 83 RMCS segments were obtained. The results indicate:

- The average tank head space mass concentration during RMCS was 1.4E-5 g waste/m^3.
- The average mass of suspended solids in the tank head space during RMCS was 4.8E-2 g waste.
- The average mass sent to the exhauster during RMCS was 5.8E-1 g waste/RMCS core.
- The average mass sent to the exhauster during RMCS was 9.1E-2 g waste/RMCS segment.

These values are conservative as no increase was seen in the exhauster HEPA filter dose rate during RMCS in any of the exhauster operating periods except for period #3, which showed a barely detectable radiation level after being operable during the time a total of 50 RMCS segments were taken. The in-tank prefilters used in both BY-106 sampling events showed no detectable contamination. Using a DF of 5 for the BY-106 prefilter skews the results high. Without this DF, the average numbers above would be reduced by about 30%.

The calculated 0.29 mCi Cs^{137} present in the exhauster housing primary HEPA filter for operating period #3 corresponds closely to the 0.28 mCi Cs^{137} shown by the NDA data for the primary HEPA in Table F-2.

Table B-1 RMCS Exhauster Operating Periods Used For Filter Housing Dose Rate Aerosol Estimates

Operating Period, and Dates of Operation	Exhauster Used	Tanks Sampled	Dose Rate at End of Sampling (mR/hr)	Specific Activity Used for Waste on Filter (µCi/g waste)	Assumed Maximum Cs^{137} Content of Housing (mCi)
#1 11/17/94 - 10/20/95	A (#2)	BY-106, BY-110	<0.5	177	0.21
#2 7/24/95 - 9/15/95	B (#3)	BY-108*, BY-105	<0.5	225*	0.21
#3 5/19/98 - 2/12/99	C (#4)	S-110, U-107, BY-105, TX-113	0.7	182	0.29
#4 9/22/98 - 4/29/99	B (#3)	TX-113	<0.5	130	0.21

* No RMCS was performed in BY-108 so the specific activity for operating period #2 is equal to the BY-105 specific activity

Table B-2 Concentrations And Aerosol Mass Quantities During RMCS Based Upon HEPA Filter Dose Rate at Side of RMCS Exhauster

Operating Period from Table B-1	Average Tank Head Space Concentration (g waste/m^3)	Average Mass of Suspended Solids in Tank Head Space (g waste)	Mass per RMCS Core to Exhauster (g waste)	Mass per RMCS Segment to Exhauster (g waste)
1	5.3E-5	8.0E-2 BY-106 1.4E-1 BY-110	8.4E-1	1.4E-1
2	5.9E-5	1.4E-1 BY-105	9.3E-1	3.1E-1
3	3.7E-6	9.4E-3 S-110 6.3E-3 U-107 8.7E-3 BY-105 7.5E-3 TX-113	2.3E-1	3.2E-2
4	4.2E-5	8.5E-2 TX-113	1.6E+0	2.7E-1
Overall Average*	1.4E-5	4.8E-2	5.8E-1	9.1E-2

* The overall average is sum of total gms waste divided by total number of cores or segments (for columns 2 or 3), total gms waste divided by total off gas volume (for column 4), and a weighted average of the tank head space mass quantities with the weighted average based upon number of segments taken in the tank (for column 5).

APPENDIX C

ESTIMATION OF AEROSOLS GENERATED DURING RMCS BASED UPON CGM IN-LINE FILTER PAPER ANALYSES

APPENDIX C - Estimation Of Aerosols Generated During RMCS Based Upon CGM In-Line Filter Paper Analyses

Summary of Method

This method of estimating RMCS aerosol generation quantities uses radionuclide assay data from in-line filter papers located upstream of continuous gas monitors (CGM) sampling the tank air for flammable gases during RMCS. The radionuclide content (μCi) of the filter paper is divided by the waste radionuclide specific activity (μCi/g) and the air flow through the CGM to obtain an estimate of the average mass concentration in the tank head space. Multiplying the estimated average tank head space mass concentration by the tank head space volume gives an estimate of the average mass of particulates in the tank head space during RMCS. To obtain the mass per RMCS core or per RMCS segment sent to the exhauster, the tank head space average mass concentration is multiplied by a correction factor to account for particulates in the head space removed by the exhauster when the CGM is not operating, then multiplied by the volume of gas sent to the exhauster, and divided by the number of RMCS cores or RMCS segments.

Description

During most tank waste intrusive activities performed since 1996, an intrinsically safe CGM located above ground is used to continually monitor the tank air for flammable gases during in-tank activities. The CGM sampling method draws air directly from the tank head space. During RMCS, the CGM sampling line is placed as close as practical to the sampling riser and between the sampling riser and the exhaust riser. A pump in the CGM draws tank air up through the line at 0.5 lit/min for measurement of the lower flammability limit (LFL) by the CGM. A filter paper is installed in the sampling line upstream of the CGM to protect the unit from internal contamination. These filter papers are normally checked in the field for contamination and discarded. However, to help measure the tank head space particulate levels during RMCS, they were saved and sent to a lab for analysis for all the tanks in which RMCS was performed since the restart of RMCS in late 1997 through the end of April 1999.

There were 14 CGM installations during RMCS when CGM filter papers were collected and analyzed. Each of these installations had Cs^{137}, total alpha and total beta quantities measured on the filter papers, resulting in 42 data points. Eight of these values were very low and had errors of >±100%, resulting in a net of 34 data points used for calculating head space radionuclide concentrations based upon CGM data. The filter paper data and the calculated head space radionuclide concentrations are provided in Appendix F, Tables F-3-1 and F-3-2.

Average tank head space mass concentrations based upon CGM filter paper data were calculated by dividing the head space radionuclide concentrations from Table F-3-2 by the waste specific activities from Table E-1. For example, the calculated SX-101 head space mass concentration based upon the Cs^{137}analysis from the CGM filter papers used during RMCS of riser 19 is:

[5.9E-10 μCi/ml ÷ 112 μCi/g waste] [28317 ml/ft^3] = 1.5E-7 g waste/ft^3

and:

[1.5E-7 g waste/ft^3] [35.31467 ft^3/m^3] = 5.3E-6 g waste/m^3

The estimated aerosol mass in the head space was calculated by multiplying this value by the tank head space volume from Table F-1-2. For the same data point as above:

[1.5E-7 g waste/ ft^3] [1.15E+5 ft^3] = 1.7E-2 g waste in tank head space

All the head space mass concentrations and mass quantities based upon CGM filter paper data were calculated in the same manner using a spreadsheet. The results are provided in Tables C-1 and C-2. The weighted average tank head space concentration and mass of waste in a tank head space in Tables C-1 and C-2 were calculated based upon the number of segments obtained for each data point.

Particulates are only generated by RMCS when purge gas is blowing out the drill string while the bit is rotating under the waste surface. This time averages about six minutes per segment. Multiplying the number of RMCS segments by six minutes per segment and dividing by the number of minutes of CGM operation indicates the creation of particulates will only occur during a nominal 3-4% of the time the CGM is operating. During RMCS, the normal practice is to install the CGM, turn it on when personnel enter a tank farm and keep the unit in operation until it is time for the crew to leave. When the portable RMCS exhauster is used, the exhauster is normally started at least an hour before RMCS is initiated, and kept in operation until it is time to halt operations for the week. Comparing exhauster operating times from Tables F-1-1 and CGM operating times from Table F-3-1, it can be seen the CGMs are in operation about 3-15% of the time the RMCS exhauster is operating on a tank. This time comparison wasn't estimated for the SX exhauster since the SX exhauster is in constant operation.

With CGM operation much longer than the time period when particulates could be generated, the majority of particulates generated by RMCS should have settled or been exhausted during the CGM operating period. However, since exhauster operation time is considerably longer than the CGM operating time, residual particulates in the tank head space when the CGM is shut off will not show up on the CGM filter paper, but could still be exhausted. Therefore, multiplying the head space concentration by just the exhauster flow rate and the CGM operating time may provide a low estimate of the mass of waste sent to the exhauster. An adjustment factor was applied to the quantity of material measured on the CGM filter papers as described in the next paragraph to account for particles that may exit to the exhauster following shut down of the CGM.

Table F-3-2 shows the tank head space changeouts made by the exhauster during CGM operating periods ranged from 0.84 to 6.2. The average was 2.4. With the CGMs operating 25-33 times longer than the aerosol generation periods, and an average of over two tank head space changeouts during CGM operation, the large majority of aerosols generated during RMCS will have settled out or been removed by the exhauster by the time the CGM is shut off. To account for particulates remaining in the tank head space after the CGM was turned off that are subsequently removed by an exhauster, it was conservatively assumed that 20% of the total mass of particles generated during RMCS were not removed from the tank head space during the CGM operating period. Therefore, the product of the tank head space concentration and the volume of air sent to the exhauster during the time of CGM operation was multiplied by a factor of 1.25 (100/80) to estimate the total mass of waste sent to the exhauster as a result of RMCS. This is shown below based upon the Cs^{137} value for the CGM filter papers used during RMCS in SX-101 riser 19:

$[1.5E\text{-}7 g/ft^3]$ $[100 ft^3/min]$ [1755 min] [1.25] = 3.3E-2 g waste to exhauster

This value was divided by the number of RMCS cores and RMCS segments from Table F-1-1 to provide the grams per core and grams per segment in Tables C-3 and C-4:

[3.3E-2 g waste to exhauster] ÷ 1 core = 3.3E-2 g waste/RMCS core to exhauster

[3.3E-2 g waste to exhauster] ÷ 5 segments = 6.6E-3 g waste/RMCS segment to exhauster

The weighted average mass per core and mass per segment sent to an exhauster in Tables C-3 and C-4 were calculated based upon the number of segments obtained for each data point.

Summary of Calculations

There were 34 valid CGM filter paper data points from 14 RMCS CGM sampling periods in eight tanks during which 15 RMCS cores and 74 RMCS segments were obtained. The results indicate:

- The average tank head space mass concentration during RMCS was 4.0E-5 g waste/m^3.
- The average mass of suspended solids in the tank head space during RMCS was 1.0E-1 g waste.
- The average mass sent to the exhauster during RMCS was 2.2E-1 g waste/RMCS core.
- The average mass sent to the exhauster during RMCS was 3.5E-2 g waste/RMCS segment.

Ignoring all CGM filter paper analytical data points with a variance >100% will result in conservative results. These data points indicate negligible radioactivity was present. If a value of zero was assigned to each data point with an analytical error of >100% instead of ignoring the data point, the weighted average particulate quantities in Tables C-1 through C-4 would be reduced by about 17%.

Tank TX-113 was the driest tank in which RMCS was performed. The interstitial liquid level (ILL), as determined from TWINS data, is approximately ten feet below the waste surface in this tank. All other tanks in which RMCS was performed had ILLs closer to, or at, the waste surface. This would lead to the expectation that aerosol generation would be higher in TX-113 than other tanks due to the lack of liquid to suppress dust formation. However, the data in Tables C-1 through C-4 show that the aerosol levels in TX-113 were considerably below average. The two tanks with the highest aerosol levels based upon CGM filter paper data were SX-102 and BY-105. Both of these tanks have ILLs near the waste surface. All aerosol levels for all tanks were very low, and there was little real difference between the aerosol levels in TX-113 in comparison to the other tanks.

