12. AREA 200 LEACH SYSTEM

Area 200 Pre-Leach and Leach Systems

Sulfuric Acid Emissions

Source Parameters:

Source ID	Emission Source	Stack Flow Rate (scfm)	Stack Diameter (ft)	Stack Height (ft)	Stack Temp. (deg F)	Gas Temperature (deg C)	Control Efficiency %
220-GHS-01	Leach Train Vent Gas Scrubber	2,500	1	35	Ambient	21	99%

Basis/Assumptions:

Sulfuric acid has an extremely low vapor pressure and a high boiling point, meaning that sulfuric acid does not readily volatilize to form gaseous H_2SO_4. However, acid mist will be carried within water vapor in the inlet stream to the scrubber. Therefore, water vapor is assumed to be the volatile substance in the EPA diffusion equation. Then the basis of acid emissions will be that the aqueous solution in the pre-leach tanks contains 1-5% H_2SO_4, assumed 5% for these calculations. Additionally, the basis of acid emissions will be that the aqueous solution in the leach tanks contains 11% H_2SO_4.

Reference	From Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemical Release Inventory Form, dated December 1987.

Based on the EPA Diffusion Equation:

$$VGR = (3.1536 \times 10^{7}) \times F \times \frac{MKAP}{RT} \times (1-CE)$$

Where:

VGR = Vapor Generation Rate (lb/yr)

M = MW of Species i, (lb/lbmol) (Water = 18.02 lb/lbmol)

A = Tank Surface Area (ft^2)

P = Partial Pressure of the Volatile Chemical, species i, in the mixture (psia)

R = Universal Gas Constant, psia-ft^3/°R-lbmol
= 10.73 psia-ft^3/°R-lbmol

T = Temperature °R
= 100°F = 559.67°R (Pre-Leach Tanks)
= 185°F = 644.67°R (Leach Tanks - Steam Added)

K = Gas-Phase Mass Transfer Coefficient, ft/s
$= 0.00438 \times (U)^{0.78} \times (18/M)^{1/3}$

U = Speed of air across liquid surface, miles/hr
= 1.7 mph (EPA default value, as defined in the attached EPCRA example calc)

3.1536×10^{7} = Conversion factor for lb/s to lb/yr

F = Dimensionless Factor
= 1.1 for agitated tank

CE = Scrubber Control Efficiency

Pre-Leach Tank Surface Area Dimensions=	346.36 ft^2	P_{Water} =	0.951 psia	at 37.8°C / 100 °F
Leach Tank Surface Area Dimensions=	346.36 ft^2	P_{Water} =	8.38 psia	at 85°C / 185 °F

Copyright 2009 Kleinfelder

Area 200 Pre-Leach and Leach Systems

Leach Circuit Calculation Parameters:												
Source ID	Emission Source	Chemical Species (i)	Mol Wt. (Species i) (lb/lbmol)	Partial Pressure (psia)	Bath Surface Area (ft^2)	Temp. (^oR)	Gas Constant R (psia-ft^3/^oR-lbmol)	Air Speed Across Liq. Surface (mph)	Gas Phase Mass Transfer Coeff. (ft/s)	Agitated Tank Factor	Percent Acid in Solution	Scrubber Control Efficiency (99%)
210-TKL-01	Pre-Leach Tank #1	Water	18.02	9.51E-01	346.4	559.67	10.73	1.7	0.00662314	1.1	5%	99%
210-TKL-02	Pre-Leach Tank #2	Water	18.02	9.51E-01	346.4	559.67	10.73	1.7	0.00662314	1.1	5%	99%
220-TKL-01	Leach Tank #1	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-02	Leach Tank #2	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-03	Leach Tank #3	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-04	Leach Tank #4	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-05	Leach Tank #5	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-06	Leach Tank #6	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-07	Leach Tank #7	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%
220-TKL-08	Leach Tank #8	Water	18.02	8.38E+00	346.4	644.67	10.73	1.7	0.00662314	1.1	11%	99%

