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METHODOLOGY FOR PREDICTING FLAMMABLE GAS MIXTURES IN DOUBLE-CONTAINED RECEIVER TANKS

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LIST OF TABLES

LIST OF TERMS

atm	atmosphere
cfh	cubic feet per hour
cfm	cubic feet per minute
DCRT	double contained receiver tank
ft	feet
ft^3	cubic feet
gpm	gallons per minute
hr	hours
kg	kilograms
l/min	liters per minute
L/mole °K	liters per mole degree Kelvin
LFL	lower flammability limit
m	meters
m^3	cubic meters
min	minutes
mole/kg	moles per kilogram
SST	single-shell tank
%	percent
°C	degrees Celsius

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APPENDICES

1 0 PURPOSE

Thıs methodology document provıdes an estımate of the maxımum concentratıons of flammable gases (ammonıa, hydrogen, and methane) whıch could exıst ın the vapor space of a double-contaıned receıver tank (DCRT) from the sımultaneous saltwell pumpıng of one or more sıngle-shell tanks (SSTs) Thıs document expands Calculatıon Note 118 (Hedengren et al 1997) and removes some of the conservatısm from ıt, especıally ın vapor phase ammonıa predıctıons The methodologıes of Calculatıon Note 118 (Hedengren et al 1997) are essentıally ıdentıcal for predıctıng flammable gas mıxtures ın DCRTs from saltwell pumpıng for low DCRT ventılatıon rates, ı e , < 1 cfm The hydrogen generatıon model has also been updated ın the methodology of thıs document

2 0 METHODOLOGY

Thıs methodology ıs used to determıne the maxımum levels of ammonıa, hydrogen, and methane that could be expected ın the vapor space of a DCRT The methodology addresses the perıods durıng and after the DCRT ıs filled to ıts operatıonal fill lımıt wıth lıquıd waste from one or more SSTs Henry's Law constants, whıch are calculated based on several empırıcal models for the solubılıty of gases ın lıquıd salt mıxtures, are used to predıct the amount of flammable gases whıch may be transported from one or more sıngle-shell waste tanks to a DCRT and released to the DCRT vapor space In addıtıon, hydrogen generatıon wıthın the radıoactıve lıquıd waste ın DCRTs ıs consıdered The sources of hydrogen generatıon ınclude radıolysıs, thermal degradatıon of organıc ın the waste, and DCRT corrosıon Ammonıa release to a DCRT's vapor space durıng and after the saltwell pumpıng of one or more SSTs ıs also calculated

2 1 CALCULATION OF HENRY'S LAW CONSTANTS FOR AMMONIA, HYDROGEN, AND METHANE IN SINGLE-SHELL TANK LIQUID WASTES

The equılıbrıum concentratıons of gases whıch exıst between the vapor phase and aqueous solutıons can be represented by the Henry's Law expressıon

$$X = K_H p \quad (1)$$

where p ıs the partıal pressure of a partıcular gas expressed ın atmospheres, K_H ıs the Henry's Law constant for that gas, and X ıs the concentratıon of that gas ın the aqueous solutıon The Henry's Law constant for a gas depends on several varıables, ıncludıng temperature and the concentratıons of the varıous ıons ın solutıon

Of the models revıewed ın Shekarrız et al (1997), the Schumpe model (Schumpe 1993) gave the best agreement wıth experımental values from saturated waste The Schumpe model ıs gıven by Equatıon 2 where c_{G0} and c_G denotes the gas solubility of gas G in pure water and in a salt solution, respectively, K_{HG} (water) and K_{HG} (solution) are Henry's Law constants for soluble gas G in pure water and salt solutions, h_i and h_G are the ion and gas specific coefficients, and c_i (mole/L) is the concentration of ion "i" in the salt solution The gas-specific constant, h_G, is assumed to be a linear function of temperature

$$\log\left(c_{G0}/c_G\right) = \log\left(\frac{K_{HG}\,(\text{water})}{K_{HG}\,(\text{solution})}\right) = \sum_i (h_i + h_G)\, c_i \qquad (2)$$

where h_{G0} is the reference value, and h_T is the temperature-specific coefficient

Values of h_{G0} and h_T for ammonia, hydrogen, and methane are given in Table 2-1

Table 2-1 Values of h_{G0} and h_T[1]

Gas	h_T, $\frac{L}{\text{mole °K}}$	h_{G0}, $\frac{L}{\text{mole}}$
Ammonia	0*	-0 0481
Hydrogen	-2 99 E-4	-0 0218
Methane	-5 24 E-4	0 0022

[1]Weisenberger and Schumpe (1996)

* h_T for ammonia is set equal to zero (Shekarriz et al 1997) since an experimentally determined value is not available For temperatures greater than 25°C if h_T were also negative lower vapor pressures would be predicted Therefore setting h_T equal to zero is more conservative since higher ammonia vapor pressures would result

The terms $\sum c_i$ and $\sum h_i c_i$ are calculated using ion concentrations obtained from a variety of sources, including the best basis data and tank characterization data and assumptions based on similar waste types The values for the ion-specific constants h_i are presented in Table 2-2

The various Henry's Law constants, K_{HG}(solution), for each tank waste solution are obtained by dividing the appropriate temperature dependent value of K_{HG}(water) calculated with one of the following equations (Equations 5, 6, or 7) by its corresponding Schumpe ratio of K_{HG}(water)/K_{HG}(solution) Definitions of the formulas used to calculate the Henry's Law constants are presented in Appendix A

The equations which are used to calculate Henry's Law constants for the major flammable gas constituents, ammonia, methane, and hydrogen, are given in Appendix A An example of the spreadsheet, which is used to calculate Henry s Law constants, is given in Appendix D An alternate method for calculating ammonia concentration in a DCRT vapor space, for higher ventilation rates (generally > 1 cfm) is given in Appendix B This model uses mass transfer coefficients, which limit the rate of ammonia transferred from the liquid waste surfaces in a DCRT to its vapor space Examples of this spreadsheet are given in Appendix C

Table 2-2 Values of h_i[1]

Ion	h_i, $\frac{L}{mole}$
Na^{+1}	0 1143
Al^{+3}	0 2174
Fe^{+3}	0 1161
Cr^{+3}	0 0648
Ni^{+2}	0 1654
K^{+1}	0 0922
OH^{1}	0 0839
NO_3^{1}	0 0128
NO_2^{1}	0 0795
CO_3^{2}	0 1423
PO_4^{3}	0 2119
SO_4^{2}	0 1117
F^{1}	0 0920
Cl^{1}	0 0318
Li^{+1}	0 0754
Br^{1}	0 0269

[1]Weisenberger and Schumpe (1996)

The Henry's Law constant obtained through the above procedure must be converted from a molal basis, moles of solute per kg of solvent (water) in solution, to a basis of moles per volume of solution The conversion is accomplished by calculating

$$K_H, \text{L liquid waste basis} = (K_H, \text{kg water basis})\,\rho_L\,\omega_L \qquad (4)$$

where ω_L is the weight fraction of water in the solution and ρ_L is the solution density

Equations for Henry's Law constants are reported for various gases including ammonia, hydrogen, and methane in water (Norton and Pederson 1995) The equation and its source for each gas at 1 atmosphere in equilibrium with water is given below The equation for methane is correctly reported in Shekarriz et al (1997)

Ammonia (Clegg and Brimblecombe 1989)

$$K_{H\,NH3}\ [\text{mole/kg water-atm}] = \exp[-8\ 0964 + 3917\ 50/T - 0\ 00314 \times T],\ T = {}^{o}K \qquad (5)$$

Hydrogen (Young 1981)

$$K_{H\,H2}\ [\text{mole/kg water-atm}] = \exp[\ 121\ 922 + 5528\ 45 / T + 16\ 8893 \times \ln T],\ T = {}^{o}K \qquad (6)$$

Methane (Clever and Young 1987)

$$K_{H\,CH4}\ [\text{mole/kg water atm}] = \exp[\ 412\ 1421 + 15557\ 56 / T + 65\ 2553 \times \ln T - 0\ 06167 \times T],\ T={}^{o}K \qquad (7)$$

2 2 CALCULATION OF MAXIMUM CONCENTRATIONS OF METHANE, AMMONIA, AND HYDROGEN IN A DOUBLE-CONTAINED RECIVER TANK

Liquid from various SSTs is saltwell pumped to their respective DCRTs The following methodology is used to calculate the maximum concentrations of methane, ammonia, and hydrogen that can be expected in the vapor space of a DCRT during and after a tank is filled to its operational fill limit Table 2- 3 gives the dimensions and orientations of the two sizes of DCRTs to be used to stage saltwell pumping liquid waste from SSTs

Table 2-3 Double-Contained Receiver Tank Characteristics

DCRT	Diameter (ft)	Diameter (m)	Height/Length (ft)	Height/Length (m)	Orientation	Total Volume (ft^3)	Total Volume (m^3)
S	15	4 57	15 5	4 72	Vertical	2712	76 8
BX, TX, U	12	3 66	35	10 67	Horizontal	4146	117 4

Methane

The mole % or volume % of methane in the vapor space of a DCRT is calculated assuming conservatively that all of the methane dissolved in the liquid waste entering the DCRT is released instantaneously to a fixed vapor space of 20% of the volume of the DCRT This is a simplistic approach, but since the methane contribution to the vapor flammability is small, this approach is adequate for these calculations The concentration of the methane in the feed liquid waste entering a DCRT is obtained by multiplying the calculated Henry's Law constant for methane in the waste solution by its partial pressure The partial pressure of methane is calculated by assuming that 5% of the trapped gas in a liquid waste is methane and that 65% is hydrogen The remaining 30% is assumed to be nonflammable gases These are reasonable median values for the gas retained in high-solids layers (Peurrung 1998) However, if SST specific measured data are available, they should be used The total pressure of the gas in the waste of a particular tank is obtained from Hodgson et al (1997) This pressure is based on the assumption that the average gas location is 22 5% of the height of wet solids from the bottom of the waste tank (Hopkins 1996) Therefore, unless tank specific data exist, 5% of the total pressure is attributed to methane and 65% of the total pressure is attributed to hydrogen The time to maximum methane concentration is the fill time of a DCRT from empty to approximately 80% full The % lower flammability limit (LFL) contribution from methane is obtained by dividing the calculated vapor space percent methane by 5 0% (100% LFL for methane [CRC Press (1973)]) and multiplying by 100%