Table C-1 Tank Head Space Mass Concentrations During RMCS Based Upon CGM Filter Paper Data*

Nuclide used as basis	SX-101 R19	SX-101 R4	SX-103 R7	SX-103 R11	SX-105 R6	SX-105 R14	SX-102 R8&4	S-110 R6	S-110 R14	U-107 R2&7	BY-105 R7	BY-105 R11B	TX-113 R3	TX-113 R5	Weighted Average
Cs^{137}	5.3E-6	2.7E-6	5.3E-5	7.5E-5	5.8E-7	1.1E-4	9.9E-6	1.2E-6	3.2E-5	5.2E-5	3.1E-5	3.5E-4	9.3E-7	1.6E-6	5.2E-5
Total α	3.3E-5	1.4E-4	-	6.8E-6	-	-	2.7E-4	-	-	-	-	3.6E-5	1.5E-5	-	8.4E-5
Total β	9.0E-6	4.1E-6	1.2E-5	1.5E-5	1.9E-7	2.2E-5	2.1E-6	2.3E-7	9.3E-6	1.0E-5	5.0E-6	6.7E-5	3.4E-7	8.9E-7	1.1E-5
Weighted Average and Range	4.0E-5 (Range = 1.9E-7 to 3.5E-4)														

* All values in g waste/m³

Table C-2 Mass of Aerosols In Tank Head Space During RMCS Based Upon CGM Filter Paper Data*

Nuclide used as basis	SX-101 R19	SX-101 R4	SX-103 R7	SX-103 R11	SX-105 R6	SX-105 R14	SX-102 R8&4	S-110 R6	S-110 R14	U-107 R2&7	BY-105 R7	BY-105 R11B	TX-113 R3	TX-113 R5	Weighted Average
Cs^{137}	1.7E-2	8.8E-3	1.3E-1	1.9E-1	1.4E-3	2.8E-1	2.9E-2	3.1-E-3	8.1E-2	8.7E-2	7.1E-2	8.1E-1	1.9E-3	3.1E-3	1.5E-1
Total α	1.1E-1	4.6E-1	-	1.7E-2	-	-	8.1E-1	-	-	-	-	8.4E-2	3.0E-2	-	1.4E-1
Total β	2.9E-2	1.3E-2	3.0E-2	3.8E-2	4.8E-4	5.5E-2	6.2E-3	5.8E-4	2.4E-2	1.7E-2	1.2E-3	1.6E-1	6.9E-4	1.8E-3	3.3E-2
Weighted Average and Range	1.0E-1 (Range = 4.8E-4 to 8.1E-1)														

* All values in g waste

Table C-3 Mass Of Waste Sent To The Exhauster Per RMCS Core Based Upon CGM Filter Paper Data*

Nuclide used as basis	SX-101 R19	SX-101 R4	SX-103 R7	SX-103 R11	SX-105 R6	SX-105 R14	SX-102 R8&4	S-110 R6	S-110 R14	U-107 R2&7	BY-105 R7	BY-105 R11B	TX-113 R3	TX-113 R5	Weighted Average
Cs^{137}	3.3E-2	2.1E-2	1.5E-1	3.4 E-1	5.6E-3	4.3E-1	3.1E-2	5.3E-3	1.5E-1	2.5E-1	2.7E-1	1.5E+0	1.5E-2	1.6E-2	3.0E-1
Total α	2.1E-1	1.1E+0	-	3.1E-2	-	-	8.4E-1	-	-	-	-	1.6E-1	2.4E-1	-	4.3E-1
Total β	5.6E-2	3.2E-2	3.3E-2	6.7E-2	1.9E-3	8.7E-2	6.5E-3	1.0E-3	4.2E-2	4.8E-2	4.4E-2	2.9E-1	5.4E-3	9.1E-3	5.2E-2
Weighted Average and Range	2.2E-1 (Range = 1.0E-3 to 1.5E+0)														

* All values in g waste/RMCS core

Table C-4 Mass Of Waste Sent To The Exhauster Per RMCS Segment Based Upon CGM Filter Paper Data*

Nuclide used as basis	SX-101 R19	SX-101 R4	SX-103 R7	SX-103 R11	SX-105 R6	SX-105 R14	SX-102 R8&4	S-110 R6	S-110 R14	U-107 R2&7	BY-105 R7	BY-105 R11B	TX-113 R3	TX-113 R5	Weighted Average
Cs^{137}	6.6E-3	5.3E-3	7.4E-2	8.4E-2	5.6E-3	8.7E-2	1.5E-2	2.7E-3	1.8E-2	4.9E-2	3.0E-2	1.7E-1	1.2E-3	2.6E-3	4.4E-2
Total α	4.2E-2	2.7E-1	-	7.7E-3	-	-	4.2E-1	-	-	-	-	1.8E-2	2.0E-2	2.1E-2	6.4E-2
Total β	1.1E-2	8.0E-3	1.6E-2	1.7E-2	1.9E-3	1.7E-2	3.2E-3	5.0E-4	5.3E-3	9.6E-3	4.9E-3	3.3E-2	4.5E-4	1.5E-3	9.8E-3
Weighted Average and Range	3.5E-2 (Range = 4.5E-4 to 4.2E-1)														

* All values in g waste/RMCS segment

APPENDIX D

ESTIMATION OF AEROSOLS GENERATED DURING RMCS BASED UPON RMCS EXHAUSTER RECORD SAMPLE DATA

APPENDIX D - Estimation Of Aerosols Generated During RMCS Based Upon RMCS Exhauster Record Sample Data

Summary of Method

This method of estimating RMCS aerosol generation quantities multiplies RMCS exhauster stack record sample concentration data (μCi/ml) by an estimated HEPA filter decontamination factor (DF) to obtain an approximation of the average radionuclide concentration in the air upstream of the HEPA. This average radionuclide concentration is then divided by the waste specific activity (μCi/g) to obtain an average mass concentration in the air to the exhauster. The average mass concentration is multiplied by the tank head space volume to obtain the average mass of particulates in the tank head space during RMCS. The average mass concentration multiplied by the volume of air passing through the exhauster and divided by the number of rotary cores or segments taken provides the mass per core or per segment sent to the exhauster.

Description

Each RMCS exhauster has an isokinetic sampler located on the stack downstream of the blower and HEPA filters. A small pump pulls air from the exhaust stack into a filter paper at a rate proportional to the exhaust flow. Radionuclides in the exhaust stream passing through the sample line are caught on the filter paper. The stack operating time and flow rate are recorded. When the record sample filter paper is removed, the filter paper is analyzed in a laboratory for radionuclides. The radionuclide concentration in the stack effluent stream is calculated by dividing the quantity of material on the filter paper by the volume of air through the sampler, and then dividing again by a factor to compensate for stack sampler and filter paper efficiency. These stack effluent concentrations are entered into databases onsite and are used for estimating yearly release quantities. RMCS exhauster stack record samples are usually taken at the end of each year and at the end of each installation on a tank.

For this document, the radionuclide concentration in a tank headspace was estimated by multiplying the stack effluent concentration by a DF to obtain a radionuclide concentration upstream of the HEPAs. For BY-106, an additional DF was included to account for a prefilter used upstream of the RMCS exhauster. The RMCS exhauster stack record sample data used in this appendix are given in Appendix F, Table F-4-6. The values in Table F-4-6 are corrected for sampling efficiency. Appendix F, Sections 4.1 and 4.2 describe how RMCS record sample data were obtained and which results were used for this document.

Actual test efficiencies were used for estimating the DF of the RMCS exhauster filter housing for this document. RMCS exhauster efficiency test data are presented in Table 5-4-4. A penetration efficiency of 0.002% (99.998% efficiency) was assumed for an RMCS exhauster housing for this document. A 0.002% penetration efficiency for the two filter unit calculates to a DF of 5E+4 (equal to 1 ÷ [1-[1-0.00002]]) for the RMCS exhauster housing.

HEPA filters are tested at the manufacturer to a minimum 99.97% efficiency using a 0.3 μm monodisperse aerosol. After installation, HEPA filters are tested in-place per ASME N510 to a minimum 99.95% efficiency using a polydisperse aerosol with an approximate droplet size distribution of 99% less than 3.0 μm, 50% less than 0.7 μm, and 10% less than 0.4 μm. The RMCS exhauster housing is tested per ASME N510 and is thus required to have a minimum removal efficiency of 99.95% for an aerosol with this approximate size distribution. The particle size distribution of the waste aerosols generated by RMCS is unknown. It was assumed for this document that the DF for RMCS aerosols was the same as the DF for ASME generated test aerosol.

A 99.95% efficiency is equivalent to a DF of 2000, while a 99.97% efficiency is equivalent to a DF of 3333. The actual DF for the RMCS exhauster housing is higher than either of these. It has two HEPA filters in series, even though the minimum efficiency specified in the NOCs for the RMCS exhausters is only equivalent to one HEPA. ERDA 1976 recommends using a DF of 3000^n for a filter bank, where n is the number of HEPA filters in series. This would result in a DF of 9E+6 for the RMCS exhauster housing. This is unrealistic. Using a DF of 9E+6 will calculate to Cs^{137} quantities on the HEPA filters that are orders of magnitude above what have been shown to be there based upon the measured dose rates and NDA. A DF of 9E+6 would mean the dose rate would have to be almost 100 mR/hr at the side of the exhauster housing instead of the 0.5-0.7 mR/hr dose rates encountered. The waste particles will not have the same particle size distribution entering the second HEPA filter as when entering the first. The majority of the waste particles will be captured on the 1st HEPA filter, and although the DF for each HEPA if tested individually using the ASME N510 aerosol test method may be 3000 (or higher), the overall DF of the two filters in series will not be 3000^2. This is because the particle size distribution entering the 2nd HEPA could have a greater percentage of smaller particles than that entering the 1st.

NUREG 1995 included an evaluation of a number of different facility stacks at the Hanford site where the HEPA filter upstream air concentrations were estimated using several different methods. This report concluded that back-calculation using a value of 3000^n overestimated the upstream radionuclide concentration by three to four orders of magnitude when compared to filter NDA data for the nine stacks for which NDA data were obtained, and by three orders of magnitude for the two stacks for which upstream air sample data were available. Back-calculation using a value of 3000^n was shown to be high by four orders of magnitude for the single stack for which a powder release estimate was available. Based upon this information, the two HEPA filter RMCS exhausters would have a DF in the 10^3 to 10^4 range. Using a DF of 5E+4 instead of 10^3 to 10^4 is conservative since the higher the HEPA DF, the higher the calculated filter inlet concentration will be for a given concentration from the stack record sampler. A DF of 5E+4 for two HEPAs in series is equivalent to a DF of 3000 on the primary filter and a DF of 17 on the secondary HEPA filter

An optional in-tank prefilter was used for the exhauster installation BY-106. No credit is taken for this prefilter in calculating abated emission quantities in NOC-1 to NOC-5. Radiological survey data on the prefilters when they were removed from BY-106 (Waldo 1999) following both the 1994 and 1995 operating periods show no detectable smearable contamination or dose rate. Thus, either the prefilters provided no DF, or there were negligible measurable particulates passing up the tank riser to the exhauster. Although no contamination showed on the in-tank prefilters, an efficiency of 80% (a DF of 5) was assumed for the in-tank prefilters used on BY-106. This efficiency approximates that of many industrial use prefilters.