Leach Circuit Emissions:		Uncontrolled Emissions: [1]				Controlled Emissions:			
Source ID	Emission Source	Sulfuric Acid Emissions (lb/hr)	Sulfuric Acid Emissions (lb/day)	Sulfuric Acid Emissions (lb/yr)	Sulfuric Acid Emissions (ton/yr)	Sulfuric Acid Emissions (lb/hr)	Sulfuric Acid Emissions (lb/day)	Sulfuric Acid Emissions (lb/yr)	Sulfuric Acid Emissions (ton/yr)
210-TKL-01	Pre-Leach Tank #1	0.01	0.31	113.54	0.06	0.013	0.31	113.54	0.06
210-TKL-02	Pre-Leach Tank #2	0.01	0.31	113.54	0.06	0.013	0.31	113.54	0.06
220-TKL-01	Leach Tank #1	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-02	Leach Tank #2	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-03	Leach Tank #3	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-04	Leach Tank #4	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-05	Leach Tank #5	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-06	Leach Tank #6	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-07	Leach Tank #7	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
220-TKL-08	Leach Tank #8	0.22	5.24	1910.93	0.96	0.22	5.24	1910.93	0.96
	Totals:	**1.77**	**43**	**15,515**	**7.76**	**1.77**	**42.51**	**15,515**	**7.76**

Note:

1. The scrubber is integral to the leach process in that it collects and recirculates process solution into the counter current decantation circuit. The leach system would not operate without the scrubber as process solution would be lost. The scrubber is electrically interlocked such that if it malfunctions, the entire leach system will shut down. Because the scrubber is integral to the leach process itself, the uncontrolled emissions are calculated as being the same as the controlled emissions.

Copyright 2009 Kleinfelder

Area 200 Pre-Leach and Leach Systems

Radionuclide Emissions

Emission Basis: **Based on Data from a Similar Uranium Mill - Radionuclide Emission Data**

Operating Parameters:

Operating hours per day	24	hour/day
Operating days per year	365	days/year

Specific Activity of Radionuclides

Radium-226	1	Ci/g
Thorium-230	0.019	Ci/g
Lead-210	88	Ci/g

Source Parameters:

		Stack Parameters					
		Flow Rate	Flow Rate	Diameter	Height	Temperature	Control
Source ID	Emission Source	(scfm)	(m^3/min)	(ft)	(ft)	(deg F)	Efficiency
220-GHS-01	Leach Train Vent Gas Scrubber	2,500	71	1	35	Ambient	99%

Emissions:

Radionuclides		**Radionuclide Compound**	**Controlled**					
Source ID	Emission Source		pCi/ml (air)	pCi/m^3	pCi/hr	pCi/day	pCi/yr	lb/yr
220-GHS-01	Leach Train Vent Gas Scrubber	Radium-226	5.0E-07	0.5	2.1E+03	5.1E+04	1.9E+07	4.10E-08
		Thorium-230	7.0E-07	0.7	3.0E+03	7.1E+04	2.6E+07	3.02E-06
		Lead-210	3.0E-07	0.3	1.3E+03	3.1E+04	1.1E+07	2.80E-10
		Total Radionuclides	1.5E-06	1.5E+00	6.4E+03	1.5E+05	5.6E+07	3.06E-06

Copyright 2009 Kleinfelder

15. AREA 500 URANIUM PRECIPITATION AND PACKAGING

Area 500 Uranium Precipitation and Packaging

Sulfuric Acid Emissions

Basis/Assumptions:

Sulfuric acid is added to the precipitation tanks for pH control. However, since the pH is held between 2.5 and 4.5 for optimal precipitation of the solution, the average amount of free acid in solution is estimated to be about 0.0002 N H_2SO_4 (0.001% H_2SO_4). Therefore, sulfuric acid emissions are assumed to be negligible.

Note: Since pH = -log (H^+) and if the average pH is 4, then the Molarity (moles/L) = 10^{-4}. Then there are 2 equivalent H+ ions when H_2SO_4 dissociates, so the Normality = 2×10^{-4}.

Source Parameters:

Source ID	Emission Source	Stack Flow Rate (scfm)	Stack Diameter (ft)	Stack Height (ft)	Gas Temp (deg F)	Control Efficiency %
530-GHS-01	Uranium Vent Gas Scrubber	2,000	1	35	225	99%

Particulate Emissions

Basis/Assumptions:

The yellowcake dryer is a vacuum dryer, where water vapor exhaust will be sent through a condenser and the water will be recycled back into the system. This system is considered a 'no emission' dryer.