Feed to DCRT = 4 gpm = 15 14 ℓ/min

Assume all CH_4 is released to dome space at 1 atm and 25 °C

Assumed ventilation rate, Vr = 3 cfh × (1 hr/60 min) = 0 050 cfm

For ideal gas behavior,

$$V = \frac{n\,R\,T}{P}, \text{ where } V \text{ is a volumetric flow rate and } n \text{ is a molar flow rate} \qquad (8)$$

$$V = Gr = X\left(\frac{15\ 14\ \ell_{liq}}{min}\right)\left(\frac{0\ 082056\ \dfrac{atm-\ell}{mole-°K}}{1\ atm}\right)(298\ 2\ °K)\left(\frac{1\ ft^3}{28\ 32\ \ell}\right) \qquad (9)$$

where,

Gr = volumetric addition rate of dissolved methane entering a DCRT in liquid waste expressed as a gas flow rate (cfm) at 1 atm and 25 °C and where X = molar concentration of methane in the liquid waste, as calculated by Equation 1 Therefore, this equation is reduced to

$$Gr = 13\,081 \times X\,(\text{cfm}) \tag{10}$$

The percent methane (CH_4) is calculated as a function of time as a DCRT is filled Equation 11 is used (Estey 1997) for this calculation

$$\%\,CH_4 = \left(\frac{Gr\left(1 - e^{-\left[(Gr + Vr)\left(t/_{Volume}\right)\right]}\right)}{Gr + Vr} \right)(100\%) \tag{11}$$

where,

CH_4 = mole percent methane in a DCRT vapor space as a function of time

Gr = volumetric flow rate of methane into a DCRT vapor space from the liquid waste entering the DCRT

Vr = ventilation rate of a DCRT vapor space

Volume = vapor space in a DCRT at end of filling with liquid waste

t = time from beginning of liquid waste pumping into a DCRT

The calculated volume percent methane in the vapor space of the DCRT and the corresponding % LFL for methane are calculated using the above equations

Ammonia

For low ventilation rates (< 1 cfm), the mole % or volume % of ammonia in the vapor space of a DCRT is calculated assuming that the partial pressure or concentration in the vapor space is always in equilibrium with the concentration in the liquid waste phase This is obtained by dividing the concentration of ammonia in the liquid waste by the appropriate Henry's Law constant for ammonia (See Henry's Law discussion earlier in this report) The % LFL contribution from ammonia is obtained by dividing the calculated vapor space percent ammonia by 15 5% (100% LFL for ammonia [CRC Press 1973]) and multiplying by 100%

However, a more accurate model may be used to predict the ammonia concentration in the vapor space of a DCRT This dynamic model, using mass transfer limiting equations, produces more accurate results when higher ventilation rates exist in a DCRT, (e g , > 1 cfm exhaust ventilation rate) The derivation of this model is given in Appendix B

Hydrogen

The mole % or volume % of hydrogen in the vapor space of a DCRT is calculated based on the assumption that all of the hydrogen dissolved in the liquid waste entering the DCRT and all of the hydrogen generated in the DCRT are released instantaneously to a variable vapor space, which for the base case, varies from 100% to approximately 20% of the volume of the DCRT as the tank is filled from empty to approximately 80% full The concentration of the hydrogen in the feed liquid waste entering a DCRT is obtained by multiplying the calculated Henry's Law constant for hydrogen in the waste solution by its partial pressure as given in Equation 1 The partial pressure of hydrogen is calculated by assuming that 65% of the trapped gas in a liquid waste is hydrogen and that 5% of it is methane (Perrung et al 1998) The remaining 30% is assumed to be nonflammable gases The total pressure of the gas in the waste of a particular tank is obtained from Hodgson et al (1997) This pressure is based on the assumption that the average gas location is 22 5% of the height of wet solids from the bottom of the waste tank (Hopkins 1996) Therefore, 5% of the total pressure is attributed to methane, and 65% of the total pressure is attributed to hydrogen

The calculation of DCRT headspace hydrogen volumes and concentrations are based upon a numerical analysis technique for the solution of initial value ordinary (i e , only one independent variable) differential equations The independent variable is time The technique used is a differential equation solver provided in the Professional Edition of Mathcad®[1] software The baseline modeled situation is that an empty DCRT begins to fill at 4 gpm until the tank is approximately 80% full (See Appendices D and E) The DCRT is provided with a positive ventilation of about 3 to 5 cfh The waste being added to the DCRT carries with it dissolved hydrogen which is immediately released upon entering the tank Additionally, the inventory of waste in the DCRT generates hydrogen due to radiolysis, chemical reactions, and corrosion of the wetted DCRT surfaces The hydrogen generation rate equations used in this analysis are provided by the models documented in Hu (1999) The dissolved hydrogen concentrations in the waste are calculated using the calculated Henry's Law constants discussed earlier and the Henry's Law expression as given in Equation 1

The basic ventilation model assumes instantaneous and uniform mixing of the headspace gases Typically, such models use constant tank ventilation rates, constant hydrogen generation rates, and constant headspace volumes In such a situation, the rate of change of hydrogen in the tank headspace is proportional to the amount of hydrogen present in the tank headspace and can be expressed as a first order ordinary differential equation

$$d(H_2 \text{ volume})/dt = k_1 - (k_2/k_3) \times (H_2 \text{ volume}) \quad (12)$$

where,

k_1 = H_2 generation rate
k_2 = tank exhaust rate (tank ventilation rate + k_1)
k_3 = tank headspace volume

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[1] Mathcad® is a registered trademark of MathSoft Inc Cambridge Massachusetts

The solution of this differential equation can be obtained via analytical techniques whereby substitution and application of the limits of integration show that time is proportional to the natural logarithm of headspace hydrogen volume/concentration ratios Conversely, the headspace hydrogen volumes or concentrations are proportional to a function which includes an exponential in time

The situation modeled in this analysis does not lend itself to solution via analytical techniques because the rate of hydrogen input to the DCRT headspace and the DCRT headspace volume vary as functions of time

In this case the differential equation is written

$$d(H_2 \text{ volume})/dt = f_1(t) - [f_2(t)/f_3(t)] \times (H_2 \text{ volume}) \quad (13)$$

where,

$f_1(t)$ = H_2 generation rate
$f_2(t)$ = tank exhaust rate [tank ventilation rate + liquid volume addition rate + $f_1(t)$]
$f_3(t)$ = tank headspace volume

In this analysis, the units of the independent variable t are hours The time period of interest is zero hours to the time at which the DCRT is 80% full at the given DCRT fill rate The solution evaluates the value of $f_1(t)$ at a given time step using the hydrogen generation models and including the dissolved hydrogen release rate associated with the DCRT fill rate The functions $f_2(t)$ and $f_3(t)$ are calculated as the fill rate continually reduces the volume of the DCRT headspace The differential equation solver is then used to estimate the volume of H_2 in the DCRT headspace at the time of interest and the corresponding value of d(H_2 volume)/dt is calculated by substituting these results into the differential equation

The time to the first maximum hydrogen concentration is the time it takes to fill a DCRT from empty to approximately 80% full A second, steady-state maximum may be reached later if the rate of generation of hydrogen within the DCRT is sufficiently high The % LFL contribution from hydrogen is obtained by dividing the calculated vapor space percent hydrogen by 4% (100% LFL for hydrogen [CRC Press 1973]) and multiplying by 100% Examples of these calculations for vertical and horizontal tanks are given in Appendix E

Total Percent Lower Flammability Limit from Ammonia, Methane, and Hydrogen in Double-Contained Receiver Tank Vapor Space The total vapor space % LFL is obtained by adding the respective % LFL contributions of methane, ammonia, and hydrogen However, the total vapor space % LFL for the steady state case results from considering only the steady-state ammonia concentration in the vapor space, the hydrogen generation within the DCRT, and the ventilation rate Methane generation within the DCRT is assumed to be small and is, therefore, not considered Examples of these calculations are given in Appendix E

Tıme to 25%, 50%, 100%, and 200% of Lower Flammable Lımıt After Loss of Actıve Ventılatıon The tımes to reach 25%, 50%, 100%, and 200% LFL assumıng only barometrıc breathıng may also be calculated Equatıon 8 from Hu (1997) ıs to be used to make these calculatıons The total % LFL ıs the sum of the hydrogen %LFL and ammonıa % LFL for steady-state calculatıons The total % LFL at end of fill ıs the sum of the hydrogen % LFL, ammonıa % LFL, and the methane % LFL Examples of these calculatıons are gıven ın Appendıx E

The ammonıa and methane concentratıons used are the steady-state and end of fill values calculated, respectıvely The hydrogen concentratıon used for tıme zero ın these calculatıons ıs the greatest value calculated durıng or after a DCRT ıs filled

3 0 ASSUMPTIONS

Sample calculatıons gıven ın thıs document present expected maxımum concentratıons of flammable gases ın a DCRT based on a scenarıo ın whıch lıquıd wastes are transferred from SST to an empty DCRT However, other scenarıos can be addressed usıng these same models These ınclude saltwell pumpıng of multıple SSTs to a sıngle DCRT whıch has an ınıtıal heel of waste The ınıtıal heel of waste gıves an ınıtıal flammable mıxture ın the DCRT vapor space, whıch must be measured or calculated The endpoınt of pumpıng may be more or less than the base case 80% fill Wastes other than those from SSTs, e g , laboratory wastes and flush water may also be addressed by thıs model If dılutıon water ıs a part of waste beıng saltwell pumped, calculatıons can be made usıng the defined models to predıct changes ın flammable gas levels ın a DCRT's vapor space on loss of dılutıon water If multıple tanks are to be sımultaneously saltwell pumped to the same DCRT, several approaches may be used ın applyıng the models descrıbed hereın For example, ıf the feed streams fluctuate ın flow rate, worst case scenarıos can be modeled to create an umbrella of acceptable saltwell pumpıng The models presented ın thıs document can also be applıed to non DCRT tank transfers of wastes The base case assumptıons are

1 The lıquıd waste beıng transferred ınto the DCRT from SSTs contaıns the dıssolved gases hydrogen and methane that are ın equılıbrıum wıth a 65% hydrogen and 5% methane gaseous mıxture The remaınıng 30% ıs assumed to be nonflammable gas The pressure used ın the calculatıons was the average gas pressure calculated for gas trapped ın the waste (Hodgson et al 1997) The conservatıve values of 65% hydrogen and 5% methane are based on work reported ın Perrung et al (1998)

2 Sınce hydrogen and methane are very ınsoluble, ıt ıs assumed that all of the methane and hydrogen are released to the vapor space as soon as they enter the DCRT No methane generatıon wıthın a DCRT ıs consıdered

3 The DCRT ventilation rate from bubbler flow is normally from 3 to 5 cfh based on the assumption that two of the bubbler tubes used for level measurements provide a total air flow of at least 3 cfh This is based on information for tank farms operation that the weight factor bubbler can be operated at maximum flow rates of 2 6 to 2 8 cfh