There were 13 RMCS exhauster operating intervals evaluated for this document, with useful data available from seven intervals. The remaining intervals weren't used either because the data were not available, no RMCS segments were taken during the interval, or the record sample results were negative or had a variance $\geq$100%. The exhauster run intervals referred to in this appendix are not to be confused with the operating periods the exhausters were grouped into in Appendix B. The operating periods in Appendix B represented periods in which the same sets of HEPA filters were in service. The run intervals referred to in this appendix refer to the time prior to each stack record sample being taken. Table D-1 lists the assumed HEPA or prefilter+HEPA efficiencies used in subsequent calculations for each run interval.

Using data from Tables D-1, E-1, F-1-1, F-1-2 and F-4-6, the average mass of aerosols in the tank head space was calculated as shown in the following example using the Sr^{90} record sample concentration reported for BY-106 in 1995.

[8.1E-14 μCi/ml Sr^{90}] [2.50E+5 DF] [2.8317E+4 ml/ft^3] = 5.7E-4 μCi Sr^{90}/ft^3 in head space

5.7E-4 μCi/ft^3 head space ÷ 1.69E+2 μCi Sr^{90}/g waste = 3.4E-6 g waste/ft^3 in head space

[3.4E-6 g waste/ft^3] [35.315 ft^3/m^3] = 1.2E-4 g waste/m^3 in head space

[3.4E-6 g waste/ft^3 head space] [5.37E+4 ft^3] = 1.8E-1 g waste in tank head space

The mass of waste sent to the exhauster per core and per segment was calculated as shown below for the same tank.

[3.4E-6 g waste/ft^3 head space] [200 ft^3/m] [18.67 h] [60 m/h] ÷ 1 core = 7.6E-1 g waste/core

[3.4E-6 g waste/ft^3 head space] [200 ft^3/m] [18.67 h] [60 m/h] ÷ 3 segments = 2.5E-1 g waste/segment

Unlike in Appendices A, B and C, no adjustment was made to change the 200 scfm to actual cfm. This is because the reported concentrations from Table F-4-6 are based upon a 200 scfm flow rate rather than the actual flow rate. Since the concentrations are on the same basis as the flow rate, there is no need to correct to acfm.

All data were input to a spreadsheet and the average tank head space mass concentration, average total mass in the tank head space, mass to exhauster per core and mass to exhauster per segment were calculated in the same manner as shown above. Results are provided in Tables D-2 to D-5.

The weighted average mass concentration in the tank head space, mass of suspended solids in the head space, mass per core and mass per segment sent to an exhauster in Tables D-2 to D-5 were calculated based upon the number of segments obtained for each data point. For the $Pu^{239/240}$ and Am^{241}composite sample results for S-110+U-107+BY-105 in 1998, a weighted average specific activity for these radionuclides was calculated based upon the number of RMCS segments taken in each tank.

Summary of Calculations

A total of 13 data points were used from five tanks during which 10 RMCS cores and 57 RMCS segments were obtained. One of these, the Am^{241} concentration for the 1998 composite for Exhauster C, is suspect. This concentration is out of proportion to the total beta and total alpha results, and is much higher and with much less of a stated error than the Cs^{137} result for the same composite. Cs^{137} is present in the waste at levels 1,200-14,000 times that of Am^{241}, and is easier to detect. The Am^{241} concentration in the 1998 composite is so high in comparison to what it probably should be that it skews all the sample results for particulate levels based upon record sample data. Without using the Am^{241} data point the calculated particulate values based upon RMCS exhauster record sample data are in the same range as those calculated in Appendices A-C using other methods. For conservatism, the result was kept in this document, but the results are stated both with and without the Am^{241} data point. The results indicate:

- The average tank head space mass concentration during RMCS was 2.2E-5 g waste/m^3 (1.0E-4 g waste/m^3 with Am^{241} data point).
- The average mass of suspended solids in the tank head space during RMCS was 4.5E-2 g waste (2.2E-1 g waste with Am^{241} data point).
- The average mass sent to the exhauster during RMCS was 1.0E+0 g waste/RMCS core (4.8E+0 g waste/core with Am^{241} data point).
- The average mass sent to the exhauster during RMCS was 1.7E-1 g waste/RMCS segment (7.8E-1 g waste/segment with Am^{241} data point).

These results do not include data points with a variance $\geq\pm$100%. These data points indicate negligible radioactivity was present on the record sample filter paper. If a value of zero had been used for all negative sample results or those with variances $\geq\pm$100%, the above average values would be reduced by about 57%.

The in-tank prefilters used in both BY-106 sampling events showed no detectable contamination. Using a DF of 5 for the BY-106 prefilter skews the results high. Without this DF, the average numbers above would be reduced by about 6%.

Table D-1 Filter DFs Used For Calculation Of Tank Head Space Concentrations From Record Sample Data

	BY-106 R10B 1995	BY-105 R12A 1995	BY-110 R12B, 7, 12B, 4	S-110 R6, 14	U-107 R7, 2	BY-105 R7 1998	BY-105 R11B 1998
Prefilter DF	5	1	1	1	1	1	1
HEPA DF	5E+4	5E+4	5E+4	5E+4	5E+4	5E+4	5E+4
Total DF	2.5E+5	5E+4	5E+4	5E+4	5E+4	5E+4	5E+4

Table D-2 Tank Head Space Mass Concentrations During RMCS Based Upon Record Sample Data[1]

Nuclide used as basis	BY-106 R10B 1995	BY-105 R12A 1995	BY-110 R12B, 7, 12B, 4	S-110 R6, 14	U-107 R7, 2	BY-105 R7 1998	BY-105 R11B 1998	Weighted Average
Sr^{90}	1.2E-4	-	9.0E-6	-	-	-	-	1.4E-5
Total α	-	-	-	1.4E-5	9.7E-5	4.0E-5	4.0E-5	3.3E-5
Total β	-	3.2E-7	-	8.8E-8	2.4E-7	2.3E-7	1.9E-7	1.4E-7
$Pu^{239+240}$	-	-	-	1.8E-5				1.8E-5
Am^{241}	-	-	-	3.7E-4[2]				3.7E-4[2]
Weighted Average and Range	2.2E-5 (1.0E-4 with Am^{241} value[2]) (Range = 8.8E-8 to 3.7E-4)							

[1] All values in g waste/m^3.
[2] Note: The concentration based upon the reported Am^{241} concentration from the 1998 record sampler composite data is suspect since the value was quite high in proportion to the other radionuclides present. For conservatism, the sample results were provided both with and without the data point.

Table D-3 Mass of Aerosols In Tank Head Space During RMCS Based Upon Record Sample Data[1]

Nuclide used as basis	BY-106 R10B 1995	BY-105 R12A 1995	BY-110 R12B, 7, 12B, 4	S-110 R6, 14	U-107 R7, 2	BY-105 R7 1998	BY-105 R11B 1998	Weighted Average
Sr^{90}	1.8E-1	-	2.4E-2	-	-	-	-	2.5E-2
Total α	-	-	-	3.6E-2	1.6E-1	9.2E-2	9.2E-2	6.5E-2
Total β	-	7.4E-4	-	2.2E-4	4.1E-4	5.2E-4	4.5E-4	2.9E-4
$Pu^{239+240}$	-	-	-	3.9E-2				3.9E-2
Am^{241}	-	-	-	8.2E-1[2]				8.2E-1[2]
Weighted Average and Range	4.5E-2 (2.2E-1 with Am^{241} value[2]) (Range = 2.2E-4 to 8.2E-1)							

[1] All values in g waste.
[2]Note: The concentration based upon the reported Am^{241} concentration from the 1998 record sampler composite data is suspect since the value was quite high in proportion to the other radionuclides present. For conservatism, the sample results were provided both with and without the data point.

Table D-4 Mass Of Waste Sent To Exhauster Per RMCS Core Based Upon Record Sample Data[1]

Nuclide used as basis	BY-106 R10B 1995	BY-105 R12A 1995	BY-110 R12B, 7, 12B, 4	S-110 R6, 14	U-107 R7, 2	BY-105 R7 1998	BY-105 R11B 1998	Weighted Average
Sr^{90}	7.6E-1	-	1.7E-1	-	-	-	-	2.2E-1
Total α	-	-	-	3.9E-1	4.5E+0	1.8E+0	4.1E+0	2.0E+0
Total β	-	4.8E-3	-	2.4E-3	1.1E-2	1.0E-2	2.0E-2	7.0E-3
$Pu^{239+240}$	-	-	-	8.7E-1				8.7E-1
Am^{241}	-	-	-	1.85E+1[2]				1.85E+1[2]
Weighted Average and Range	1.0E+0 (4.8E+0 with Am^{241} value[2]) (Range = 2.4E-3 to 1.85E+1)							

[1] All values in g waste/RMCS core.
[2]Note: The concentration based upon the reported Am^{241} concentration from the 1998 record sampler composite data is suspect since the value was quite high in proportion to the other radionuclides present. For conservatism, the sample results were provided both with and without the data point.

Table D-5 Mass Of Waste Sent To Exhauster Per RMCS Segment Based Upon Record Sample Data[1]

Nuclide used as basis	BY-106 R10B 1995	BY-105 R12A 1995	BY-110 R12B, 7, 12B, 4	S-110 R6, 14	U-107 R7, 2	BY-105 R7 1998	BY-105 R11B 1998	Weighted Average
Sr^{90}	2.5E-1	-	2.7E-2	-	-	-	-	3.3E-2
Total α	-	-	-	7.7E-2	9.0E-1	2.0E-1	4.6E-1	2.8E-1
Total β	-	1.6E-3	-	4.8E-4	2.3E-3	1.2E-3	2.3E-3	1.1E-3
$Pu^{239+240}$	-	-	-	1.4E-1				1.4E-1
Am^{241}	-	-	-	2.9E+0[2]				2.9E+0[2]
Weighted Average and Range	1.7E-1 (7.8E-1 with Am^{241} value[2]) (Range = 4.8E-4 to 2.9E+0)							

[1] All values in g waste/RMCS segment.
[2]Note: The concentration based upon the reported Am^{241} concentration from the 1998 record sampler composite data is suspect since the value was quite high in proportion to the other radionuclides present. For conservatism, the sample results were provided both with and without the data point.

APPENDIX E

TANK WASTE RADIONUCLIDE CONCENTRATIONS USED FOR AEROSOL CALCULATIONS

APPENDIX E - Tank Waste Radionuclide Concentrations Used for Aerosol Calculations

The RMCS exhauster NDA data, HEPA filter dose rate data, CGM filter paper data and stack record sample data provide information on the quantity of radionuclides (in μCi or μCi/ml) on the exhauster filters, in the tank head space, or the exhauster stack during RMCS. These radioactivity quantities need to be divided by the waste radionuclide concentration (specific activity-μCi/g) to determine the mass of waste in the tank head space and in the tank gases sent to the exhauster.

The mass quantities in this document were calculated using dry basis radionuclide concentrations. Waste particles carried into the tank head space by the purge gas could be wet or dry. If wet, some of the non-chemically bound water will start to evaporate immediately providing the tank relative humidity is <100%. The water present in a waste particle may be chemically bound as a hydrate, or free. The chemically bound water will not readily evaporate, therefore even a "dry" particle may have some water associated with it. It is impractical to measure the actual water content of the waste particulates caught on the CGM filter paper, the exhauster HEPA filters or the stack record sample paper. Since the quantity of water in the waste particulates is unknown, particulate levels were calculated using dry basis radionuclide concentrations. Thus, all particulate values given in this document are stated on a dry basis.

