WASTE TANK VENTILATION SYSTEM WASTE MATERIAL ACCUMULATIONS

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Abstract: This paper calculates the amount of material that accumulates
in the ventilation systems of various Tank Waste Remediation System
facilities and estimates the amount of material that could be released
due to a rapid pressurization.

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This calculation note describes the method used by Savino (1996) to calculate the amount of material that could accumulate in the ventilation systems of various tank farm facilities. To perform this calculation, Savino modeled 3.7×10^{10} Bq (1 Ci) of gamma emitters in different filter configurations and then calculated the contact doses that could accumulate on the housings of these filters. Depending on the source material (Cowley 1996), the gamma emitters used in the calculation were different. For example, for single-shell solids, Savino used ^{90}Sr , ^{90}Y , ^{137}Cs , and ^{154}Eu for the gamma emitters; while, for double-shell liquids Savino used predominantly ^{137}Cs (the other gamma emitters in double-shell tanks have much smaller concentrations and therefore weren't included in the calculation). The spreadsheet tables in this calculation note indicate the relative amounts of all radionuclides used for each of the cases that were analyzed.

Different filter geometries were modeled to calculate material accumulations in the various tank ventilation systems. These geometries include high-efficiency particulate air (HEPA) filters and prefilters. After inputting the filter geometry and the source material that might be present, a dose rate (mSv/hr) was calculated.

HEPA filters and prefilters have pre-specified operating limits. These operating limits were used, along with the calculated dose rate, to form a ratio of the operating limit to the calculated dose limit. This ratio gives the fraction of the assumed waste volume that could be accumulated on the filter for the specified operating limit. The amount of material that could be released to the environment from a blowout of a single bank of filters in a tank ventilation system was calculated using one of the following schemes, depending on the tank ventilation system being analyzed.

- The tank ventilation system is a standard, active ventilation system with a prefilter, and a first-stage and second-stage HEPA filter. An additional amount of release material, equal to another prefilter loading, was used to account for material that might come out of the ventilation duct work. That is, two prefilter volumes plus two HEPA filter volumes were used in the calculation.
- The tank ventilation system is passively ventilated. This system consists of one HEPA filter, sitting on a riser. There is no prefilter and there is no ventilation ducting to speak of. That is, one HEPA filter volume was used in the calculation.
- The tank ventilation system has two de-entrainers, and a first-stage and second-stage HEPA filter. To account for the accumulation of material in the de-entrainers and the material that might come out of the ventilation duct work, an additional volume, equivalent to three HEPA filters, was used in the calculation. A total of five times the material accumulation for one HEPA filter was used in the calculation.

- The tank ventilation system consists of a prefilter, low-efficiency filter (treated as another prefilter), and first-stage and second-stage HEPA filters. In addition, a volume of material equal to that used for the prefilter was used in the calculation to account for material from the ventilation system ducting. A total of three prefilter volumes and two HEPA filter volumes were used in the calculation.

The following spreadsheet pages also identify how many filter banks are in operation in a ventilation system at the same time. The total amount of material that could be released from a ventilation system can be determined by multiplying the calculated filtration system loading by the appropriate release fraction. For ventilation system filter blowout, the release fraction is 1/100 as given in Section 5.4.4.2 of DOE-HDBK-3010-94 (DOE 1994) of the accumulated volume is released. This corresponds to the material that would be released from crushing a filter in an unconfined space. The calculated release volumes in the following spreadsheet pages were used to calculate the radiological and toxicological doses as documented in calculation note WHC-SD-WM-CN-055 (Van Vleet 1996). An example calculation is shown here for single-shell tanks with active ventilation containing HEPA filter of dimension 61 cm x 61 cm x 31.5 cm (24 x 24 x 12 in.). Other ventilation system arrangements are treated in a similar fashion.

EXAMPLE

Savino (1996) evaluated the single-shell tank solid source term (Van Keuren and Savino 1996). He determined that Sr^{90} , Y^{90} , Cs^{137} , and Eu^{154} were the gamma emitters that would contribute to contact doses on the filter housing. Alpha and beta emitters will be shielded out by the HEPA filter itself or the metal housing of the filter enclosure. He apportioned 3.7×10^{10} Bq (1 Ci) of activity on the HEPA filter in the same ratio as they appear in the single-shell tank solid source term (Cowley 1996). That is 1.8×10^{10} Bq (0.484 Ci) of Sr^{90} , 1.8×10^{10} Bq (0.484 Ci) of Y^{90} , 1.1×10^9 (0.0303 Ci) of Cs^{137} , and 6.3×10^7 Bq (0.0017 Ci) of Eu^{154} . This loading is equivalent to 0.0112 L of single-shell tank solids on the filter. Single-shell tank solids were assumed since the vast majority of the single shell tanks do not have supernatant layers.

This loading on the HEPA filter was modelled using the Microshield computer code. A contact dose rate of 0.257 mSv/hr was calculated at the filter housing. An operating limit equal of 200 mR/hr was chosen by operations. For the purpose of this analysis, this is equivalent to a contact dose rate of 2 mSv/hr, i.e., a quality factor of 1 was assumed.