4 Since ammonia is a soluble gas, it is not reasonable to assume that 100% of the ammonia is released Therefore, for ventilation rates less than 1 cfm, it assumed the DCRT vapor space is to continuously have a concentration of ammonia which is in equilibrium with the ammonia in the liquid waste entering the DCRT However, a dynamic model, presented in Appendix B, may be used for higher ventilation rates, e g , > 1 cfm This model takes credit for mass transfer limiting phenomena for the transfer of ammonia from the liquid to the gaseous phase of the vapor space

5 The total % LFL of flammable gases in a DCRT is the sum of the individual % LFL contributions of hydrogen, methane, and ammonia These are the significant flammable gases in SSTs

6 Hydrogen bubble transport into DCRTs is discussed in Peurrung (1998) This discussion concludes that the transport of hydrogen via bubbles entrained in liquid being pumped into a DCRT is negligible Based on the referenced discussion and the conservative assumption that 100% of the soluble hydrogen in a SST is transported to a DCRT, it is assumed that no hydrogen is transported from the SST to a DCRT via bubbles

4 0 APPLICATION OF METHODOLOGY

The methodologies of this document can be used to predict flammable gas concentrations which could exist in the vapor space of a DCRT from the simultaneous saltwell pumping of one or more SSTs If several waste streams are added simultaneously to a DCRT or if the waste being added is denser than that in a DCRT, credit may be taken for mixing The minimum temperature used in the analysis for waste or vapor space in a DCRT shall be 80 degrees Fahrenheit because of heating which can take place from warm ventilation air during the summer The methodology can also be adapted to waste transfers between other cylindrical tanks which are vertical or horizontal

This document considers the buildup of three flammable gases in DCRTs from the waste that is transferred into them These gases are methane, ammonia, and hydrogen Other flammable gases are of insignificant concentrations Nitrous oxide levels are sufficiently low to preclude its adverse effect on the total lower flammability limit of the methane, ammonia, and hydrogen mixtures Organic layer tanks, such as 241-C 103, are not to be pumped through DCRTs and are not covered by the methodology of this document

The equilibrium model for ammonia is adequate for DCRT ventilation rates less than or equal to bubbler air flow rates of 5 cfh However, for ventilation rates above about 1 cfm, the equilibrium model is overly conservative in predicting high ammonia concentrations in the vapor phase For these higher ventilation rate cases, the dynamic model yields more accurate predictions of vapor phase ammonia concentrations

Ventilation rates for DCRTs 241 TX-244, 241-A-244, 241-S-244, and 241-BX-244 have been estimated based on the measured decay rate of tracer gas injected into each of these DCRTs as part of a test discussed in Bauer and Hedengren (1999)

5 0 VALIDATION OF METHODOLOGY

The results of a series of ammonia solubility measurements in high concentration salt solutions indicate that the Schumpe model under predicts the solubility of ammonia in high salt solutions These laboratory measurements were performed at Washington State University-Tri-Cities The results of this testing show that as salt concentrations increase, ammonia solubility decreases progressively slower The currently used Schumpe model, which is based on low salt concentration measurements, increasingly under predicts ammonia solubility as salt concentrations increase above 10 molar (anions plus cations) The consequence of using the Schumpe model for high concentration salt solutions is over predicting concentrations of vapor phase ammonia in waste tank dome spaces This work performed by D C Hedengren (see Appendix F) shows that at room temperature, the Schumpe model discussed in this document under predicts the solubility of ammonia in concentrated 241-SY-101 simulant by a factor of 6 Also, this work showed that for a 1 1 dilution of this 241-SY-101 simulant, the Schumpe model under predicts ammonia solubility by a factor of 2 7 at room temperature

Vapor space ammonia measurements which have been made in the TX and S DCRTs are consistently lower than those predicted by the Schumpe model for the equilibrium condition

Appendix G presents calculations which are being used for various safety analysis applications

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APPENDIX A
CHECKLIST FOR INDEPENDENT REVIEW

Document RPP-4941 Rev. 0
Author D.C. Hedengren, et al.
Scope of Review
Did not review Appendix C, D, E, F, G

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

Daniel A Reynolds [signature]
Reviewer (Printed Name and Signature

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

APPENDIX A

DEFINITIONS OF FORMULAS USED TO CALCULATE HENRY'S LAW CONSTANTS

Definition of Formulas Used to Calculate Henry's Law Constants

Ammonia	**Units**	**Formula**
concentration in liquid	$\frac{moles}{\ell}$	$= \frac{X\ \mu g / mL}{(1{,}000)(molecular\ weight\ NH_3)}$
h (G)	$\frac{\ell}{mole}$	$= h_{G0} + h_T \times (T - 25)$, Temperature in °C
K_{water}/K_{salt}	none	$= 10^{\{\sum(h_i \times C_i) + h(G) \times \sum C_i\}}$
K_{water}	$\frac{mole}{kg\ H_2 0 - atm}$	$= e^{[8\ 0964 + 3917\ 50/T\ \ 0\ 00314 \times T]}$, Temperature in K
$K_H = K_{salt}$	$\frac{mole}{L_{(liquid)} - atm}$	$= \left(\frac{K_{water}}{K_{water}/K_{salt}}\right)\left(\frac{liq\ density}{1{,}000}\right)\left(mass\ fraction\ H_2 0\ in\ liq\right)$
Partial Pressure	atm	$= \frac{concentration\ in\ liquid}{K_H}$

Hydrogen	**Units**	**Formula**
h (G)	$\frac{\ell}{mole}$	$= h_{G0} + h_T \times (T - 25)$, Temperature in °C
K_{water}/K_{salt}	none	$= 10^{\{\sum(h_i \times C_i) + h(G) \times \sum C_i\}}$
K_{water}	$\frac{mole}{kg\ H_2 0 \times atm}$	$= e^{[121\ 922 + 5528\ 45 / T + 16\ 8893 \times \ln T]}$, Temperature in K
$K_H = K_{salt}$	$\frac{mole}{L_{(liquid)} \times atm}$	$= \left(\frac{K_{water}}{K_{water}/K_{salt}}\right)\left(\frac{liq\ density}{1{,}000}\right)\left(mass\ fraction\ H_2 0\ in\ liq\right)$

Methane	Units	Formula
h (G)	$\frac{\ell}{mole}$	$= h_{G\,0} + h_T \times (T - 25)$, Temperature in °C
K_{water}/K_{salt}	none	$= 10^{\{\sum(h_i \times C_i) + h(G) \times \sum C_i\}}$
K_{water}	$\frac{mole}{kg\ H_2 0 \times atm}$	$= e^{[412\ 1421 + 15557\ 56 / T + 65\ 2553 \times \ln T \quad 0\ 06167 \times T]}$ Temperature in K
$K_H = K_{salt}$	$\frac{mole}{L_{(liquid)} \times\ atm}$	$= \left(\frac{K_{water}}{K_{water}/K_{salt}}\right)\left(\frac{liquid\ density}{1\ 000}\right)(mass\ fraction\ H_2 0\ in\ liq)$

APPENDIX B

ALTERNATE METHOD OF CALCULATING AMMONIA IN A VAPOR SPACE

(FOR VENTILATION RATES > 1 CFM)

For ventilation rates in DCRTs less than about 1 cfm, the equilibrium model is a good estimate of the ammonia in the DCRT vapor space during and after waste addition However, as ventilation rates increase above about 1 cfm, the equilibrium model significantly over predicts the levels of ammonia in the vapor space from liquid waste in a DCRT Therefore, a model has been developed to address ammonia levels in DCRTs that have a ventilation rate above 1 cfm This model is based on the Analysis Framework, which includes a model developed by Sandia National Laboratory for the Hanford underground waste storage tanks The Analysis Framework is the analytical method for analyzing the impact of potential controls for flammable gases on risk in Hanford Site single-shell tanks and double-shell tanks The part of the model, which was adapted for this application, is presented in the Analysis Framework document, HNF-SD-WM-ES-410, Rev 2, Section 3 3, "Ammonia Releases During Buoyant Displacement Gas Release Event and Waste Transfers" with special emphasis on Section 3 3 3, "Ammonia Release During Transfers " Since ammonia release is a surface controlled phenomenon, the ammonia release model of the Analysis Framework divides the liquid waste surfaces involved into three zones

- Falling Waste Zone surfaces of the falling waste
- Turbulent Splash Zone waste surface located where the falling waste lands
- Secondary Disturbance Zone disturbed waste outside of the Turbulent Splash Zone

Two additional sources of ammonia release to the DCRT vapor space are also considered These are

- Undisturbed Surface Zone undisturbed waste outside of the Turbulent Splash Zone and the Secondary Splash Zone
- Bubbler Air bubbler air that is discharged below the liquid waste surface

Each of these five sources of ammonia release to the vapor space of a DCRT is discussed below The modeling of these sources is also presented

1 Falling Waste

The liquid waste coming out of a transfer line into a DCRT may or may not be a continuous stream If the stream is continuous, some droplets and discontinuous slugs may form because of gravitational acceleration and air resistance This model accounts for the possible increase in surface area using a factor f_1 equal to 10 This factor is multiplied by the surface area of a continuous solid cylinder of water that corresponds to the waste addition rate and expected stream velocity at the discharge pipe exit The factor of 10 is based on an analysis contained in Section 3 3 of the Analysis Framework The overall mass transfer coefficient for the falling waste is determined by the calculation of its liquid film mass transfer coefficient and its gas film mass transfer coefficient

Liquid Film Coefficient The equation derived in the Analysis Framework for a liquid film coefficient for a growing transfer film thickness with time is given as

$$h_l = \sqrt{\frac{D_L}{4\Phi t}} \quad (1)$$

where,

t is the time after the waste leaves the discharge pipe and

Ø is the tortuosity factor affecting diffusion in the waste If only liquids are present, Ø=1

For a differential element of liquid in free fall, the distance covered in time t is given as

$$L = U_o\ t + \frac{1}{2} g t^2 \quad (2)$$

where,

U_o is the vertical velocity of the waste coming out of the pipe and

g is the gravitational constant

The time for a differential element of liquid to fall from the end of the inlet pipe to the surface of the waste is

$$t_L = \frac{1}{g}\left[\sqrt{U_o^2 + 2gL} - U_o\right] \quad (3)$$

where,

L is the distance from the end of the inlet pipe to the waste surface

The average value of h_l can be determined as the integral of h_l over height divided by the length L to the tank waste surface so that

$$h_{l\ avg} = \frac{1}{L}\int h_l dL = \frac{1}{L}\int\sqrt{\frac{D_l}{4\Phi t}}\, dL \quad (4)$$