The waste radionuclide concentrations, on a dry basis, were calculated from data available in the Tank Waste Information Network System (TWINS). The Best Basis Inventory/Best Basis Summary numbers were used. These values are the most complete and up to date, readily available, estimates for Hanford waste tank contents. The information was downloaded from TWINS into a spreadsheet. The total chemical, total beta (including Pu-241) and total alpha (excluding Pu-241) quantities were summed in the spreadsheet for all the tanks which were sampled, and concentrations for Cs^{137}, Sr^{90}, total beta and total alpha automatically calculated in μCi/g. These concentrations are provided in Table E-1.

The radionuclide concentrations obtained from TWINS were obtained in January, 1999. No corrections were made for decay for this document.

The average specific activity for a tank was used as the particulate specific activity for this document. As can be seen from the radionuclide data in Tables F-2, F-3-1 and F-4-6, the measured radionuclide values are not always in the same ratio to each other as given by TWINS, nor are all radionuclides detected that TWINS indicates are present. Radionuclides can be distributed unevenly in a tank. Soluble fission products (primarily Cs^{137}) are found in the liquid, saltcake and in sludges. Insoluble fission products and actinides are found largely in sludges as these are chemical precipitates. Sludge could be mixed with saltcake, be present in a distinct layer at the bottom of a tank, or in several layers in the tank depending upon how waste was transferred into a tank. Waste particles may thus not have the same specific activity on a microscopic scale as they would have on a macro scale were the tank contents homogenized. During RMCS, a top to bottom core sample is attempted, resulting in the drill bit and purge gas (which causes aerosols to form) passing through the entire waste matrix. Assuming the aerosol generation rate is approximately constant during drilling, the average specific activity of a radionuclide in the suspended solids should be roughly the same as the average specific activity of the same radionuclide in the tank waste. While the waste specific activity is probably not homogeneous from top to bottom in a tank, and the aerosol generation rate will likely also vary, it is beyond the scope of this document to provide an in-depth analysis of all the factors affecting aerosol radionuclide concentration. Although sample radionuclide data were not always in the same ratio as provided by TWINS. For the purpose of this document the simplifying assumption was made that the average tank specific activity is adequate to provide an approximation of the suspended solids specific activity. Average tank specific activities were used in the preparation of the exhauster NOCs.

The mass data presented in this document are only as accurate as the TWINS data. The combined radionuclide content of all Hanford waste tanks is known fairly well since the overall content is based upon reactor production records, Cs^{137}/Sr^{90} recovery data and processing plant discharges. Thus, TWINS data for all tanks combined should be reliable. There may be differences between TWINS data and the contents of a specific tank. While the individual radionuclide data used in this document for a specific tank may not be exact, deviations between assumed and actual concentrations are assumed to balance out over the number of tanks sampled.

Table E-1 Tank Contents From TWINS Best Inventory Database And Calculated Specific Activities[1]

Contents	BY-105	BY-106	BY-108	BY-110	S-110	SX-101	SX-102	SX-103	SX-105	TX-113	U-107
Mass (kg)	2.32E+6	2.94E+6	8.47E+5	1.58E+6	1.44E+6	2.18E+6	2.01E+6	2.38E+6	2.45E+6	2.38E+6	1.73E+6
Cs^{137} (Ci)	5.22E+5	7.04E+5	3.51E+5	1.95E+5	3.26E+5	2.43E+5	4.51E+5	5.66E+5	6.14E+5	3.09E+5	2.10E+5
Sr^{90} (Ci)	6.20E+5	4.96E+5	1.95E+5	2.63E+5	4.05E+5	2.66E+5	4.60E+5	5.19E+5	4.80E+5	1.33E+5	1.60E+5
$Pu^{239+240}$ (Ci)	1.22E+2	6.14E+1	5.97E+1	6.94E+1	4.06E+2	8.73E+2	2.60+2	1.97E+2	2.70E+2	1.05E+2	1.91E+2
Am^{241} (Ci)	1.43E+2	1.23E+2	2.47E+1	3.55E+1	6.39E+1	2.05E+2	1.44E+2	1.92E+2	2.64E+2	6.77E+1	2.58E+1
Total Beta (Ci)	2.27E+6	2.39E+6	1.08E+6	9.15E+5	1.46E+6	1.03E+6	1.83E+6	2.19E+6	2.22E+6	8.82E+5	7.49E+5
Total Alpha (Ci)	3.23E+2	1.96E+2	1.84E+2	1.63E+2	4.87E+2	1.10E+3	4.33E+2	4.17E+2	5.62E+2	1.78E+2	2.22E+2
Cs^{137} (μCi/g)	**2.25E+2**	**2.40E+2**	4.14E+2	**1.23E+2**	**2.27E+2**	**1.12E+2**	**2.24E+2**	**2.38E+2**	**2.51E+2**	**1.30E+2**	**1.21E+2**
Sr^{90} (μCi/g)	2.67E+2	**1.69E+2**	2.30E+2	**1.66E+2**	2.82E+2	1.22E+2	2.29E+2	2.18E+2	1.96E+2	5.60E+1	9.30E+1
$Pu^{239+240}$ (μCi/g)	**5.24E-2**	2.09E-2	7.04E-2	4.39E-2	**2.82E-1**	4.01E-1	1.29E-1	8.28E-2	1.10E-1	4.42E-2	**1.11E-1**
Am^{241} (μCi/g)	**6.15E-2**	4.19E-2	2.92E-2	2.24E-2	**4.44E-2**	9.42E-2	7.16E-2	8.06E-2	1.08E-1	2.84E-2	**1.49E-2**
Total Beta (μCi/g)	**9.77E+2**	8.12E+2	1.27E+3	5.78E+2	**1.02E+3**	**4.72E+2**	**9.12E+2**	**9.17E+2**	**9.01E+2**	**3.71E+2**	**4.33E+2**
Total Alpha (μCi/g)	**1.39E-1**	6.65E-2	2.17E-1	1.03E-1	**3.38E-1**	**5.04E-1**	**2.15E-1**	**1.75E-1**	2.29E-1	**7.48E-2**	**1.29E-1**

[1] Numbers in bold are those used in this document.

APPENDIX F

ROTARY MODE CORE SAMPLING EXHAUSTER AND CORE SAMPLE DATA

APPENDIX F - Rotary Mode Core Sampling Exhauster and Core Sample Data

This appendix provides the data obtained during RMCS operations and used in the preparation of this document. All raw and derived data used in this document are provided. Derived data are concentrations or other values calculated from raw data. This appendix is divided into sections for core sampling data, NDA data, CGM filter paper data, and RMCS stack record sample data.

Any core that has one or more segments taken in rotary mode is designated an RMCS core. A segment is a nominal 19 inch sample. Any segment in which rotary sampling was performed is designated an RMCS segment.

1.0 Core Sampling Data

1.1 Basic Operational Data

There have been three RMCS exhausters and three RMCS sampling trucks deployed since startup of nitrogen-purged systems in November 1994. The exhausters are formally designated 296-P-32, 296-P-33 and 296-P-34. These were originally referred to as parts of RMCS Systems #2, #3 and #4 respectively in the Notices of Construction (NOC) (References NOC-1 to NOC-5) submitted to the Washington Department of Health (WDOH) and the Environmental Protection Agency (EPA) for these units. The exhauster designations were changed for routine field use in 1996 to exhausters A, B and C to avoid confusion with core sampling trucks 2, 3 and 4, since any exhauster could be used with any RMCS truck. Exhauster A (#2) and RMCS Truck#2 have not been used for RMCS since 1995, and are no longer in service for core sampling.

Rotary mode core sampling has been conducted in four general time frames since 1994. The time frames were:

The first time frame lasted from November 1994 to January 1995. RMCS Truck #2 and Exhauster #2 (A) were used on Tank BY-106 along with an in-tank prefilter. This tank provided the initial deployment and testing of the nitrogen-purged equipment in a waste tank. During this period, radiation dose rates were taken at the side of the exhauster housing. Stack record samples were taken in December 1994 and January 1995.

The second time frame lasted from July 1995 through October 1995. RMCS Trucks #2 and #4 were used with Exhausters #2 and #3 (A and B) on BY-105, BY-108 and BY-110. No RMCS samples were taken from BY-108, all samples were taken in push mode for this tank. During this period, radiation dose rates were taken at the sides of the exhauster housings. Stack record samples were taken after completion of sampling on each tank.

The third time frame began when RMCS was restarted in December 1997. Trucks #3 and #4 were used for sampling of SX-101, SX-103, SX-105 and SX-102 in conjunction with the SX tank farm exhauster. The RMCS exhausters were not used. During this period radiation dose rates were taken at the sides of the SX exhauster housing as part of HPT routine surveys. However, this data is not useful for estimating RMCS aerosol generation rates due to background radiation present and because the exhauster is pulling on thirteen tanks in series or in parallel with the tank being sampled. Stack record samples for the SX farm exhauster stack were taken when required by normal operating procedures, but were also not usable for estimating aerosols generated during RMCS because the exhauster is pulling on thirteen tanks in series or in parallel with the tank being sampled. Beginning with RMCS in SX farm, radionuclide analyses were performed on the filter papers protecting the CGMs, which draw air out of the tank vapor space for flammable gas detection.

The fourth time frame began in May 1998. Trucks 3 and 4 were used with Exhausters B and C (3 and 4) on S-110, U-107, BY-105 and TX-113. This period marked the first use of the RMCS trucks and RMCS exhausters together following resolution of flammable gas concerns and modifications to the exhausters. Between 10/95 and 5/98, Exhausters B and C were extensively modified with new filter housings and other equipment to meet new NOC requirements. New filters were installed. This period is ongoing as of April 1999. Radiation dose rates were taken at the sides of the exhauster housings. Stack record samples were taken after completion of sampling for each exhauster installation. Radionuclide analyses were performed on the CGM filter papers. Finally, a NDA was performed on the Exhauster C housing following completion of the first core on TX-113. The housing filters when assayed contained aerosols captured by the exhauster following RMCS in S-110, U-107, BY-105 (1998) and the first core of TX-113.

A description of each RMCS tank sampling operation is provided below.

Tank 241-BY-106, 11/94 to 12/94

RMCS using the nitrogen purge gas system with an exhauster was formally begun on 11/17/94 on tank BY-106, riser 10B. Exhauster #2 (A)and Truck #2 were used. A sintered metal prefilter was inserted in the riser between the tank and the exhauster. A total of eight segments were taken in rotary mode and five segments in push mode until sampling was halted on 12/21/94. One RMCS core was obtained. The total exhauster run time was 48.78 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr. The in-tank prefilter was smeared for contamination when removed from the tank, with the smears showing less than detectable levels of radionuclides present (Waldo 1999). The prefilter had been washed with an installed spray system prior to removal from the tank, but subsequent testing showed the water flow and pressure were too low to have been effective at removing contamination.

Tank 241-BY-106, 1/95

Following some process modifications, RMCS in BY-106 riser 10B began again on 1/18/95. Exhauster #2 (A) and Truck #2 were used. The sintered metal prefilter was inserted in the riser between the tank and the exhauster. RMCS was halted on 1/24/95 over authorization basis and equipment reliability issues for RMCS. A total of three segments were taken in rotary mode and eleven segments in push mode. One RMCS core was obtained. The total exhauster run time was 18.67 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr. The in-tank prefilter was smeared for contamination when removed from the tank, with the smears showing less than detectable levels of radionuclides present (Waldo 1999). The prefilter was not washed this time.