Copyright 2009 Kleinfelder

17. AREA 700 VANADIUM PRECIPITATION AND PACKAGING

Area 700 Vanadium Precipitation and Packaging

Operating Parameters:

Operating hours per day	24	hour/day
Operating days per year	365	days/year

Ammonia Emissions (Drying & Packaging)

Basis/Assumptions:

730-GHS-01: The vanadium precipitation process will use ammonia and ammonium sulfate for pH control to maintain optimal precipitation of the vanadium product. Ammonia emissions are calculated using the EPA Diffusion Equation. Ammonia will then be driven off in the rotary kiln when heated to 698 °F. By mass balance, the amount of ammonia generated by the belt filter vacuum and the rotary kiln is 117 lb/hr, as inlet to the scrubber.

Source Parameters:

Source ID	Emission Source	Stack Flow (scfm)	Stack (ft)	Stack Height (ft)	Gas Exit (deg F)	Control
730-GHS-01	Packed Bed Wet Vent Scrubber	1,000	0.67	35	225	99%

*vent gases from precip tanks 1-5, belt filter vacuum, rotary kiln, dryer

Ammonia Emission Factor:

$EF_{Ammonia}$ = 117 lb/hr

Emissions:

Ammonia		Uncontrolled [1]			Controlled		
Source ID	Emission Source	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)
730-GHS-01	Packed Bed Wet Vent Scrubber	1.17	28.08	5.12	1.17	28.08	5.12

Copyright 2009 Kleinfelder

Area 700 Vanadium Precipitation and Packaging

Ammonia Emissions (Precipitation)

Source Parameters:

Source ID	Emission Source	Stack Flow Rate (scfm)	Stack Diameter (ft)	Stack Height (ft)	Stack Temp. (deg F)	Control Efficiency %
730-GHS-01	Packed Bed Wet Vent Scrubber	1,000	0.67	35	225	99%

Basis/Assumptions:

Since the concentration of ammonia in solution is very small (<0.01%), the vapor pressure of water will be used in the EPA diffusion equation. The concentration of ammonia in solution is estimated to be much less than 1%, however due to buffering and for conservative emission calculations, the basis will be that the aqueous solution in the vanadium precipitation tanks contains 1% ammonia.

Based on the EPA Diffusion Equation:

$$VGR = (3.1536 \times 10^{7}) \times F \times \frac{MKAP}{RT} \times (1-CE)$$

Where:

VGR = Vapor Generation Rate (lb/yr)

M = MW of Species i, (lb/lbmol) (Ammonia = 17.03 lb/lbmol)

A = Tank Surface Area (ft^2)

P = Partial Pressure of the Volatile Chemical, species i, in the mixture (psia)

R = Universal Gas Constant, psia-$ft^3/^oR$-lbmol
= 10.73 psia-$ft^3/^oR$-lbmol

T = Temperature ^oR
= 149^oF = 608.67^oR

K = Gas-Phase Mass Transfer Coefficient, ft/s
= $0.00438 \times (U)^{0.78} \times (18/M)^{1/3}$

U = Speed of air across liquid surface, miles/hr
= 1.7 mph (EPA suggested value)

3.1536×10^7 = Conversion factor for lb/s to lb/yr

F = Dimensionless Factor
= 1.1 for agitated tank

CE = Scrubber Control Efficiency

Precipitation Tank Surface Area = 50.27 ft^2 P_{Water} = 3.73 psia at 65^oC / 149 ^oF

Vanadium Precipitation Circuit Calculation Parameters:

Source ID	Emission Source	Chemical Species (i)	Mol Wt. (Species i) (lb/lbmol)	Partial Pressure (psia)	Bath Surface Area (ft^2)	Temp. (^oR)	Gas Constant R (psia-$ft^3/^oR$-lbmol)	Air Speed Across Liq. Surface (mph)	Gas Phase Mass Transfer Coeff. (ft/s)	Agitated Tank Factor	Percent Acid in Solution	Scrubber Control Efficiency (99%)
710-TKP-01	Vanadium Precipitation Tank #1	Ammonia	17.03	3.73E+00	50.3	608.67	10.73	1.7	0.006749064	1.1	1%	99%
710-TKP-02	Vanadium Precipitation Tank #2	Ammonia	17.03	3.73E+00	50.3	608.67	10.73	1.7	0.006749064	1.1	1%	99%
710-TKP-03	Vanadium Precipitation Tank #3	Ammonia	17.03	3.73E+00	50.3	608.67	10.73	1.7	0.006749064	1.1	1%	99%
710-TKP-04	Vanadium Precipitation Tank #4	Ammonia	17.03	3.73E+00	50.3	608.67	10.73	1.7	0.006749064	1.1	1%	99%
710-TKP-05	Vanadium Precipitation Tank #5	Ammonia	17.03	3.73E+00	50.3	608.67	10.73	1.7	0.006749064	1.1	1%	99%

Copyright 2009 Kleinfelder

Area 700 Vanadium Precipitation and Packaging

Vanadium Precipitation Circuit Emissions:		Uncontrolled Emissions: [1]				Controlled Emissions:			
Source ID	Emission Source	Ammonia Emissions (lb/hr)	Ammonia Emissions (lb/day)	Ammonia Emissions (lb/yr)	Ammonia Emissions (ton/yr)	Ammonia Emissions (lb/hr)	Ammonia Emissions (lb/day)	Ammonia Emissions (lb/yr)	Ammonia Emissions (ton/yr)
710-TKP-01	Vanadium Precipitation Tank #1	0.001	0.03	11.45	0.01	0.001	0.03	11.45	0.01
710-TKP-02	Vanadium Precipitation Tank #2	0.001	0.03	11.45	0.01	0.001	0.03	11.45	0.01
710-TKP-03	Vanadium Precipitation Tank #3	0.001	0.03	11.45	0.01	0.001	0.03	11.45	0.01
710-TKP-04	Vanadium Precipitation Tank #4	0.001	0.03	11.45	0.01	0.001	0.03	11.45	0.01
710-TKP-05	Vanadium Precipitation Tank #5	0.001	0.03	11.45	0.01	0.001	0.03	11.45	0.01
	Totals:	**0.01**	**0.16**	**57.23**	**0.03**	**0.01**	**0.16**	**57.23**	**0.03**

Copyright 2009 Kleinfelder

Area 700 Vanadium Precipitation and Packaging

Particulate Emissions (Dryer)

Basis/Assumptions:

730-DCS-01: Vanadium particulate from the dryer will be controlled with a baghouse (730-DCS-01), however, the emissions from the baghouse will be further controlled by the packed bed scrubber (730-GHS-01). The baghouse exhaust will be rated at 0.02 gr/scf. The belt filter and rotary kiln exhaust is vented to the packed bed scrubber only (730-GHS-01) and emissions are estimated to be 10 ppm, as inlet to the scrubber.

Dryer Baghouse Exhaust: 0.02 gr/scf
Where lb/hr = gr/scf x lb/gr x scf/hr
E_{PM} = 0.051 lb/hr

Source ID	Emission Source	Stack Flow (cfm)	Stack (ft)	Stack (ft)	Gas Exit (deg F)	Control %
730-DCS-01	Vanadium Dryer Dust Collector	300	TBD	TBD	190	99%

Particulate Emissions Calculation (belt filter and rotary kiln)

$E_{PM} = (C_{PM}) \times Q \times d_{Air} \times (1 \text{ tonne}/1000 \text{ kg}) \times (1 \text{ lb} / 453.59 \text{ g}) \times (60 \text{ min/hr})$

Where:
E_{PM} = *Particulate Emissions (kg/yr)*
C_{PM} = *Conc of PM in gas stream (g/tonne)*
Q = *Flow Rate (m^3/min) - @STP*
d_{Air} = *Density of Air (1.29 kg/m^3 at STP)*

Basis:
Particulate inlet to scrubber (belt filter & kiln): 10 ppm E_{PM} = 0.048 lb/hr
Where: 10 ppm (mass) = 10 g / tonne

Emissions (Dryer Baghouse + Rotary Kiln + Belt Filter):