With $dL = Udt$ and $U = U_o + gt$, the integration gives

$$h_{l\ avg} = \frac{1}{L}\sqrt{\frac{D_l}{4\Phi}}\left(2U_o\ t_L^{1/2} + \frac{2}{3} g t_L^{3/2}\right) \quad (5)$$

Gas Film Coefficient The velocity at the interface between two fluids is not normally zero However, if one of the surfaces is a solid, the fluid velocity parallel to the surface is zero Because tank waste being saltwell pumped is usually a dense liquid, the assumption is made that mass-transfer correlations for a fluid flowing across a solid plate are valid For Reynolds numbers below about 5 x 10^5, a laminar boundary layer exists and the average mass-transfer coefficient from the leading edge to a distance x is given as

$$Sh = \frac{h_g x}{D_g} = 0\ 664\ Re^{1/2}\ Sc^{1/3} \tag{6}$$

where,

Sh is the Sherwood number,

Sc is the Schmidt number, and

Re is the Reynolds defined as

$$Re = \frac{\rho_g U x}{\mu_g} \tag{7}$$

with U defined as the bulk gas velocity relative to the surface and d, the stream diameter, is used for the distance x

Sc is defined as

$$Sc = \frac{\mu_g}{\rho_g D_g} \tag{8}$$

where,

μ_g is the gas viscosity,

ρ_g is the gas density, and

D_g is the diffusion coefficient in the gas phase

The overall mass transfer coefficient for falling waste (h_{fw}) is given as

$$h_{fw} = \frac{1}{\left(\frac{1}{h_{l\ avg}} + \frac{KRT}{h_g}\right)} \tag{9}$$

where,

K is the calculated Henry's Law constant,

T is the temperature of the liquid waste that is being saltwell pumped into a DCRT, and

R is the gas constant

$h_{l\ avg}$ and h_g are the liquid and vapor film coefficients, respectively

The product KRT is a dimensionless Henry's Law constant

2 Turbulent Splash

In the splash zone, vapor motion is induced by the falling waste and the liquid at the surface of the splash zone is disturbed by the falling waste so that significant turbulence is expected

Gas Film Coefficient The mass transfer coefficient for the gas film is assumed to be the same as for the falling waste, as an estimation, because of the complexity in modeling the splash zone Several rudimentary tests (one is reported in the Analysis Framework and one was performed by the author of this document) suggest that the factor f_2 be set equal to 10 This factor is multiplied by the diameter of a continuous solid cylinder of water which corresponds to the waste addition rate and expected stream velocity at the discharge pipe exit This adjusted diameter is assumed to be the diameter of the splash zone

Liquid Film Coefficient This model estimates the effect of the disturbance of the splash zone on the liquid phase mass transfer using the surface renewal model of the Analysis Framework The renewal time is defined as the characteristic dimension of the splash zone, d_{splash} divided by the velocity of the waste when it reaches the surface That is,

$$\tau_{renew} = \frac{d_{splash}}{U_{max}} \tag{10}$$

where

$$U_{max} = U_o + gt_L \tag{11}$$

According to surface renewal theory, as discussed in the Analysis Framework, the mass transfer coefficient for the liquid film is defined as

$$h_l = \sqrt{\frac{D_L}{\tau_{renew}}} \tag{12}$$

where,

τ_{renew} is the characteristic surface renewal time

Overall Mass Transfer Coefficient

The overall mass transfer coefficient for turbulent splash (h_{ts}) is given as

$$h_{ts} = \frac{1}{\left(\frac{1}{h_l} + \frac{KRT}{h_g}\right)} \tag{13}$$

where K is the calculated Henry's Law constant and T is the temperature of the liquid waste which is being saltwell pumped into a DCRT

3 Secondary Disturbance

Estimation of the mass transfer resistance offered by liquid phase in the secondary disturbance zone is complicated by the motion of waves and the small currents produced at the surface by these waves In order to avoid modeling the complicated motions, this model, as is suggested by the Analysis Framework, assumes that the gas phase resistance is limiting If the liquid phase transfer were limiting, then the predicted mass transfer rate would be conservative because the predicted release rate would be higher than that computed for the liquid phase

Gas Film Coefficient The mass transfer coefficient for the gas film is derived in the Analysis Framework by taking an equation for natural convection from a horizontal heated plate, using the Chilton-Colburn analogy (discussed in the Analysis Framework) to relate natural convection heat transfer to mass transfer, and solving for the gas film coefficient resulting in the following equation

$$h_g = 0\ 15 \frac{D_g}{L_c} Sc^{1/3}\ Gr^{1/3} \tag{14}$$

where the Grashoff number, Gr, is a measure of buoyancy defined as

$$Gr = \frac{g\beta\rho_g^2 L_c^3 \Delta T}{\mu_g^2} \tag{15}$$

where ΔT is the temperature difference between the waste surface and the bulk gas, and β is the thermal expansion coefficient For an ideal gas,

$$\beta = \frac{1}{V}\frac{R}{P} = \frac{1}{T} \tag{16}$$

where,

V is molar volume if gas at pressure P

For natural convection from a horizontal heated plate, the characteristic length, L_c, is the top surface area of the plate divided by the perimeter Therefore, for a circular area L_c is equal to one-fourth the diameter However, L_c is raised to the third power in the Grashoff number, Gr, and Gr is raised to the 1/3 power in Equation 14 This L_c cancels with the L_c in the denominator of Equation 14 Therefore, the mass transfer coefficient for the gas film has no dependence on L_c It should also be noted that the temperature dependence of the mass transfer coefficient for the gas film, h_g, is weak because the Grashoff number, Gr, is raised to the 1/3 power

Overall Mass Transfer Coefficient

The overall mass transfer coefficient for secondary disturbance (h_{sd}) is given as

$$h_{sd} = \frac{h_g}{KRT} \tag{17}$$

where K is the calculated Henry s Law constant and T is the temperature of the liquid waste which is being saltwell pumped into a DCRT

4 Undisturbed Surface

Mass transfer of ammonia from the undisturbed surface of liquid waste is calculated using the entire liquid surface in a DCRT This conservative assumption can, therefore, be applied to both saltwell pumping and non-saltwell pumping situations

Gas Film Coefficient The mass transfer coefficient for the gas film is derived in the Analysis Framework by taking an equation for natural convection from a horizontal heated plate, using the Chilton-Colburn analogy to relate natural convection heat transfer to mass transfer, and solving for the gas film coefficient resulting in the following equation

$$h_g = 0\ 15 \frac{D_g}{L_c} Sc^{1/3}\ Gr^{1/3} \tag{14}$$

This is the same equation as was derived for the mass transfer coefficient for the gas film in the secondary disturbance case previously discussed The associated discussion also applies to the undisturbed surface case

Liquid Film Coefficient The analysis, which was used to obtain the gas film coefficient for both the secondary disturbance case and the undisturbed surface case, can be applied to mass transfer of ammonia from a liquid surface to the vapor phase The vapor film mass transfer coefficient, as discussed previously, is derived from a Chilton-Colburn analogy between heat and mass transfer for the *fluid above a heated plate An estimate of the liquid film mass transfer* coefficient can also be arrived at using the same analog with the input of liquid properties instead of vapor properties It is assumed that natural thermal convection occurs due to the heat generation in the liquid waste and the cooler surface temperature due to evaporation at the surface In the case of the hot plate, the highest temperature is at the plate and the highest fluid temperature is at the vapor film right at the hot plate In the case of hot liquid waste, the highest temperature is not necessarily at the bottom of the waste However, the use of Equation 14 does not require a convective layer thickness, but only a temperature difference Therefore, although it is expected that the region of liquid where there exists a temperature gradient is smaller than the whole liquid volume, Equation 14 can still be applied to the region where there is a temperature gradient Mass transfer through that region is then analogous to heat transfer through that region Equation 14, with the L_c cancelled, thus becomes (using liquid rather than gas parameters)

$$h_l = 0\ 15 D_L \left(\frac{\mu_L}{D_L \rho_L}\right)^{\frac{1}{3}} \left(\frac{g\beta\, \rho_L^2\, \Delta T}{\mu_L^2}\right)^{\frac{1}{3}} \tag{18}$$

Overall Mass Transfer Coefficient

The overall mass transfer coefficient for undisturbed surface (h_{us}) is given as

$$h_{us} = \frac{1}{\left(\frac{1}{h_l} + \frac{KRT}{h_g}\right)} \tag{13}$$

where K is the calculated Henry's Law constant and T is the temperature of the liquid waste which is being saltwell pumped into a DCRT

5 Bubbler Air

Approximately two-thirds of the bubbler air is bubbled through the liquid waste in a DCRT for level and density measurements It is assumed that this air is saturated with ammonia The molar flow rate of ammonia into the DCRT vapor space from this source is calculated using the ideal gas law and the appropriate Henry's Law constant as

$$n = \frac{C_L NH_3 V}{K_{NH3} RT} \qquad (19)$$

where,

V is the volumetric bubbler flow of air through the liquid waste,

$C_{L\ NH_3}$ is the concentration of ammonia in the liquid waste,

R is the gas constant, and

T is the liquid waste temperature

Calculation of Ammonia in a DCRT Vapor Space

The molar flow rate of ammonia into the vapor space of a DCRT from the first four sources discussed previously is given as

$$q = \left(\sum_i h_i A_i\right)\left(C_{L\ NH3} - 1{,}000 K C_t P \gamma\right) \qquad (20)$$

where,

q is the molar flow rate of ammonia into the vapor space of a DCRT

h_i is the overall mass transfer coefficient for each of the first four sources of ammonia given previously, i e , falling waste, turbulent splash, secondary disturbance, and undisturbed surface

A_i is the mass transfer area associated with each of the four sources of ammonia listed above

$C_{L,NH3}$ is concentration of ammonia in the liquid waste

H is Henry s Law constant for ammonia in the liquid waste of the DCRT

C_t is the concentration of ammonia in the vapor space of a DCRT at time t

P is the pressure in the vapor space of a DCRT

γ is the molar volume of gas in the vapor space

The mass balance for ammonia in a DCRT vapor space is given as

$$V \frac{dC_t}{dt} = q - QC_t \qquad (21)$$

where,

V is the vapor space volume

C_t is the concentration of ammonia in the vapor space of a DCRT at time t

q is the molar flow rate of ammonia into the vapor space of a DCRT

Q is the volumetric exhaust ventilation flow rate from a DCRT

Substituting q in Equation 20 into Equation 21 and treating Q and V as constants, two constants, k_1 and k_2 are defined as

$$k_1 \equiv -\frac{\left[\left(\sum_i h_i A_i\right)(1{,}000\,KP\gamma) + Q\right]}{V} \tag{22}$$

and

$$k_2 \equiv \frac{\left(\sum_i h_i A_i\right) C_{L\,NH3}}{V} \tag{23}$$

The resulting differential equation can be written as

$$\frac{dC_t}{dt} = k_2 + k_1\, C_t \tag{24}$$

Rearranging this equation and integrating from an initial vapor space ammonia concentration of C_o to a final vapor space ammonia concentration of C_t at time t yields the following equation

$$C_t = \frac{1}{k_1}\left[\left(k_1 C_o + k_2\right) e^{k_1 t} - k_2\right] \tag{25}$$