Tank 241-BY-110, 7/95 to 10/95

Following resolution of RMCS authorization basis and equipment issues, and completion of the fabrication and testing of Trucks #3 and #4, RMCS was begun in BY-110 on 7/11/95. Exhauster #2 (A) and Truck #2 were used. Samples were taken from risers 12B, 7, 12B again, and 4. There was no in-tank prefilter used in this or any subsequent RMCS periods. Sampling was performed until 10/25/95 when RMCS was halted over flammable gas issues. A total of 13 RMCS segments and 56 PMCS segments were taken. Two RMCS cores were obtained. The total exhauster run time was 112.5 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr.

Tank 241-BY-108, 7/95 to 8/95

Core sampling was begun in BY-108 on 7/25/95. Exhauster #3 (B) and Truck #4 were used. Sampling was done in risers 12A and 7. The tank material proved soft enough so that no RMCS segments were required, all segments were obtained in push mode, although the exhauster was operated. Sampling was completed 8/18/95. A total of 16 PMCS segments were taken. The total exhauster run time was 66.17 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr.

Tank 241-BY-105, 8/95 to 10/95

RMCS was begun in BY-105 riser 12A on 8/30/95. Exhauster #3 (B) and Truck #4 were used. This tank has a concrete layer on top about 12-18 inches thick which had to be drilled through. Problems were encountered with the sampling operation. Part way through sampling, questions arose as to the flammable gas status of the tank and RMCS was halted on 10/6/95. A total of 3 RMCS and 7 PMCS segments were taken. One RMCS core was obtained. The total exhauster run time was 44.13 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr.

Tank 241-SX-101, 12/97 to 2/98

Following resolution of extensive regulatory issues, and installation of equipment modifications, RMCS started in SX-101 with Truck #4 on 12/4/97. An RMCS exhauster was not used since all SX farm tanks, excluding SX-113 and SX-115, are ventilated with the SX exhauster. Sampling was performed in risers 19 and 4, and was completed on 2/10/98. A total of 9 RMCS and 6 PMCS segments were taken. Two RMCS cores were obtained. SX exhauster stack record samples and filter housing dose rates were obtained as part of routine operations for the SX exhauster, not as part of the RMCS process. SX record sampler and filter housing dose rate data were not evaluated for this document. Because of the low head space aerosol concentrations, the background radiation around the SX filter housing, the number of tanks being ventilated and the involved off-gas header routings, it would not be practical using filter dose rate or stack record sample data to estimate the aerosol addition, if any, due to RMCS to the SX ventilation system. However, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. Two filter papers were needed for each core, as moisture in the tank vapors condensed on the papers in the cold weather and began to restrict tank gas flow to the CGM.

Tank 241-SX-103, 4/98 to 5/98

RMCS started in SX-103 with Truck #4 on 4/27/98. The SX exhauster was used for ventilation (see SX-101 above). Sampling was performed in risers 7 and 11, and was completed on 5/11/98. A total of 6 RMCS and 18 PMCS segments were taken. Two RMCS cores were obtained. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used during each core. SX exhauster stack record samples and filter housing dose rates during core sampling in SX farm were not evaluated for this document (see SX-101 above).

Tank 241-SX-105, 2/98 to 5/98

RMCS started in SX-105 with Truck #3 on 2/25/98. The SX exhauster was used for ventilation (see SX-101 above). Sampling was performed in risers 6 and 14, and was completed on 5/15/98. A total of 6 RMCS and 20 PMCS segments were taken. Two RMCS cores were obtained. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. Two filter papers were needed for the first core, as moisture in the tank vapors condensed on the papers in the cold weather and began to restrict tank gas flow to the CGM. One filter paper was used for the second core. SX exhauster stack record samples and filter housing dose rates during core sampling in SX farm were not evaluated for this document (see SX-101 above).

Tank 241-SX-102, 6/98 to 7/98

RMCS started in SX-102 with Truck #4 on 6/17/98. The SX exhauster was used for ventilation (see SX-101 above). Sampling was performed in risers 8 and 4, and was completed on 7/7/98. A total of 2 RMCS and 18 PMCS segments were taken. Two RMCS cores were obtained. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used for each core. SX exhauster stack record samples and filter housing dose rates during core sampling in SX farm were not evaluated for this document (see SX-101 above).

Tank 241-S-110, 5/98 to 6/98

RMCS was begun in S-110 on 5/18/98. Exhauster C (#4) and Truck #3 were used. This tank marked the first use of an RMCS exhauster since 1995. Sampling was completed on 6/4/98. Risers 6 and 14 were sampled. A total of 10 RMCS and 8 PMCS segments were taken. Two RMCS cores were obtained. The total exhauster run time was 159.78 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used for each core. Waste particles retained on the housing filters were part of the inventory subsequently measured by NDA following completion of the first core in TX-113.

Tank 241-U-107, 6/98 to 7/98

RMCS was begun in U-107 on 6/10/98. Exhauster C and Trucks #3 and #4 were used. Sampling was completed on 7/15/98. Risers 7 and 2 were sampled. A total of 10 RMCS and 19 PMCS segments were taken. Two RMCS cores were obtained. The total exhauster run time was 273.85 hours. The stack record sample was removed and analyzed following this run period. Dose rates taken at the side of the exhauster housing during RMCS were all <0.5 mR/hr. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used for each core. Waste particles retained on the housing filters were part of the inventory subsequently measured by NDA following completion of the first core in TX-113.

Tank 241-BY-105, 7/98 to 8/98

RMCS was begun in BY-105 again on 7/22/98. Exhauster C and Trucks #3 and #4 were used. Sampling was completed on 8/25/98. Risers 7 and 11B were sampled. A total of 18 RMCS and 18 PMCS segments were taken. The material was hard enough to require rotary mode sampling all the way to the bottom of the tank, but negligible recovery was obtained. After RMCS was performed to the tank bottom, a PMCS core was taken in the same hole to recover material. Two RMCS cores were obtained. The exhauster run time was 135.77 hours for the first RMCS core and 307.92 hours for the second RMCS core. Stack record sample information in ABCASH shows 305.58 hours operation for the second core, but the sampler data sheet shows the time counter was mistakenly reset 2.34 hours into the run. No correction was made to the BY-105 2^{nd} core record sample concentration for this document since the error is conservative and results in slightly higher (<1%) record sample radionuclide concentrations for this core. The stack record sample was removed and analyzed following each core, giving two record samples for BY-105 in 1998. Dose rates taken at the side of the exhauster housing during RMCS were almost all <0.5 mR/hr, but a few readings indicated 0.7 mR/hr. This was either due to different personnel reading the instrument differently, or the fact that the exhauster had been used on enough tanks that by now there was sufficient activity on the filters to cause readings approximately at the background detection level. The final reading when both cores were completed was <0.5 mR/hr. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used for each core. Waste particles retained on the housing filters were part of the inventory subsequently measured by NDA following completion of the first core in TX-113.

Tank 241-TX-113, 9/98 to 5/99

Core sampling was begun in TX-113 riser 3 on 9/22/98. Exhauster B (#3) and Truck #4 were used at the start. Exhauster B ran for a total of 87.38 hours until being disconnected on 10/23/98. During the time Exhauster B operated two PMCS segments were taken and no RMCS segments. Exhauster C was then installed and started up for a short period 12/10/98. RMCS segments weren't taken until 2/99. Sampling was completed on the core from riser 3 on 2/12/99. Exhauster C ran for a total of 358.28 hours. A total of 12 RMCS segments were obtained during the time Exhauster C was operating. Exhauster flow rate for both exhausters was a nominal 200 scfm. Stack record samples for the first core were taken following Exhauster B removal, at the end of the year for Exhauster C, and following completion of the first core with Exhauster C. The stack record sample data for Exhauster B are available, although only PMCS samples were taken with Exhauster B. The data from the two Exhauster C stack record samples are not yet available. No RMCS samples were taken during the first Exhauster C run interval from 12/10/98 to the end of the year.. Dose rates taken at the side of the exhauster housing during the short PMCS only sampling period with Exhauster B were all <0.5 mR/hr. Dose rates with Exhauster C varied between <0.5 mR/hr and 0.7 mR/hr. The final reading on Exhauster C following completion of the first core was 0.7 mR/hr. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used for the core. Waste particles retained on the housing filters were part of the inventory subsequently measured by NDA following completion of this core.

Sampling in riser 5 was begun on 4/12/99 using Exhauster B and Truck #3. A total of 6 RMCS and 1 PMCS segments were taken for this core before sampling was halted on 4/28/99. The total exhauster run time for this core was 117.12 hours. Problems with high vacuum in the tank required the exhauster flow rate to be reduced to 190 scfm to keep the system within pressure limits. The stack record sample for the second core was removed and analyzed following the run period. Dose rates taken at the side of the exhauster housing during the second core were all <0.5 mR/hr. During sampling, filter papers used in the suction line for the CGM were saved and analyzed in the laboratory to estimate the airborne radionuclide concentration in the tank head space. One filter paper was used.

The basic core sampling operational data used in this document includes the number of RMCS cores and segments, the exhauster run times and flow rates, the RMCS exhauster HEPA filter dose rates, and tank vapor space temperatures. Table F-1-1 lists the basic operational data from core sampling and exhauster operations during RMCS. This information, excluding tank vapor space temperature data, was obtained from procedural data sheets in the sampling work packages (References WP-1 to WP-21).

Tank temperature data for the tanks ventilated with the RMCS exhausters was obtained from the TWINs database. Plots for each tank were prepared for the time RMCS was conducted and the average value of the highest thermocouple located in the tank (the lowest temperature reading) was estimated.

The SX exhauster flow rates listed in Table F-1-1 are estimates only. The combined flow rate for SX-101 through SX-106, plus SX-109, (7 tanks) averaged 440 cfm during CY1996 (Kaiser 1997) for an average of 63 cfm per tank. Based upon inlet flow measurements at the tank inlet HEPA filters (Farris 1998), the flow through each individual tank (SX-101 through SX-106 plus SX-109) was <55 cfm at the breather filter. Assuming an exhaust flow of 100 cfm for each SX farm tank sampled is therefore conservative.

1.2 Derived Core Sampling Data

Derived basic core sampling data used in this document include the tank head space volumes and the number of tank head space changeouts made by an exhauster during RMCS.

Tank head space volume includes the dome volume above the top of the sidewall plus the void space between the waste surface and the top of the sidewall. The formula used to calculate tank head space volumes was:

Head Space Volume in $ft^3 = (DS_v + [(H_{sw})(12) + H_k + H_b - H_w](V_{in})) \div 7.48$

Where: DS_v = dome space volume, gal

H_{sw} = height of tank body sidewall above knuckle, ft

H_k = height of tank knuckle area, in.

H_b = height of tank bottom below knuckle, in.

H_w = height of waste in tank, in.

V_{in} =2755.5 gal/in. of waste in SX tanks, 2754 gal/in. in all others

The height of waste in each tank at the time of core sampling was obtained from the TWINS database. Tank dimensional and waste level data are given in Table F-1-2, along with the calculated tank head space volumes. The tank dome space volumes, height of tank sidewall above the knuckle, height of tank knuckle area, and height of tank bottom below the knuckle were obtained from Reynolds 1999.