To arrive at the maximum loading that would give the operating limit, the following equation was used.

$$\begin{aligned} M_{HEPA} &= \left(\frac{\text{Operating Limit}}{\text{Calculated Rate}} \right) (\text{Initial Loading}) \\ &= \left(\frac{2 \text{ mSv/hr}}{0.257 \text{ mSv/hr}} \right) (0.0112 \text{ L}) \\ &= 0.0872 \text{ L} \end{aligned}$$

A similar calculation was done for the pre-filters.

$$\begin{aligned} M_{prefilter} &= \left(\frac{2 \text{ mSv/hr}}{0.34 \text{ mSv/hr}} \right) (0.0112 \text{ L}) \\ &= 0.0659 \text{ L} \end{aligned}$$

For this ventilation system, the standard ventilation scheme described above was used. In that scheme there is 1 prefilter, a first stage HEPA, and a second stage HEPA. All filters are assumed to have waste accumulations so that the contact dose rate is equivalent to 2 mSv/hr. In order to account for the loading on the ventilation ducting, another volume equal to a prefilter is assumed to be available for release. The the total volume in one bank of the ventilation system is.

$$\begin{aligned} M_{bank} &= 2(M_{HEPA}) + 2(M_{prefilter}) \\ &= 2(0.0872) + 2(0.0659) \\ &= 0.306 \text{ L} \end{aligned}$$

The total amount of material released during a high pressure event, for this example, is found by multiplying the number of operating filter banks, the material released from one filter bank, and the release fraction of 1/100 (DJE 1994).

$$\begin{aligned} M_{total} &= (\text{Number of Banks}) (M_{bank}) (\text{Release Fraction}) \\ &= (2) (0.306) (0.01) \\ &= 0.0061 \text{ L} \end{aligned}$$

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WHC-SD-WM-SARR-037					SX, C-106			SST's with Passive Breather Filters					
	SST Solids (Bq/L)	SST Liquids (Bq/L)	DST Liquids (Bq/L)	AWF Liquids (Bq/L)	SST Solids on a 3X3 Array of 24x24x12 Filters			SST Solids on a 24x24x12 Filter			SST Solids on a 12x12x12 Filter		
					(Ci)	(Bq)	(L)	(Ci)	(Bq)	(L)	(Ci)	(Bq)	(L)
Co60	4.2E+08	9.5E+06	7.0E+06	7.7E+05									
Sr90	1.6E+12	1.1E+10	4.6E+09	5.6E+09	0.4840	1.8E+10	0.011	0.4840	1.8E+10	0.011	0.4840	1.8E+10	0.011
Y 90	1.6E+12	1.1E+10	4.6E+09	5.6E+09	0.4840	1.8E+10	0.011	0.4840	1.8E+10	0.011	0.4840	1.8E+10	0.011
Cs137	1.0E+11	2.2E+10	5.9E+10	8.8E+10	0.0303	1.1E+09	0.011	0.0303	1.1E+09	0.011	0.0303	1.1E+09	0.011
Eu154	5.8E+09	2.4E+09	4.2E+07	0.0E+00	0.0017	6.3E+07	0.011	0.0017	6.3E+07	0.011	0.0017	6.3E+07	0.011
Np237	3.0E+07	0.0E+00	2.3E+05	9.2E+04									
Pu238	1.9E+08	9.2E+04	1.8E+06	2.8E+03									
Pu239	4.4E+08	3.6E+07	7.7E+06	1.2E+06									
Pu241	3.2E+09	2.6E+08	1.8E+07	3.4E+05									
Am241	2.3E+08	4.2E+07	3.4E+07	1.1E+06									
Cm244	2.3E+06	4.2E+05	1.2E+05	1.1E+04									
				TOTAL	1.00	3.7E+10	0.011	1.00	3.7E+10	0.011	1.00	3.7E+10	0.011
MicroShield Calculated Dose for HEPA (mSv/hr)						0.257				1.11			4.15
HEPA Operating Limit (mSv/hr)						2				2			2
OL/CD						7.782				1.129944			0.421053
HEPA Loading to give OL (L)						0.087245				0.012668			0.00472
1% Release (L)						0.000872				0.000127			4.72E-05
MicroShield Calculated Dose for Prefilter (mSv/hr)						0.34				No Prefilter			No Prefilter
Prefilter Operating Limit (mSv/hr)						2							
OL/CD						5.882353							
Prefilter Loading to give OL (L)						0.065947							
1% Release (L)						0.000659							
Volume Released from One Filter Bank (L)					D	3.06E-03		P	1.27E-04		P	4.72E-05	
Number of Parallel Banks Operating at the Same Time						2			1			1	
TOTAL RELEASED (L)						6.13E-03			1.27E-04			4.72E-05	
D = Two HEPA's, a Prefilter, and another volume equal to the prefilter for stuff coming out of the ventilation ducting													
= 2*HEPA Volume + 2* Prefilter Volume													
P = Passive breather HEPA, no prefilter, no second HEPA, and no appreciable ventilation ducting													
= 1*HEPA Volume													
A = Two (2) HEPA's, no prefilter but there are two (2) de-entrainers and material in the ventilation ducting (1)													
= 5*HEPA Volume													
C = Two HEPA's, a prefilter, a low efficiency filter (treated as a prefilter), and another volume equal to the prefilter for material in the vent. ducting.													
= 2*HEPA Volume + 3*Prefilter Volume													

WHC-SD-WM-CN-054, Rev. 0

8

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Scope of Review: Entire document.

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

C. H. Huang C. H. Huang
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