This equation can then be used to solve for the ammonia concentration as a function of time in a DCRT vapor space assuming a fixed volume of waste and a fixed vapor space in the DCRT Results for various fill conditions can be examined to obtain a conservatively high estimate that can exist in a DCRT at any time during its fill This maximum value can be added to contributions from hydrogen and methane to obtain a total concentration of flammable gases in the vapor space of the DCRT

APPENDIX C

Vapor Phase Ammonia Calculations for Vertical and Horizontal DCRT's

Using Mass Transfer Limiting Model of Appendix B

(Vertical DCRT Pages C-2 Through C-8

and

Horizontal DCRT Pages C-9 Through C-15)

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-S
Case 3

Table S3-4 Henry's Law Constant Calculation for Tank SX-105 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1210	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	168 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non-Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs-137	µCi/ml	384			
Temperature	°F	167			

Author D C Hedengren Date 1/26/00 Checked by [illegible] Date [illegible]

DCRT 244-S
Case 3

Table S3-4 (Cont'd) Henry's Law Constant Calculation for Tank SX-105 (2 pages)

Source Tank	SX 105	INPUT DATA	Date	36551 50554		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1210
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 071048166
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E-05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{-2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{-1}	19	5 466E 03	0 092	0 000502894				
Cl^{-1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		75						167
								Temperature
								deg C
								75
					PNL-10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part. P atm	
Ammonia		0 071048166	-0 0481	11 89866249	7 867518994	0 416120578	0 170739371	
Hydrogen			-3 675E-02	2 045E+01	7 499E-04	2 308E-05	0 000E+00	
Methane			2 400E-02	3 757E+01	9 021E-04	1 511E-05	0 000E+00	

Author D C Hedengren Date 1/25/00 Checked by [signature] Date 1/26/00

Rev 0-E		1/26/00 12 07			**Dynamic Model of Ammonia in the Vapor Space**
Prepared by D C Hedengren					(with surface release and delta concentration)
	Non-Numeri	**Name of**	**Numeric**		
	Data	**Variable**	**Data**	**Units**	——————Comments——————
Input Data					
Tank Specific Data					
Source Tank	SX-105				
Receiving Tank	244 S				
Percent of Fill of Receiving Tank			80	%	
Volume of Vapor Space		Vvs	15359	L	
Length of Waste Fall		L	0 94	m	
Flow Rate of Waste into DCRT		Q	4	gpm	
Temperature of Waste		Tw	348 2	°K	
Henry's Law Constant for NH_3		K	0 416	m/L-atm	
Total Pressure in Vapor Space		P	1	atm	
Partial Pressure of NH_3		PP	1 707E-01	atm	
Conc of NH_3 in Liquid Waste		$C_{NH3\ L}$	71 048	mole/m^3	
Inside Diameter of Receiving Tank		D	4 572	m	
Total Bubbler Flow Rate		BF_T	0 0236	L/s	
Total Ventilation Flow Rate		Q_{vent}	0 02	L/s	
Initial Concentration of NH_3		C_o	0	mole/m^3	

Author ______ Date 1/26/00 Checked by ______ Date 1/26/00

	Non-Numeri Data	Name of Variable	Numeric Data	Units	Comments
Input Data					
Generic Data (generally fixed)					
Gravitational Constant		g	9 8	m/s^2	
Tortuosity Factor		Ø	1	(none)	
Density of Gas		ρ_g	1 17	kg/m^3	
Diffusion Coefficient in Gas Phase		Dg	2 50E-05	m^2/s	
Viscosity of Gas		μ_g	2 0E-05	kg/m-s	
Diffusion Coefficient in Liquid Phase		D_L	2 8E-09	m^2/s	
Factor for Falling Waste		f_1	10	(none)	
Factor for Turbulent Splash		f_2	10	(none)	
Factor for Secondary Disturbance		f_3	30	(none)	
Delta Temp bet waste surf & gas		T_D	1	^oK	
Thermal Expansion Coef of Gas		β_g	3 30E-03	$(^oK)^{-1}$	
Temperature of Air in Vapor Space		T_A	349 15	^oK	
Universal Gas Constant		R	0 0821	L-atm/mole ^oK	
Gas Pressure in Vapor Space		P_{vs}	1 0	atm	
Density of Liquid		ρ_L	1468	kg/m^3	
Viscosity of Liquid		μ_L	6 82E-04	kg/m-s	
Thermal Expansion Coef of Liquid		β_L	3 02E-04	$(^oK)^{-1}$	
Surface Area of Still Waste		A_w	16 417	m^2	

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

Calculations					
Calculated Parameter·	**Name of Variable**	**Numeric Value**	**Units**		**Comments**
Flow Rate of Waste into DCRT	Q	2 524E-04	m^3/s		
Stream Diam (flow ≤ 16 gpm)	d	0 0254	m		For flow > 16 gpm d=0 0508 m
Disch Stream Vel (flow ≤ 16 gpm)	Uo	0 498	m/s		For flow > 16 gpm Uo=0 498*(Q/16gpm) Q in gpm
Area of Column of Waste	A_{column}	0 075	m^2		Area does not include ends of cylinder of waste
Effective Area of Falling Waste	A	0 754	m^2		
KRT_W	KRT	11 89	(none)		
Fall Time for Differential Element	t_L	0 39	s		
Average Velocity for Differential El	U_{avg}	2 92	m/s		
Thickness of Falling Waste	X	0 0254	m		Set equal to Stream Diameter d
Reynolds Number	Re_g	4342	(none)		
Liquid Film Coefficient	$h_{L\ avg\ fall}$	6 22E-05	m/s		
Schmidt Number	Sc	0 684	(none)		
Vapor Film Coefficient	$h_{g\ fall}$	3 79E-02	m/s		
Overall Mass Transfer Coefficient	h_{fall}	6 10E-05	m/s		
NH_3 Release Rate - Falling Waste	$q_{NH3\ fall}$	**3 27E-03**	**mole/s**		Contribution from Falling Waste
Max Velocity for Differential Elem	U_{max}	4 33	m/s		
Splash Diameter	d_{splash}	0 254	m		
Splash Area	A_{splash}	5 067E-02	m^2		
Renewal Time in Splash Zone	t_{renew}	5 863E-02	s		
Liquid Film Coef In Splash Zone	$h_{L\ splash}$	2 185E-04	m/s		
Overall Mass Trans Coef -Splash	h_{splash}	2 045E 04	m/s		
NH_3 Release Rate - Splash Zone	$q_{NH3\ splash}$	**7 363E-04**	**mole/s**		Contribution from Splash Zone

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

Calculations (continued)					
Calculated Parameter	**Name of Variable**	**Numeric Value**	**Units**		**Comments**
Secondary Disturbance Diameter	$d_{secondary}$	0 762	m		
Secondary Disturbance Area	$A_{secondary}$	0 456	m^2		
Characteristic Length	L_c	1 143	m		
Grashoff Number	Gr	1 65E+08	(none)		
Vapor Film Coef For Sec Dist	$h_{g\ secondary}$	1 59E-03	m/s		
Overall Mass Trans Coef -Secon	$h_{secondary}$	1 33E-04	m/s		
NH_3 Release Rate - Sec Dis Zone	**$q_{NH3\ secondary}$**	**4 32E-03**	**mole/s**		Contribution from Secondary Disturbance Zone
Liquid Film Coef for Still Surface	$h_{L,surface}$	5 52E-06	m/s		
Overall Mass Trans Coef -Surface	$h_{surface}$	5 30E-06	m/s		
NH_3 Release Rate - Still Surface	**$q_{NH3\ surface}$**	**6 19E-03**	**mole/s**		
NH_3 Release Rate - Bubblers	**$q_{NH3\ bubblers}$**	**9 369E-05**	**mole/s**		
Initial Concentration of NH_3	C_o	0	$mole/m^3$		
Molar Vol of Gas in Vapor Space	v	2 867E-02	$m^3/mole$		
Volume of Vapor Space	V	1 536E+01	m^3		
Total Ventilation Flow Rate	Q_v	2 359E-05	m^3/s		Includes total bubbler flow rate
Total Pressure in Vapor Space	P	1	atm		
Henry's Law Constant for NH_3	K	0 416	m/L-atm		
Conc of NH_3 in Liquid Waste	$C_{NH3\ L}$	71 048	$mole/m^3$		
Sum of h_iA_i	Σh_iA_i	2 043E-04	m^3/s		
Calculated Constant #1	k_1	-1 602E-04	s^{-1}		
Calculated Constant #2	k_2	9 510E-04	$mole\text{-}s/m^3$		

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

Total Generation Rate of NH_3	G_r	0 4187	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	17 07	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	3 414E-02	0 10	0 63	
0 0183	66	6 244E-02	0 18	1 15	
0 0333	120	1 130E-01	0 32	2 09	
0 0617	222	2 074E-01	0 59	3 84	
0 1033	372	3 434E-01	0 98	6 35	
0 1750	630	5 699E-01	1 63	10 54	
0 332	1194	1 034E+00	2 96	19 11	
0 620	2232	1 785E+00	5 12	33 01	
1 035	3726	2 668E+00	7 65	49 35	
2 27	8154	4 329E+00	12 41	80 06	
3 35	12060	5 077E+00	14 55	93 89	
5 38	19362	5 670E+00	16 25	104 86	
8 27	29784	5 887E+00	16 88	108 87	
9 68	34860	5 915E+00	16 96	109 39	
10 9	39300	5 926E+00	16 99	109 60	
13 2	47640	5 934E+00	17 01	109 75	
16 6	59580	5 937E+00	17 02	109 79	
41 7	150000	5 937E+00	17 02	109 80	
67 6	243444	5 937E+00	17 02	109 80	Time to fill from 0% to 80% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J. D. Bofin Date 1/27/00

DCRT 244-U
Case 3

Table U3-1 Henry's Law Constant Calculation for Tank U-103 (2 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-103				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank.	244-U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1400	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	224000	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32500	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	28	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	190	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	180	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4320	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	34613	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	197000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	139000	Temperature of Air in Vapor Space	°F	89 8
CO_3^{2}	µg/ml	17200	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3430	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3840	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	1730	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	10900	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non-Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	48 67			
Specific Gravity	unitless	1 41			
Total Organic Carbon	g/l	12 781			
Cs-137	µCi/ml	467			
Temperature	°F	88			