The tank head space changeouts when using the RMCS exhauster were calculated by multiplying the exhauster flow rate by the time of exhauster operation and dividing the result by the tank head space volume. Tank head space changeouts are listed in Table F-1-2.

2.0 RMCS Exhauster Non-Destructive Assay Data

An NDA was performed on Exhauster C following its use for RMCS in S-110, U-107, BY-105 (1998) and the first core in TX-113. No filter changeouts were made during this period, the accumulated particulates from these RMCS events were retained on the housing prefilter, primary HEPA and secondary HEPA. NDA results are provided Greager 1999. The results are restated in Table F-2.

The NDA compared the count rate from the exhauster housing opposite the prefilter, 1st HEPA filter and 2nd HEPA filter with the count rate of an 0.887 μCi Cs^{137} source in an equivalent geometry to the RMCS exhauster housing with filters installed.

3.0 Combustible Gas Monitor (CGM) Filter Paper Data

3.1 CGM Operational Data

The use of CGM filter paper data for estimating aerosol levels is discussed in Appendix C. While routine monitoring of tank head spaces for flammable gas has been performed for a number of years within tank farms, the CGM filter papers have been discarded after monitoring them in the field for contamination. From the fall of 1997 until April 1999 the filter papers were retained and analyzed in the 222-S laboratory following removal from a tank. Data were collected for the four tanks in SX farm in which RMCS was performed, and the next four tanks on which the RMCS exhauster was deployed. A summary report containing all the field operating data sheets for CGM usage, and lab data, was prepared following completion of sampling on each tank, for all tanks except TX-113. For TX-113 a separate report was prepared following each core.

The CGM operational data used to estimate aerosol levels during RMCS includes CGM operating times, CGM flow rates, and filter paper analytical data. The CGM data are provided in Table F-3-1, and were obtained from References CGM-1 to CGM-9.

3.2 Derived CGM Filter Paper Data

The efficiency used for most stack samplers onsite is 73% (see RMCS Record Sample Data below). Estimates attached to References CGM-1 to CGM-9 indicate the CGM filter paper sampling method used should have a sampling efficiency exceeding 73%. For conservatism, a sampling efficiency of 50% was assumed in this document for the CGM filter paper method. The estimated Cs^{137}, total alpha and total beta concentrations in the tank vapor space were calculated by dividing the radionuclide quantity on the filter paper (from Table F-3-1) by the assumed CGM sampling efficiency of 0.5 and the volume of gas going to the CGM. The volume of gas going to the CGM was calculated by multiplying the time of CGM operation by the CGM flow rate of 500 ml/min. Results are given in Table F-3-2.

Tank head space changeouts during CGM operation were calculated by multiplying the exhauster flow rates (from Table F-1-1) by the CGM run times (from Table F-3-1) and dividing by the tank head space volumes (from Table F-1-2).

Tank head space radionuclide concentrations, based upon CGM filter paper data, and tank head space changeouts by the tank exhauster during CGM operation are given in Table F-3-2.

4.0 RMCS Stack Record Sample Data

4.1 Reported Record Sample Data

All exhausters within Tank Waste Remediation System (TWRS) (now designated River Protection Project (RPP)) are assigned a specific record sample source code that is used for data recording and retrieval. When nitrogen-purged RMCS was begun in 1994, a different code was applied for each tank on which the exhauster was installed. Prior to restart of RMCS with the RMCS exhausters in CY 1998, the source code numbering changed so that there was a specific code for each RMCS exhauster only. Following are the source codes for the RMCS exhausters:

E303 – Exhauster #2 (Exhauster A) on BY-106
E304 – Exhauster #3 (Exhauster B) on BY-105 [1995]
E305 – Exhauster #2 (Exhauster A) on BY-110
E306 – Exhauster #3 (Exhauster B) on BY-108
E307 – Exhauster B (Exhauster #3[revised name in 1996]) on all tanks from 1998 on
E308 – Exhauster C (Exhauster #4[revised name in 1996]) on all tanks from 1998 on

The RMCS exhauster stack record sampler filter papers for each source code are analyzed upon removal for total alpha and total beta. A correction is then applied to account for various inefficiencies in the sampling process, and the results are entered into the Automated Bar Coding of Air Samples at Hanford (ABCASH) database. For 1994 & 1995 the correction used was to divide the lab result by 0.91 or 0.921. For 1998 the correction was to divide the lab result by 0.73. This correction factor is a product of a filter paper correction factor and a stack sampling efficiency. Per discussion with environmental personnel (Gleckler 1997), an overall sampling efficiency of 0.73 is used for most stacks on the Hanford site.

At the end of the year the filter papers from each source code are usually composited and analyzed for Sr^{90}, $Pu^{239/240}$, Am^{241} and additional radionuclides. These latter results are entered into the Environmental Release Summary (ERS) database. The original total alpha and total beta results entered into the ABCASH database, without the correction factor, are also entered into the ERS database. The values in the ERS database are the "raw" stack record sample data. These need to have an overall sampling efficiency correction factor applied prior to being used for calculation of actual stack concentrations.

Table F-4-1 summarizes the data obtained from ABCASH for the RMCS stack record samplers. Some of the numbers are negative and most have variances of ±>100%. The negative values and high error bands result when the record sampler filter paper count rate is below or close to the background count rate. The references for the ABCASH data are ABCASH-1 to ABCASH-13.

Table F-4-2 lists ERS data for the RMCS exhauster. Many of the ERS database numbers are negative or have variances of >100%. The only concentrations shown in Table F-4-2 besides those for total alpha and total beta are for Sr^{90}, Cs^{137}, $Pu^{239/240}$ and Am^{241}. No other radionuclides showed any concentrations with <100% error. The references for the ERS data are ERS-1 to ERS-9.

The RMCS exhauster stack record sampler filter papers for S-110, U-107 and BY-105 (both installations) in CY 1998 were recounted for total alpha, total beta and GEA to see if a longer lab counting time could reduce the variances to <100%. When reanalyzed with a longer count time, the total alpha error for all four samples was reduced to <100% and the total beta error rates, which were already <100% error (as can be seen from the ABCASH and ERS results in Tables F-4-1 and F-4-2), were further reduced. However, the sample results for the recounted data points showed no useful individual radionuclide values with <100% error rate. Table F-4-3 lists the recounted filter paper total alpha, total beta and Cs^{137} quantities, and stack sampler flow data. The recounted RMCS filter paper data for 1998 were obtained from WSCF 1999. The stack sampler flow volumes were obtained from data sheets in the appropriate work packages.

Table F-4-4 provides the available RMCS exhauster aerosol test data. This information was obtained from Waldo 1999. Prior to 1998 the RMCS exhauster primary HEPA filter efficiency and either the secondary

HEPA filter or the overall efficiency for both filters were tested. Starting in 1998 only the primary and secondary HEPA filter efficiency were measured.

4.2 Derived Record Sample Data

Table F-4-5 uses the data from Table F-4-3 to provide calculated total alpha, total beta and Cs^{137} concentrations in the RMCS exhauster off gas for the four recounted 1998 data points (S-110, U-107, BY-105 R7, BY-105 R11B). Concentrations were calculated by dividing the radionuclide quantities by the stack sampler flow volumes. These values do not have any correction factors applied for sampling efficiency.

To summarize the RMCS exhauster record sample data, Tables F-4-1, F-4-2 and F-4-5 provide various data on RMCS stack record sample concentrations. Table F-4-1 numbers have correction factors applied, while Tables F-4-2 and F-4-5 have no correction factors. Many of the numbers are negative or have variances ≥100%. The total alpha and total beta numbers in Tables F-4-1 and F-4-2 are the same result, with a correction factor applied in Table F-4-1.

Deleting all negative results and those with a variance ≥100% from Tables F-4-1, F-4-2 and F-4-5, and deleting numbers from exhauster installations when no RMCS samples were taken (BY-108 in 1995 and TX-113 in 1998) leaves 20 data points. Of these remaining 20, duplicate values include two total beta analyses for BY-105 riser 11B, two total beta analyses for U-107, three total beta analyses for BY-105 riser 7 and three total beta analyses for BY-105 riser 11B. Since the ABCASH total beta numbers are equal to the ERS data when the correction factors are removed, deleting the ABCASH numbers and the lower of the ERS or 1998 Recount data values for total beta leaves thirteen remaining data points.

The 13 RMCS exhauster stack record sample data points used for estimation of aerosol quantities are restated for clarity in Table F-4-6. Table F-4-6 lists the 13 data points used, the source of the data, a factor to correct the data to account for overall sampling efficiency, and a final sample result. These final sample results were used in Appendix D. A correction factor for sampling efficiency of 0.73 was used. Test data (AMC 1997) indicate that for the RMCS exhauster in its present sampling configuration the stack sampler efficiency is 0.785. Allowing for filter paper efficiency should result in an overall correction factor consistent with the 0.73 value used for the RMCS exhausters in 1998, and for many other stacks and Hanford.

Table F-1-1 Basic RMCS And Exhauster Operational Data

	BY-106[1]	BY-106[1]	BY-110	BY-108	BY-105	SX-101[2]		SX-103[2]		SX-105[2]		SX-102	S-110[2]		U-107	BY-105[3]	BY-105[3]	TX-113	TX-113
Riser Sampled	10B	10B	12B, 7, 12B, 4	12A, 7	12A	19	4	7	11	6	14	8, 4	6	14	7, 2	7	11B	3	5
Sampling Period	11/17/94-12/21/94	1/20/95-1/24/95	7/7/95-10/20/95	7/24/95-8/18/95	9/5/95-9/15/95	12/4/97-2/10/98		4/27/98-5/11/98		2/25/98-5/15/98		6/17/98-7/7/98	5/19/98-6/4/98		6/10/98-7/15/98	7/21/98-7/31/98	8/17/98-9/4/98	9/22/98-2/12/99	4/12/99-4/29/99
# RMCS Cores	1	1	2	0	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
# RMCS Segments	8	3	13	0	3	5	4	2	4	1	5	2	2	8	10	9	9	12	6
Exhauster Used	2 (A)	2 (A)	2 (A)	3 (B)	3 (B)	SX		SX		SX		SX	4 (C)		4 (C)	4 (C)	4 (C)	3 (B), 4 (C)	3(B)
RMCS Exhauster Run Time (hr)	48.78	18.67	112.5	66.17	44.13	N/A		N/A		N/A		N/A	159.78		273.85	135.77	305.58+ 2.34= 307.92[5]	87.38+ 358.28= 445.67	117.12
Exhauster Flow (scfm for RMCS, cfm for SX)	200	200	200	200	200	100[4]		100[4]		100[4]		100[4]	200		200	200	200	200	190
RMCS Exhauster HEPA Dose Rate at End of Sampling (mR/hr)	<0.5	<0.5	<0.5	<0.5	<0.5	N/A		N/A		N/A		N/A	<0.5		<0.5	<0.5	<0.5	0.7	<0.5
Tank Vapor Space Temperature (°F) (RMCS Exhauster Only)	84	81	80	81	85	N/A		N/A		N/A		N/A	74		72	76	78	63	61

[1] Two columns shown for BY-106 in '94-'95 because separate stack record samples were taken for each core
[2] Two columns show for some rows because separate CGM filter paper(s) used for each core
[3] BY-105 (1998) shown in two columns because separate stack record samples taken and separate CGM filter papers were used for each core
[4] Assumed flow rate, see text
[5] Stack record sample information in ABCASH indicates 305.58 hours, but the exhauster run counter was mistakenly reset 2.34 hrs into run. A value of 307.92 hours was used in this document. See Section 1.1.