Particulate (PM / PM_{10} / $PM_{2.5}$)		Uncontrolled [1]			Controlled		
Source ID	Emission Source	(lb/hr)	(lb/day)	(ton/yr)	(lb/hr)	(lb/day)	(ton/yr)
730-GHS-01	Packed Bed Wet Vent Scrubber	9.97E-04	2.39E-02	4.37E-03	9.97E-04	2.39E-02	4.37E-03

Copyright 2009 Kleinfelder

Area 700 Vanadium Precipitation and Packaging

Radionuclide Emissions

Emission Basis: Based on Data from a Similar Uranium Mill - Radionuclide Emission Data

Operating Parameters:

Operating hours per day	24	hour/day
Operating days per year	365	days/year

Specific Activity of Radionuclides

Radium-226	1	Ci/g
Thorium-230	0.019	Ci/g
Lead-210	88	Ci/g

Source Parameters:

		Stack Parameters					
Source ID	Emission Source	Flow Rate (scfm)	Flow Rate (m^3/min)	Diameter (ft)	Height (ft)	Temp (deg F)	Control Efficiency
730-GHS-01	Packed Bed Wet Scrubber	1,000	28	0.67	35	225	99%

Emissions:

Radionuclides		Radionuclide Compound	Controlled					
Source ID	Emission Source		pCi/ml (air)	pCi/m^3	pCi/hr	pCi/day	pCi/yr	lb/yr
730-GHS-01	Packed Bed Wet Scrubber	Radium-226	5.0E-08	0.1	8.5E+01	2.0E+03	7.4E+05	1.64E-09
		Thorium-230	5.0E-07	0.5	8.5E+02	2.0E+04	7.4E+06	8.63E-07
		Lead-210	2.0E-06	2.0	3.4E+03	8.2E+04	3.0E+07	7.46E-10
		Total Radionuclides	2.6E-06	2.6E+00	4.3E+03	1.0E+05	3.8E+07	8.66E-07

Note:

1. The scrubber (730-GHS-01) is integral to the vanadium precipitation process in that it recovers and recirculates process solution into the pre-leach thickener tank as well as cooling the scrubbed air prior to venting. The vanadium precipitation system would not operate without the scrubber as process solution would be lost. Because the scrubber is integral to the vanadium precipitation process, the uncontrolled emissions are calculated as being the same as the controlled emissions.

Copyright 2009 Kleinfelder

Area 700 Vanadium Precipitation and Packaging

Particulate Emissions (Furnace, Casting Wheel, & Packaging)

Basis/Assumptions:
730-GHS-02: The fusion furnace, casting wheel, and packaging system is estimated to yield 200 ppm of vanadium particulate, as inlet to the scrubber.

Source Parameters:

Source ID	Emission Source	Stack Flow Rate (scfm)	Stack Diameter (ft)	Stack Height (ft)	Gas Exit Temperature (deg F)	Control Efficiency %
730-GHS-02	Wet Venturi Scrubber	5,000	1.33	35	250	99%

* vent gases from fusion furnace, hood vent of casting wheel, hood vent of packaging system

Particulate Emissions Calculation:
$E_{PM} = (C_{PM}) \times Q \times d_{Air} \times (1 \text{ tonne}/1000 \text{ kg}) \times (1 \text{ lb} / 453.59 \text{ g}) \times (60 \text{ min/hr})$

Where:
E_{PM} = *Particulate Emissions (kg/yr)*
C_{PM} = *Conc of PM in gas stream (g/tonne)*
Q = *Flow Rate (m^3/min) - @STP*
d_{Air} = *Density of Air (1.29 kg/m^3 at STP)*

Basis:
Particulate inlet to scrubber: 200 ppm
Where: 200 ppm (mass) = 200 g / tonne

Particulate (PM / PM_{10} / $PM_{2.5}$) Emissions:

Source ID	Emission Source	Uncontrolled (lb/hr)	Uncontrolled (lb/day)	Uncontrolled (ton/yr)	Controlled (lb/hr)	Controlled (lb/day)	Controlled (ton/yr)
730-GHS-02	Wet Venturi Scrubber	4.83	115.97	21.16	0.05	1.16	0.21

Copyright 2009 Kleinfelder