Author D C Hedengren Date 1/26/00 Checked by J D Bigler Date 1/27/00

DCRT **244 U**
Case **3**

Table U3 1 (Cont'd) Henry's Law Constant Calculation for Tank U 103 (2 pages)

Source Tank	U 103	INPUT DATA	Date	36551 51549		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1400
Na^{+1}	22 99	9 7433515	0 1143	1 113665072	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 20	0 2174	0 261878654				0 08220449
Fe^{+3}	55 85	0 00	0 1161	5 84139E-05				
Cr^{+3}	52	3 654E 03	0 0648	0 00023677	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	3 066E 03	0 1654	0 000507104				
K^{+1}	39 09	1 105E 01	0 0922	0 01018941	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 04	0 0839	0 170751008	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	3 18	0 0128	0 040667663	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 02	0 0795	0 240199638				
CO_3^{2}	60 0092	0 29	0 1423	0 040786474				
PO_4^{-3}	94 9676	0 04	0 2119	0 007653303				
SO_4^{2}	96 0576	3 998E 02	0 1117	0 004465314				
F^{-1}	19	9 105E 02	0 092	0 00837684				
Cl^{-1}	35 453	3 074E 01	0 0318	0 009776892				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 06061405		1 909212555				
Mass fraction water in liq		0 49						Temperature
Liquid density (kg/m3)		1410 000						deg F
T (C)		31						88
								Temperature
								deg C
								31 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 08220449	-0 0481	8 796238969	45 77208045	3 570952654	0 023020325	
Hydrogen			2 363E-02	2 724E+01	7 610E-04	1 917E-05	0 000E+00	
Methane			-1 002E-03	7 747E+01	1 292E-03	1 145E-05	0 000E+00	

Author [illegible] Date 1/26/00 Checked by [illegible] Date 1/27/00

Rev 0-E		1/26/00 12 22			**Dynamic Model of Ammonia in the Vapor Space**
Prepared by D C Hedengren					(with surface release and delta concentration)
	Non-Numeri Data	**Name of Variable**	**Numeric Data**	**Units**	**Comments**
Input Data					
Tank Specific Data					
Source Tank	U-103				
Receiving Tank	244-U				
Percent of Fill of Receiving Tank			50	%	
Volume of Vapor Space		Vvs	58700	L	
Length of Waste Fall		L	1 83	m	
Flow Rate of Waste into DCRT		Q	4	gpm	
Temperature of Waste		Tw	304 3	°K	
Henry's Law Constant for NH_3		K	3 571	m/L-atm	
Total Pressure in Vapor Space		P	1	atm	
Partial Pressure of NH_3		PP	2 302E-02	atm	
Conc of NH_3 in Liquid Waste		$C_{NH3\ L}$	82 204	mole/m³	
Inside Diameter of Receiving Tank		D	3 6576	m	
Total Bubbler Flow Rate		BF_T	0 0236	L/s	
Total Ventilation Flow Rate		Q_{vent}	0 02	L/s	
Initial Concentration of NH_3		C_o	0	mole/m³	

Author D C Hedengren Date 1/26/00 Checked by J.D.R. Date 1/27/00

	Non-Numeri Data	Name of Variable	Numeric Data	Units	Comments
Input Data					
Generic Data (generally fixed)					
Gravitational Constant		g	9 8	m/s^2	
Tortuosity Factor		Ø	1	(none)	
Density of Gas		ρ_g	1 17	kg/m^3	
Diffusion Coefficient in Gas Phase		Dg	2 50E-05	m^2/s	
Viscosity of Gas		μ_g	2 0E-05	kg/m s	
Diffusion Coefficient in Liquid Phase		D_L	2 8E-09	m^2/s	
Factor for Falling Waste		f_1	10	(none)	
Factor for Turbulent Splash		f_2	10	(none)	
Factor for Secondary Disturbance		f_3	30	(none)	
Delta Temp bet waste surf & gas		T_D	1	^oK	
Thermal Expansion Coef of Gas		β_g	3 30E-03	$(^oK)^{-1}$	
Temperature of Air in Vapor Space		T_A	305 2611111	^oK	
Universal Gas Constant		R	0 0821	L-atm/mole-^oK	
Gas Pressure in Vapor Space		P_{vs}	1 0	atm	
Density of Liquid		ρ_L	1410	kg/m^3	
Viscosity of Liquid		μ_L	6 82E 04	kg/m-s	
Thermal Expansion Coef of Liquid		β_L	3 02E-04	$(^oK)^{-1}$	
Surface Area of Still Waste		A_w	39 02	m^2	

Author DCHedengren Date 1/26/00 Checked by [signature] Date 1/27/00

Calculations

Calculated Parameter	Name of Variable	Numeric Value	Units	Comments
Flow Rate of Waste into DCRT	Q	2 524E-04	m^3/s	
Stream Diam (flow ≤ 16 gpm)	d	0 0254	m	For flow > 16 gpm d=0 0508 m
Disch Stream Vel (flow ≤ 16 gpm)	Uo	0 498	m/s	For flow > 16 gpm Uo=0 498*(Q/16gpm) Q in gpm
Area of Column of Waste	A_{column}	0 146	m^2	Area does not include ends of cylinder of waste
Effective Area of Falling Waste	A	1 459	m^2	
KRT_W	KRT	89 20	(none)	
Fall Time for Differential Element	t_L	0 56	s	
Average Velocity for Differential El	U_{avg}	4 03	m/s	
Thickness of Falling Waste	X	0 0254	m	Set equal to Stream Diameter d
Reynolds Number	Re_g	5989	(none)	
Liquid Film Coefficient	$h_{L\ avg\ fall}$	5 06E-05	m/s	
Schmidt Number	Sc	0 684	(none)	
Vapor Film Coefficient	$h_{g\ fall}$	4 46E-02	m/s	
Overall Mass Transfer Coefficient	h_{fall}	4 60E-05	m/s	
NH_3 Release Rate - Falling Waste	$q_{NH3\ fall}$	**5 52E-03**	**mole/s**	Contribution from Falling Waste
Max Velocity for Differential Elem	U_{max}	6 01	m/s	
Splash Diameter	d_{splash}	0 254	m	
Splash Area	A_{splash}	5 067E-02	m^2	
Renewal Time in Splash Zone	t_{renew}	4 228E-02	s	
Liquid Film Coef In Splash Zone	$h_{L,splash}$	2 573E-04	m/s	
Overall Mass Trans Coef -Splash	h_{splash}	1 698E-04	m/s	
NH_3 Release Rate - Splash Zone	$q_{NH3\ splash}$	**7 075E-04**	**mole/s**	Contribution from Splash Zone

Author D C Hedengren Date 1/26/00 Checked by J D Bl... Date 1/27/00

Calculations (continued)					
	Name of	Numeric			
Calculated Parameter	Variable	Value	Units		——————Comments——————
Secondary Disturbance Diameter	$d_{secondary}$	0 762	m		
Secondary Disturbance Area	$A_{secondary}$	0 456	m^2		
Characteristic Length	L_c	0 9144	m		
Grashoff Number	Gr	8 46E+07	(none)		
Vapor Film Coef For Sec Dist	$h_{g\ secondary}$	1 59E-03	m/s		
Overall Mass Trans Coef -Secon	$h_{secondary}$	1 78E 05	m/s		
NH_3 Release Rate - Sec Dis Zone	$q_{NH3\ secondary}$	**6 67E-04**	**mole/s**		Contribution from Secondary Disturbance Zone
Liquid Film Coef for Still Surface	$h_{L,surface}$	5 45E-06	m/s		
Overall Mass Trans Coef -Surface	$h_{surface}$	4 17E 06	m/s		
NH_3 Release Rate - Still Surface	$q_{NH3\ surface}$	**1 34E-02**	**mole/s**		
NH_3 Release Rate - Bubblers	$q_{NH3\ bubblers}$	**1 445E-05**	**mole/s**		
Initial Concentration of NH_3	C_o	0	mole/m^3		
Molar Vol of Gas in Vapor Space	v	2 506E-02	m^3/mole		
Volume of Vapor Space	V	5 870E+01	m^3		
Total Ventilation Flow Rate	Q_v	2 359E-05	m^3/s		Includes total bubbler flow rate
Total Pressure in Vapor Space	P	1	atm		
Henry's Law Constant for NH_3	K	3 571	m/L-atm		
Conc of NH_3 in Liquid Waste	$C_{NH3\ L}$	82 204	mole/m^3		
Sum of h_iA_i	Σh_iA_i	2 466E-04	m^3/s		
Calculated Constant #1	k_1	-3 764E-04	s^{-1}		
Calculated Constant #2	k_2	3 456E-04	mole-s/m^3		

Author D C Hedengren Date 1/26/00 Checked by J D Bohm Date 1/27/00

Total Generation Rate of NH_3	G_r	0 5084	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	2 30	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time, hours	T, sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	1 236E 02	0 03	0 20	
0 0183	66	2 253E 02	0 06	0 36	
0 0333	120	4 055E 02	0 10	0 66	
0 0617	222	7 360E 02	0 18	1 19	
0 1033	372	1 200E-01	0 30	1 94	
0 1750	630	1 938E-01	0 49	3 13	
0 332	1194	3 324E-01	0 83	5 37	
0 620	2232	5 218E-01	1 31	8 44	
1 035	3726	6 923E-01	1 74	11 19	
2 27	8154	8 755E-01	2 19	14 16	
3 35	12060	9 084E-01	2 28	14 69	
5 38	19362	9 176E 01	2 30	14 84	
8 27	29784	9 182E 01	2 30	14 85	
9 68	34860	9 182E-01	2 30	14 85	
10 9	39300	9 182E-01	2 30	14 85	
13 2	47640	9 182E-01	2 30	14 85	
16 6	59580	9 182E-01	2 30	14 85	
41 7	150000	9 182E-01	2 30	14 85	
64 6	232605	9 182E-01	2 30	14 85	Time to fill from 0% to 50% at 4gpm

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APPENDIX D

Calculation of Henry's Law Constants for Ammonia, Hydrogen, and Methane

Using Schumpe Model

Author DC Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-S
Case 3

Table S3-4 (Cont'd) Henry s Law Constant Calculation for Tank SX-105 (2 pages)

Source Tank	SX-105	INPUT DATA	Date	36551 50622		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1210
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 071048166
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E-05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		75						167
								Temperature
								deg C
								75
					PNL-10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part. P atm	
Ammonia		0 071048166	-0 0481	11 89866249	7 867518994	0 416120578	0 170739371	
Hydrogen			-3 675E-02	2 045E+01	7 499E-04	2 308E-05	0 000E+00	
Methane			2 400E-02	3 757E+01	9 021E-04	1 511E-05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D B[illegible] Date 1/27/00