Table F-1-2 Tank Dimensional Data, Head Space Volumes And Head Space Changeouts during RMCS

	BY-106[1]	BY-106[1]	BY-110	BY-108	BY-105	SX-101[2]	SX-103[2]	SX-105[2]	SX-102	S-110[2]	U-107	BY-105[3]	BY-105[3]	TX-113	TX-113
Riser Sampled	10B	10B	12B, 7, 12B, 4	12A, 7	12A	19,4	7,11	6,14	8, 4	6,14	7, 2	7	11B	3	5
Sampling Period	11/17/94-12/21/94	1/20/95-1/24/95	7/7/95-10/20/95	7/24/95-8/18/95	9/5/95-9/15/95	12/4/97-2/10/98	4/27/98-5/11/98	2/25/98-5/15/98	6/17/98-7/7/98	5/19/98-6/4/98	6/10/98-7/15/98	7/21/98-7/31/98	8/17/98-9/4/98	9/22/98-2/12/99	4/12/99-4/29/99
Nominal Waste Level (in.)	244	244	140	87.3	167	166.5	236.5	240.5	193.5	148.7	156.5	168	168	197	197
Height of Sidewall above Knuckle(ft)	19.95	19.95	19.95	19.95	19.95	31.08	31.08	31.08	31.08	20.01	14.01	19.95	19.95	19.95	19.95
Height of Knuckle (in.)	48	48	48	48	48	0	0	0	0	48	48	48	48	48	48
Height Below Knuckle (in.)	12	12	12	12	12	14.875	14.875	14.875	14.875	12	12	12	12	12	12
Dome Space Volume (gal)	2.49E+4	2.49E+4	2.49E+4	2.49E+4	2.49E+4	2.47E+4	2.47E+4	2.47E+4	2.47E+4	2.49E+4	2.47E+4	2.49E+4	2.49E+4	2.49E+4	2.49E+4
Tank Headspace Volume (ft^3)	5.37E+4	5.37E+4	9.20E+5	1.11E+5	8.21E+4	1.15E+5	8.87E+4	8.73E+4	1.05E+5	8.91E+4	5.94E+4	8.17E+4	8.17E+4	7.10E+4	7.10E+4
Tank Headspace Changeouts during RMCS Exhauster Operation	11.5	4.4	15.4	N/A	6.8	>25*	>25*	>25*	>25*	22.3	57.1	20.7	47.2	61.4	19.0

* Number of head space changeouts in SX farm shown as >25 since SX exhauster operated constantly during RMCS period

Table F-2 Exhauster C Housing NDA Data After RMCS In S-110, U-107, BY-105 (1998) And TX-113

Location	mCi Cs^{137}
Prefilter	0.134
1st HEPA Filter	0.281
2nd HEPA Filter	0.015
Total	0.430

Table F-3-1 Combustible Gas Monitor Operational And Filter Paper Analysis Data

	SX-101[1]	SX-101[1]	SX-103	SX-103	SX-105[1]	SX-105	SX-102	S-110	S-110	U-107	BY-105	BY-105	TX-113	TX-113
Riser Sampled	19	4	7	11	6	14	8, 4	6	14	7, 2	7	11B	3	0.5
Number of CGM Filter Papers Used	2	2	1	1	2	1	1	1	1	1	1	1	1	1
CGM Operating Time (min)	1755 (952+803)	2185 (415+1770)	790	1280	2760 (1900+860)	1100	873	590	615	1300	1200	593	2166	1495
CGM Flow Rate (lpm)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cs^{137} on Filter Paper (μCi)	2.60E-4 ±10.0% (3.09E-5 +2.29E-4)	1.67E-4 ±19.8% (1.89E-5 +1.48E-4)	2.50E-3 ±1.78%	5.65E-3 ±1.41%	1.00E-4 ±12.6% (0+ 1.00E-4)	7.69E-3 ±1.19%	4.85E-4 ±6.56%	4.11E-5 ±25.6%	1.12E-3 ±2.72%	2.03E-3 ±2.01%	2.06E-3 ±1.97%	1.16E-2 ±0.76%	6.57E-5 ±16.5%	7.56E-5 ±28.1%
Total Alpha on Filter Paper (μCi)	7.39E-6 ±48.6% (4.52E-7 +6.94E-6)	3.89E-5 ±13.1% (4.34E-7 +3.85E-5)	3.36E-7 ±113%	3.81E-7 ±96.5%	4.80E-7 ±168% (3.04E-7 +1.76E-7)	4.13E-7 ±367%	1.28E-5 ±13.4%	4.1E-7 ±500%	4.1E-7 ±500%	3.51E-7 ±500%	3.40E-7 ±180%	7.46E-7 ±71.4%	6.12E-7 ±72.3%	3.40E-7 ±500%
Total Beta on Filter Paper (μCi)	1.87E-3 ±2.35% (3.09E-5 +1.84E-3)	1.06E-3 ±1.27% (4.21E-6 +1.06E-3)	2.13E-3 ±0.81%	4.36E-3 ±0.53%	1.21E-4 ±5.25% (3.00E-5 +9.07E-5)	5.55E-3 ±0.46%	4.17E-4 ±1.83%	3.47E-5 ±7.42%	1.46E-3 ±0.95%	1.42E-3 ±1.61%	1.45E-3 ±0.90%	9.70E-3 ±0.35%	6.92E-5 ±4.54%	1.24E-4 ±3.30%

[1]Two filter papers used for these cores. Error estimated by: $Error_{sum} = [(Conc_1)(Error_1) + (Conc_2)(Error_2)] \div Conc_{sum}$

Table F-3-2 Derived Combustible Gas Monitor Filter Paper Data

	SX-101 R19	SX-101 R4	SX-103 R7	SX-103 R11	SX-105 R6	SX-105 R14	SX-102 R8, 4	S-110 R6	S-110 R14	U-107 R7, 2	BY-105 R7	BY-105 R11B	TX-113 R3	TX-113 R5
Assumed Sampling Efficiency	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cs^{137} Concentration in Head Space (μCi/ml)	5.9E-10	3.1E-10	1.3E-8	1.8E-8	1.5E-10	2.8E-8	2.2E-9	2.8E-10	7.3E-9	6.2E-9	6.9E-9	7.8E-8	1.2E-10	2.0E-10
Total Alpha Concentration in Head Space (μCi/ml)	1.7E-11	7.1E-11	1.7E-12*	1.2E-12	7.0E-13*	1.5E-12*	5.9E-11	2.8E-12*	2.7E-12*	1.1E-12*	1.1E-12*	5.0E-12	1.1E-12	9.1E-13*
Total Beta Concentration in Head Space (μCi/ml)	4.3E-9	2.0E-9	1.1E-8	1.4E-8	1.8E-10	2.0E-8	1.9E-19	2.4E-10	9.5E-9	4.4E-9	4.9E-9	6.5E-8	1.3E-10	3.3E-10
Tank Head Space Changeouts by Exhauster during CGM Operation	1.5	1.9	0.89	1.4	3.2	1.3	0.84	1.4	1.4	4.5	3.0	1.5	6.2	4.0

* These values not used in Appendix C, error range is >100%

Table F-4-1 RMCS Stack Record Sample Data From ABCASH[1]

	BY-106 1994	BY-106 1995	BY-108 1995	BY-105 1995	BY-110 1995	S-110 1998	U-107 1998	BY-105 R7 1998	BY-105 R11B 1998	TX-113 R3 1998 Ex B	TX-113 R3 1998 Ex C	TX-113 R3 1999 Ex C	TX-113 R5 1999 Ex B
Stack Sampler Time hrs	825.33[2]	18.70	66.20	44.10	112.5	159.78	273.85	135.77	305.58[3]	87.38	Data Not Available	302	117.12
Total Alpha (μCi/ml)	3.6E-15[2] ±231%	-1.3E-15 ±411%	-3.3E-16 ±428%	8.8E-16 ±350%	1.6E-15 ±113%	2.8E-16 ±376%	4.0E-16 ±194%	7.6E-16 ±204%	1.6E-16 ±358%	9.6E-16 ±287%	Data Not Available	Data Not Available	3.7E-16 ±427%
Total Beta (μCi/ml)	8.2E-15[2] ±118%	1.6E-15 ±490%	-1.1E-15 ±140%	4.8E-15 ±93%	4.3E-17 ±% not stated	1.2E-15 ±121%	2.1E-15 ±52%	4.6E-15 ±36%	4.0E-15 ±36%	8.9E-15 ±43%	Data Not Available	Data Not Available	1.6E-15 ±129%

[1] ABCASH values include correction factors for stack sampler efficiency

[2] Note: Reported stack sampler time is incorrect for BY-106 in 1994. Correct time is 48.78 hours. The 825.33 hour time was the total time from exhauster installation in mid November 1994 to December 31, 1994. The actual run time was 48.78 hours, per Table F-1-1. It is unclear whether the total alpha and total beta concentrations are based upon 825.33 or 48.78 hours. However, since the error values were >100% the numbers are not used in Appendix D anyway.

[3] Note: Actual run time was 307.92 hours, see Section 1.1. Concentrations not corrected as error is conservative and <1%.

Table F-4-2 RMCS Stack Record Sample Data From ERS Records[1]

	BY-106 1994	BY-106 1995	BY-108 1995	BY-105 1995	BY-110 1995	S-110 1998	U-107 1998	BY-105 R7 1998	BY-105 R11B 1998[3]	TX-113 R3 1998 Ex B[2]	TX-113 R3 1998 Ex C	TX-113 R3 1999 Ex C	TX-113 R5 1999 Ex B
Total Alpha (μCi/ml)	No Data	-1.2E-15 ±410%	-3.1E-16 ±430%	8.4E-16 ±350%	1.5E-15 ±110%	2.0E-16 ±380%	2.8E-16 ±190%	5.4E-16 ±200%	1.2E-16 ±360%	6.7E-16 ±290%	Data Not Available	Data Not Available	Data Not Available
Total Beta (μCi/ml)	No Data	1.5E-15 ±490%	-1.0E-15 ±140%	4.5E-15 ±91%	4.1E-17 ±>999%	8.6E-16 ±120%	1.5E-15 ±48%	3.2E-15 ±46%	2.8E-15 ±30%	6.2E-15 ±39%	Data Not Available	Data Not Available	Data Not Available
Sr^{90} (μCi/ml)	No Data	5.9E-14 ±15%	-3.6E-15 ±110%	3.6E-15 ±190%	2.2E-14 ±35%	-1.8E-16 ±310%				7.9E-15 ±85%	Data Not Available	Data Not Available	Data Not Available
Cs^{137} (μCi/ml)	No Data	-6.5E-15 ±170%	1.2E-16 ±>999%	1.2E-15 ±415%	1.5E-15 ±120%	1.0E-17 >±999%				3.4E-15 ±120%	Data Not Available	Data Not Available	Data Not Available
$Pu^{239/240}$ (μCi/ml)	No Data	6.9E-17 ±>999%	7.8E-16 ±120%	1.3E-15 ±100%	-6.4E-17 ±360%	3.8E-17 ±80%				1.5E-16 ±120%	Data Not Available	Data Not Available	Data Not Available
Am^{241} (μCi/ml)	No Data	3.6E-16 ±260%	4.9E-16 ±>999%	9.9E-16 ±110%	4.6E-16 ±110%	2.2E-16 ±39%				1.1E-15 ±86%	Data Not Available	Data Not Available	Data Not Available

[1] ERS data contain no correction factors for stack sampler efficiency.