DCRT **244 U**
Case **3**

Table U3-1 (Cont'd) Henry's Law Constant Calculation for Tank U-103 (2 pages)

Source Tank	U 103	INPUT DATA	Date	36551 51626		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1400
Na^{+1}	22 99	9 7433515	0 1143	1 113665072	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 20	0 2174	0 261878654				0 08220449
Fe^{+3}	55 85	0 00	0 1161	5 84139E-05				
Cr^{+3}	52	3 654E 03	0 0648	0 00023677	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	3 066E 03	0 1654	0 000507104				
K^{+1}	39 09	1 105E 01	0 0922	0 01018941	Ammonia	0	-0 0481	
OH^{-1}	17 0074	2 04	0 0839	0 170751008	Hydrogen	-0 299	-0 0218	
$NO_3^{\ 1}$	62 0049	3 18	0 0128	0 040667663	Methane	-0 524	0 0022	
$NO_2^{\ 1}$	46 0055	3 02	0 0795	0 240199638				
$CO_3^{\ 2}$	60 0092	0 29	0 1423	0 040786474				
PO_4^{-3}	94 9676	0 04	0 2119	0 007653303				
SO_4^{-2}	96 0576	3 998E 02	0 1117	0 004465314				
F^{-1}	19	9 105E 02	0 092	0 00837684				
Cl^{-1}	35 453	3 074E 01	0 0318	0 009776892				
Li^{+1}	6 94	0 00	0 0754	0				
$Br^{\ 1}$	79 916	0 000E+00	0 0269	0				
								Average
		20 06061405		1 909212555				
Mass fraction water in liq		0 49						Temperature
Liquid density (kg/m3)		1410 000						deg F
T (C)		31						88
								Temperature
								deg C
								31 11111111
					PNL-10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 08220449	-0 0481	8 796238969	45 77208045	3 570952654	0 023020325	
Hydrogen			2 363E-02	2 724E+01	7 610E-04	1 917E-05	0 000E+00	
Methane			1 002E-03	7 747E+01	1 292E-03	1 145E-05	0 000E+00	

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APPENDIX E

Calculation of Flammable Gas Mixtures in DCRTs

(Vertical DCRT Pages E-2 Through E-29

and

Horizontal DCRT Pages E-30 Through E-58)

Author DC Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

CH2MHILL
Hanford Group Inc.

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d) DCRT 244-S CASE 3

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh)--Includes ammonia from SX-102 and methane from S-107

$d := 15\,ft$

Input length of DCRT (L)

$L := 15.5\,ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10^{-6})

$flow := 4\cdot\frac{gal}{min}$ $\quad flow = 8.912\times 10^{-3}\,ft^3\,sec^{-1}$ $\quad \frac{flow}{\left(\frac{ft^3}{hr}\right)} = 32.083$

Higher Input flow rate

$flow_2 := 4\cdot\frac{gal}{min}$ $\quad flow_2 = 8.912\times 10^{-3}\,ft^3\,sec^{-1}$ $\quad \frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 32.083$

Calculate total DCRT volume (tvol)

$$tvol := L\,\pi\left(\frac{d}{2}\right)^2$$

Assume DCRT has flat ends [Eqn 1]

$tvol = 2739\,ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.0\cdot tvol + 0\,hr\cdot 0\cdot\frac{gal}{min}$ $\quad tvol_{init} = 0.000\,ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 34\,hr$

Time at pumping rate 2

$time_2 := 35\,hr$

Volume of fill at start of pumping rate 2

$tvol_2 := tvol_{init} + time\cdot flow$ $\quad tvol_2 = 1091\,ft^3$

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Calculate hours of fill time for the DCRT (t)

$\%full := 81$ Input percentage of tank fill

$time_{fill} := \left(\frac{\%full}{100} tvol - tvol_{init}\right) flow^{-1}$ $time_{fill} = 69\ 153\,hr$ [Eqn 2]

$mantissa(x) := x - floor(x)$

Rounding Off at the Halfway Point

$roundoff(x) := if(mantissa(x) < 0\ 5, floor(x), ceil(x))$

Rounding Off at Arbitrary Point

$RoundOff(x,t) := if(mantissa(x) < t, floor(x), ceil(x))$

Time to fill" is rounded to allow use as an integer counter Roundoff functions are not built-in MathCad functions

$lim := roundoff\left(time_{fill}\,hr^{-1}\right) hr$ $lim = 69\ 000\,hr$

$lim := \begin{vmatrix} 2\ 4\ 10^3\,hr\ \text{ if } lim > 2\ 4\ 10^3\,hr \\ lim\ \text{ otherwise} \end{vmatrix}$ ⇐

$t := 0\,hr\ \ lim$

A time limit greater than 2400 hrs creates very large arrays and the solver equation becomes very slow The solver cannot handle array sizes greater than ~1,000,000

Input DCRT waste and vapor temperature (K)

$T := (273\ 15 + 75\ 0) K$ $T = 348\ 150\,K$ (Reference)

$T_{vap} := (273\ 15 + 75\ 0) K$ $T_{vap} = 348\ 150\,K$

Input rate at which saltwell pumping introduces hydrogen to the DCRT ($gr_{sol\ molar}$)(mole/liter) & convert to ft^3/hr

$gr_{sol\_molar} := 1\ 471\ 10^{-4} \frac{mole}{liter}$ (Reference)

$gr_{sol} := gr_{sol\_molar}\ 22\ 4 \frac{liter}{mole}\ flow \frac{T}{273\ 15\,K}$ $\frac{gr_{sol}}{\left(\frac{ft^3}{hr}\right)} = 0\ 135$ [Eqn 3]

Input DCRT ventilation rate (vr)

$vr := 0\ 08333 \frac{ft^3}{min}$ $\frac{vr}{\left(\frac{ft^3}{hr}\right)} = 5\ 000$

Input saltwell waste specific gravity (r)

$\rho := 1\ 468$ (Reference)

Input saltwell waste nitrate concentration (molar)

$NO_3 := 2\ 66 \frac{mole}{liter}$ (Reference)

Input saltwell waste nitrite concentration (molar)

$NO_2 := 3\ 10 \frac{mole}{liter}$ (Reference)

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Input saltwell waste aluminum concentrations (molar)

$Al := 1.63 \cdot \frac{mole}{liter}$ (Reference)

Input saltwell waste TOC concentrations (grams carbon per liter)

$TOC := 3.228 \cdot \frac{gm}{liter}$ (Reference)

Input radiolytic power from waste (Ci/mL) and then calculate DCRT radiolytic power (power generation per cubic foot of waste)

$decays = 1$ define decays as a unit of measure

$Ci = 3.7 \cdot 10^{10} \frac{decays}{sec}$ define Curies (Ci) as a unit of measure in decays/sec

$wastepower := \left(384 \cdot 10^{-6} \cdot \frac{Ci}{mL}\right) \cdot \left(1.61 \cdot 10^{-2} \cdot \frac{BTU}{hr \cdot Ci}\right)$ [Eqn 5]

$wastepower = 6.182 \times 10^{-6} \frac{BTU}{hr \cdot mL}$

Conversion based on 137Cs - 137Ba pair Ref Kirkpatrick T D , and Brown R C 1984, Basis and Values for Specific Activity and Decay Heat Generation Rates for Selected Radionuclides, RHO-SD-RE-TI-131, Rockwell Hanford Operations Richland Washington

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Input source of waste, DST or SST

tank_type := "SST" Tank type must be in quotes

Constants and other input for H_2 generation by radiolysis

Hu, T A, 1999, Empirical Rate Equation Model of Hydrogen Generation for Hanford Tank Waste, HNF-3851 Rev 0 Lockheed Martin Hanford Inc , Richland, Washington

$k_{rad} := 2.49 \cdot 10^{6} \cdot \frac{molecules}{100 \cdot eV}$ Pre-exponential factor of G in organic radiolysis (Hu 1999 - eqn 4-16)

$Ea_{rad} := 44.32 \cdot \frac{kilo\_joule}{g\_mol}$ Activation energy of G in organic radiolysis (Hu, 1999 - eqn 4-16)

$Liq_{wt\_frac} := 1$ Weight fraction liquid in material

$E_{toc\_rad} = \begin{cases} 0.4 & \text{if tank\_type = "SST"} \\ 0.7 & \text{otherwise} \end{cases}$ Reactivity coefficient of TOC (0 7 for DSTs 0 4 for SSts) (Hu 1999 - eqn 4-16)

$E_{toc\_rad} = 0.400$

Constants and other input for H_2 generation by chemical reaction

Hu, T A, 1999 Empirical Rate Equation Model of Hydrogen Generation for Hanford Tank Waste HNF-3851 Rev 0 Lockheed Martin Hanford Inc , Richland Washington

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$k_{thm} := 2.76 \cdot 10^{9} \cdot \frac{g\_mol}{kg \cdot day}$ Thermolysis pre-exponential factor (Hu 1999 - eqn 4-8)

$Ea_{thm} := 89.33 \cdot \frac{kilo \cdot joule}{g\_mol}$ Activation energy of H_2 generation (Hu, 1999 - eqn 4-8)

$$E_{toc\_thm} := \begin{cases} 0.4 & \text{if } tank\_type = \text{"SST"} \\ 0.7 & \text{otherwise} \end{cases}$$

[TOC] efficiency coefficient 0 70 for DSTs 0 40 for SSTs (Hu 1999 - eqn 4-8)

$E_{toc\_thm} = 0.400$

Define unit rate of <u>corrosion</u> hydrogen production (R)

$$R_{corr} := \begin{cases} 1.2 \cdot 10^{-7} \cdot \frac{ft^3}{ft^2 \cdot min} \cdot \frac{mole}{22.4 \cdot liter} & \text{if } tank\_type = \text{SST} \\ 6.0 \cdot 10^{-8} \cdot \frac{ft^3}{ft^2 \cdot min} \cdot \frac{mole}{22.4 \cdot liter} & \text{otherwise} \end{cases}$$

eference 6 0E-08 for DSTs and 1 2E-07 for SSTs 3/min/ft2) (Hu, 1999)

$$R_{corr} = 1.200 \times 10^{-7} \frac{ft^3}{ft^2 \, min} \cdot \frac{mole}{22.4 \, liter}$$

Initial condition of the ODE ft3 of hydrogen in the tank headspace at time t=0

$vol_{H2_0} := 0.0 \cdot ft^3$ (Reference)

If there is a combustion gas moniter (cgm) measurement, calculate the H_2 concentration

$flag_{cgm} := \text{"no"}$ <=== User inputs "yes" or "no" to indicate if a cgm measurement is available