[2] Data not used, no RMCS segments taken

[3] See note 3 in Table F-4-1.

Table F-4-3 Stack Sampler Flows And Data From Recount Of 1998 RMCS Stack Record Samples With Longer Counting Times

	S-110 1998	U-107 1998	BY-105 R7 1998	BY-105 R11B 1998
Total Alpha (pCi)	2.9E-2 ±90%	1.3E-1 ±30%	2.9E-2 ±90%	6.7E-2 ±40%
Total Beta (pCi)	5.4E-1 ±15%	9.9E-1 ±12%	5.8E-1 ±14%	2.8E-1 ±20%
Cs^{137} (pCi)	2.8E-1 ±110%	-1.3E-1 ± 238%	-2.2E-1 ±167%	-2.0E-1 ±149%
Stack Sampler Flow (scf)	14,641	25,159	12,431	28,119 + 236 = 28355*

*Extra 236 scf is added due to stack record sampler being reset 2.34 hrs. into run. See Section 1.1.

Table F-4-4 RMCS Exhauster HEPA Filter Aerosol Test Data

Measured Elements	BY-106 1994-1995	BY-110 1995	BY-108 1995	BY-105 Aug. 1995	S-110 1998	U-107 1998	BY-105 1998	TX-113 (B) 1998	TX-113 (C) 1998-1999	TX-113 (B) 1999
Primary HEPA %	0.002*	0.002	0.002	not available	0.002	0.003	0.002	0.002	0.004	0.002
Secondary HEPA %	not measured	0.002	0.002	not available	0.002	0.002	0.002	0.002	0.002	0.002
Overall %	0.002*	0.002	not measured	<0.05	not measured	not measured	not measured	not measured	not measured	not measured

* Data are from 2/95 after exhauster was removed from BY-106. The only data available for 11/94 shows >99.95% efficiency (<0.05% penetration).

Table F-4-5 RMCS Stack Concentrations Based On Recount Of 1998 Record Samples With Longer Counting Times

	S-110 1998	U-107 1998	BY-105 R7 1998	BY-105 R11B 1998
Total Alpha (μCi/ml)	7.0E-17 ±90%	1.8E-16 ±30%	8.2E-17 ±90%	8.3E-17 ±40%
Total Beta (μCi/ml)	1.3E-15 ±15%	1.4E-15 ±12%	1.6E-15 ±14%	3.5E-16 ±20%
Cs^{137} (μCi/ml)	6.8E-16 ±110%	-1.8E-16 ±238%	-6.3E-16 ±167%	-2.5E-16 ±149%

Table F-4-6 RMCS Exhauster Record Sample Data Used For Particulate Calculations In Appendix D

	BY-106 1995	BY-105 1995	BY-110 1995	S-110 1998		U-107 1998		BY-105 1998		BY-105 1998		S-110 + U-107 + BY-105 + BY-105 Composite	
Riser Sampled	10B	12A	12B, 7, 12B, 4	6, 14		7, 2		7		11B		at left	
Concentrations used from Tables 5-4-2 and 5-4-5 (μCi/ml)	Sr^{90} 5.9E-14	Total Beta 4.5E-15	Sr^{90} 2.2E-14	Total Alpha 7.0E-17	Total Beta 1.3E-15	Total Alpha 1.8E-16	Total Beta 1.5E-15	Total Alpha 8.2E-17	Total Beta 3.2E-15	Total Alpha 8.3E-17	Total Beta 2.8E-15	$Pu^{239+240}$ 3.8E-17	Am^{241} 2.2E-16
Source of Data Point	ERS	ERS	ERS	1998 Recount	1998 Recount	1998 Recount	ERS	1998 Recount	ERS	1998 Recount	ERS	ERS	ERS
Correction Factor for Stack Sampling Efficiency	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
RMCS Exhauster Effluent Concentration Used for Particulate Calculations (μCi/ml)	Sr^{90} 8.1E-14	Total Beta 6.2E-15	Sr^{90} 3.0E-14	Total Alpha 9.6E-17	Total Beta 1.8E-15	Total Alpha 2.5E-16	Total Beta 2.1E-15	Total Alpha 1.1E-16	Total Beta 4.4E-15	Total Alpha 1.1E-16	Total Beta 3.8E-15	$Pu^{239+240}$ 5.2E-17	Am^{241} 3.0E-16

APPENDIX G

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APPENDIX G - References

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ABCASH-2	ABCASH Air Sample Report for E303, Sample Number S133345 [BY-106 1995]
ABCASH-3	ABCASH Air Sample Report for E304, Sample Number S167071 [BY-105 1995]

ABCASH-4	ABCASH Air Sample Report for E305, Sample Number S167080 [BY-110 1995]
ABCASH-5	ABCASH Air Sample Report for E306, Sample Number S159393 [BY-108 1995]
ABCASH-6	ABCASH Air Sample Report for E308, Sample Number S256477 [S-110 1998]
ABCASH-7	ABCASH Air Sample Report for E308, Sample Number S263878 [U-107 1998]
ABCASH-8	ABCASH Air Sample Report for E308, Sample Number S264975 [BY-105 1998]
ABCASH-9	ABCASH Air Sample Report for E308, Sample Number S269625 [BY-105 1998]
ABCASH-10	ABCASH Air Sample Report for E308, Sample Number unknown [TX-113 1998]
ABCASH-11	ABCASH Air Sample Report for E308, Sample Number S288839 [TX-113 1999]
ABCASH-12	ABCASH Air Sample Report for E307, Sample Number S276826 [TX-113 1998]
ABCASH-13	ABCASH Air Sample Report for E307, Sample Number S299228 [TX-113 1999]

CGM Data

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ERS Data

ERS-1	ERS report ROTMOD: Rotary Mode Core Sampler Stack X303 [BY-106 1995 GEA]
ERS-2	ERS report ROTMOD: Rotary Mode Core Sampler Stack E303 [BY-106 1995 TA/TB]
ERS-3	ERS report ROTMOD: Rotary Mode Core Sampler Stack X304 [BY-105 1995 GEA]
ERS-4	ERS report ROTMOD: Rotary Mode Core Sampler Stack E304 [BY-105 1995 TA/TB]
ERS-5	ERS report ROTMOD: Rotary Mode Core Sampler Stack X305 [BY-110 1995 GEA]
ERS-6	ERS report ROTMOD: Rotary Mode Core Sampler Stack E305 [BY-110 1995 TA/TB]
ERS-7	ERS report ROTMOD: Rotary Mode Core Sampler Stack X306 [BY-108 1995 GEA]
ERS-8	ERS report ROTMOD: Rotary Mode Core Sampler Stack E306 [BY-108 1995 TA/TB]
ERS-9	ERS report ROTMOD: Rotary Mode Core Sampler Stack X308 [S-110, U-107, BY-105, TX-113 1998-1999 GEA]
ERS-10	ERS report ROTMOD: Rotary Mode Core Sampler Stack E308 [S-110, U-107, BY-105, TX-113 1998-1999 TA/TB]
ERS-11	ERS report ROTMOD: Rotary Mode Core Sampler Stack X307 [TX-113 1998-1999 GEA]
ERS-12	ERS report ROTMOD: Rotary Mode Core Sampler Stack E307 [TX-113 1998-1999 TA/TB]

Notices of Construction

NOC-1 DOE/RL-93-40, Radioactive Air Emissions Program Notice of Construction, Rotary Mode Core-Sampling Truck and Exhauster. Approved by Letter AIR 93-707, A. W. Conklin, WDOH to J. E. Rasmussen, DOE/RL, 7/8/93

NOC-2 DOE/RL-94-118 Rev 0, Radioactive Air Emissions Program Notice of Construction for the Rotary Mode Core-Sampling Systems Three and Four. Approved by Letter AIR 95-603, A. W. Conklin, WDOH to J. E. Rasmussen, DOE/RL, 6/30/95

NOC-3 DOE/RL-94-118 Rev 1, Radioactive Air Emissions Program Notice of Construction for the Rotary Mode Core-Sampling Systems Three and Four. Approved by Letter AIR 98-301, W. W. Conklin, WDOH to J. E. Rasmussen, DOE/RL, 3/6/98

NOC-4 DOE/RL-97-70, Radioactive Air Emissions Program Notice of Construction for Rotary Mode Core-Sampling in SX Tank Farm. Approved by Letter AIR 97-1101, A. W. Conklin, WDOH to J. E. Rasmussen, DOE/RL, 11/30/97

NOC-5 DOE/RL-94-116, National Emission Standard for Hazardous Air Pollutants Application for Approval to Construct Rotary Mode Core-Sampling Systems Three and Four. Approved by Letter OAQ-107, A. J. Frankel, USEPA to J. E. Rasmussen, DOE/RL, 8/4/97

Work Packages

WP-1	ES-94-00808	241-BY-106 Perform Rotary Core Sample [Riser 10B]
WP-2	ES-95-00258	241-BY-110 Rotary Core Sample [Risers 12B, 7, 12B, 4]
WP-3	ES-95-00045 -	241-BY-108 Obtain Rotary Core Sample [Risers 12A & 7]
WP-4	ES-95-00434 -	241-BY-105 Rotary Mode Core Sample [Riser 12A]
WP-5	WS-97-00173 -	241-SX-101 Rotary Mode Core Sample Riser 19
WP-6	WS-97-00174 -	241-SX-101 Rotary Mode Core Sample Riser 4
WP-7	WS-97-00143 -	241-SX-103 Rotary Mode Core Sample Riser 7
WP-8	WS-97-00144 -	241-SX-103 Rotary Mode Core Sample Riser 11
WP-9	WS-97-00207 -	241-SX-105 RMCST Obtain Core Sample Riser 6
WP-11	WS-97-00208 -	241-SX-105 RMCST Core Sample Riser 14
WP-12	WS-98-00049 -	241-SX-102 Rotary Mode Core Sample Riser 8
WP-13	WS-97-00050 -	241-SX-102 Rotary Mode Core Sample Riser 4
WP-14	WS-97-00224 -	241-S-110 RMCST Obtain Core Sample Riser 6
WP-15	WS-97-00225 -	241-S-110 RMCST Obtain Core Sample Riser 14
WP-16	WS-97-00230 -	241-U-107 RMCST Core Sample Riser 7
WP-17	WS-97-00231 -	241-U-107 RMCST Core Sample Riser 2
WP-18	ES-97-00452 -	241-BY-105 RMCST Core Sample Riser 7
WP-19	ES-97-00453 -	241-BY-105 RMCST Core Sample Riser 11B
WP-20	WS-98-00072 -	241-TX-113 Rotary Core Sample Riser 3
WP-21	WS-98-00073 -	241-TX-113 RMCST Core Sample Riser 5

DISTRIBUTION SHEET

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Project Title/Work Order		Date August 30, 1999
EXPERIENCE WITH A AEROSOL GENERATION DURING ROTARY MODE CORE SAMPLING IN THE HANFORD SINGLE SHELL WASTE TANKS		EDT No. 623414
		ECN No.

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