$conc_{LFL\_cgm0} := 0\%LFL$ $conc_{LFL\_cgm0} = 0 \, ppm$ (Reference)

Adjust H2 cgm reading for minimum detection limit (1220 ppm (3%LFL) combustable gas per WHC-SD-WM-TRP-256)

$conc_{LFL\_cgm} := if(conc_{LFL\_cgm0} < 3 \cdot \%LFL, 1220 \cdot ppm, conc_{LFL\_cgm0})$ $conc_{LFL\_cgm} = 1.220 \times 10^{3} \, ppm$

$conc_{NH3\_cgm} := 0 \cdot ppm$ $conc_{NH3\_cgm} = 0.000 \, \%LFL_{NH3}$

Calculation H2 concentration in the dome space based on the CGM measurement

$$conc_{H2\_cgm} := \left(\frac{conc_{LFL\_cgm}}{\frac{1220 \, ppm}{.03}} - \frac{conc_{NH3\_cgm}}{150000 \, ppm} \right) \cdot 40000 \, ppm$$

$conc_{H2\_cgm} = 3.000 \, \%LFL_{H2}$ $conc_{H2\_cgm} = 1200 \, ppm$

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$vol_{H2_0} = if[flag_{cgm} = "yes", conc_{H2\_cgm}(tvol - tvol_{init}), vol_{H2_0}]$

$vol_{H2_0} = 0\ 000\ ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 72.15 \cdot \%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 1.89 \cdot \%LFL_{CH4}$ (Reference)

End of Input Section

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow\ t - tvol_{init}$ $hvol(lim) = 525\ 326\ ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft^2) $2\pi\left(\frac{d}{2}\right)^2 + \pi\ d\ L = 1084\ ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\ d\ \frac{flow\ t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\ (flow\ t + tvol_{init})}{d}$$ [Eqn 8]

$$Awet(t) := \pi\left(\frac{d}{2}\right)^2 + \frac{4\ (flow\ t + tvol_{init})}{d}$$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim) = 767\ 048\ ft^2$

$Awet(0\ hr) = 176\ 715\ ft^2$ Check the answers

$Awet(1\ hr) = 185\ 270\ ft^2$ $Awet(lim) = 767\ 048\ ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 2\ 660 \qquad \frac{NO_2}{\left(\frac{mole}{liter}\right)} = 3\ 100 \qquad \frac{Al}{\left(\frac{mole}{liter}\right)} = 1\ 630 \qquad \frac{TOC}{\left(\frac{gm}{liter}\right)} = 3\ 228$$

Definition of the hydrogen production by corrosion (ft^3 per day)

$$H_{2cr}(t) = R_{corr}\left[Awet(t)\left[\left(22\ 4\ \frac{liter}{mole}\right)\left(\frac{T}{273\ 15\ K}\right)\right]\right] \qquad \text{[Eqn 10]}$$

$$C = R_{corr}\left(22\ 4\ \frac{liter}{mole}\right)\left(\frac{T}{273\ 15\ K}\right) \qquad \text{[Eqn 11]}$$

$$H_{2cr}(t) = (Awet(t)\ C) \qquad \text{[Eqn 12]}$$

Maximum hydrogen production rate from corrosion (ft^3 per day)

$$\frac{H_{2cr}(lim)}{\left(\frac{ft^3}{day}\right)} = 0\ 169 \qquad H_{2cr}(\ 1\ hr) = 0\ 0391\ \frac{ft^3}{day}$$

Definition of the hydrogen radiolysis G factor (molecules hydrogen per 100 ew) and the hydrogen production by radiolysis (ft^3 per day)

$G_{H2O\_sat} = 0.005\ \frac{molecules}{100\cdot eV}$ Default water radiolysis value for saturated salts waste

$sp\_g = \rho$ Add units back into definition of density

$\rho_{liq} = sp\_g\ 1\ \frac{gm}{mL} \qquad \rho_{liq} = 1\ 468\ \frac{gm}{mL}$

$TOC = 0\ 003\ \frac{kg}{liter}$ Redefine [TOC] as weight percent

$$[TOC] = \frac{TOC}{\rho_{liq}}\ 100$$

$$[TOC] = 0\ 220$$

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$Al = 1\ 630 \frac{mole}{liter}$ $mw_{Al} = 26\ 9815 \frac{gm}{mole}$ **Redefine [Al] as weight percent**

$$[Al] = \frac{Al\ mw_{Al}}{\rho_{liq}} 100$$

$$[Al] = 2\ 996$$

$$mw_{NO2} = (14\ 0067 + 2\ 15\ 9994) \frac{gm}{mole}$$

$$mw_{NO3} = (14\ 0067 + 3\ 15\ 9994) \frac{gm}{mole}$$

$NO_2 = 3\ 100 \frac{mole}{liter}$ $[NO_2] = NO_2$ **Change of nomenclature**

$NO_3 = 2\ 660 \frac{mole}{liter}$ $[NO_3] = NO_3$ **Change of nomenclature**

$wastepower = 1\ 812 \times 10^{-3} \frac{watt}{liter}$ **Convert wastepower $\left(\frac{watt}{liter}\right)$ to Heat Load $\left(\frac{watt}{kg}\right)$**

$$H_{load} = \frac{wastepower}{\rho_{liq}}$$

$$H_{load} = 1\ 234 \times 10^{-3} \frac{watt}{kg}$$

Reference (Hu 1999) **[Eqn 13]**

$$G_{H2O} = \left[0\ 45 - 0\ 43 \left[\frac{[NO_2]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}} - 0\ 56 \left[\frac{[NO_3]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}}\right] \frac{molecules}{100\ eV} \qquad G_{H2O} = -0\ 953 \frac{molecules}{100\ eV}$$

$$G_{H2O} = if\left(G_{H2O} \le G_{H2O\_sat}, G_{H2O\_sat}, G_{H2O}\right) \qquad G_{H2O} = 0\ 005 \frac{molecules}{100\ eV}$$

$$G_{org} = k_{rad}\ exp\left(\frac{-Ea_{rad}}{R_{const}\ T}\right) [TOC]\ E_{toc\_rad} \qquad G_{org} = 0\ 049 \frac{molecules}{100\ eV}$$

$$\left[H_{2rad}(t) = \left(G_{H2O} + G_{org}\right) H_{load}\right] Liq_{wt\_frac} \left(\frac{g\_mol}{6\ 02\ 10^{23}\ molecules}\right) \left(tvol_{init} + flow\ t\right) \rho_{liq}$$ **[Eqn 14]**

$$E = \left(G_{H2O} + G_{org}\right) \left(H_{load}\ flow\right) \left(\frac{g\_mol}{6\ 02\ 10^{23}\ molecules}\right)$$ **[Eqn 15]**

$$E_{const} = \left(G_{H2O} + G_{org}\right) \left(H_{load}\ tvol_{init}\right) \left(\frac{g\_mol}{6\ 02\ 10^{23}\ molecules}\right)$$ **[Eqn 16]**

$$F = \rho_{liq}\ Liq_{wt\_frac} \left(\frac{T}{273\ 15\ K}\right)$$ **[Eqn 17, Eqn 17b]**

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$$H_{2rad}(t) = (E\ t\ F + E_{const}\ F)$$ [Eqn 18]

Maximum hydrogen production rate from radiolysis (ft³ per day)

$$\frac{H_{2rad}(lim)}{\left(\frac{ft^3}{day}\right)} = 0.0555 \qquad \frac{H_{2rad}(1\ hr)}{\left(\frac{ft^3}{day}\right)} = 8.049\times 10^{-4}$$

Definition of the hydrogen production by chemical reaction (ft³ per day) Reference (Hu 1999) [Eqn 19]

$$H_{2ch}(t) = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0.4}\,Liq_{wt\_frac}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)\left[\rho_{liq}\left(flow\ t + tvol_{init}\right)\right]$$

$$G = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0.4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right) flow$$ [Eqn 20]

$$G_{const} = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0.4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right) tvol_{init}$$ [Eqn 20a]

$$H_{2ch}(t) = (G\ F\ t + G_{const}\ F)$$ [Eqn 21]

Maximum hydrogen production rate from chemical reaction (ft³ per day)

$$\frac{H_{2ch}(lim)}{\left(\frac{ft^3}{day}\right)} = 1.3842 \qquad \frac{H_{2ch}(1\ hr)}{\left(\frac{ft^3}{day}\right)} = 0.0201$$

Total hydrogen generation rate (ft³ per day)

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)$$ [Eqn 22]

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t) \qquad gr\gamma(lim) = 1.609\,ft^3\,day^{-1}$$ [Eqn 23]

Maximum total hydrogen production rate (ft³ per day)

$$Sum = gr\gamma(lim)$$ [Eqn 24]

$$\frac{Sum}{\left(\frac{ft^3}{day}\right)} = 1.609$$

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Determine the relative amounts of hydrogen produced by each mechanism in percent

$Corrosion = 100\left(Awet(lim)\ C\ Sum^{-1}\right)$ Corrosion = 10 502 [Eqn 25]

$Radiolysis = 100\left(E\ lim\ F + E_{const}\ F\right) Sum^{-1}$ Radiolysis = 3 452 [Eqn 26]

$Chemical = 100\left(G\ F\ lim + G_{const}\ F\right) Sum^{-1}$ Chemical = 86 046 [Eqn 27]

$Total = 100\ Sum\ Sum^{-1}$ Total = 100 000 [Eqn 28]

Prepare equations for solution of ordinary differential equation

Accumulation = Input - Output

Accumulation ==> $\frac{w}{dt} = w$

Input ==> H2 released by salt well pumping + H2 generated

==> $gr_{sol} + gr\gamma(t) = grtot = gr_{sol} + \left(H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)\right)$

==> $gr_{sol} + \left(Awet(t)\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right)$

Output ==> H2 vented based on generation rate + vent rate + volume reduction

==> $(grtot(t) + vr + flow)\ \frac{vol_{H2}}{hvol(t)}$

==> $\left[gr_{sol} + \left(Awet(t) + E\ t\ F + E_{const}\ F + G{\cdot}F\ t + G_{const}\ F\right) + vr + flow\right] \frac{vol_{H2}}{\left(tvol - flow\ t - tvol_{init}\right)}$

Solve (i e , find $vol_{H2t} = f(t)$) the following initial walue problem

$vol_{H2t} - [gr_t - (gr_t + vr_t)(vol_{H2t}/hvol_t)] = 0$ where

vol_{H2t} is the volume of H_2 (ft^3) in the DCRT headspace at time t

$vol_{H2t} = d(vol_{H2t})/dt$, the rate of change of the hydrogen volume in the tank headspace (ft^3/day), gr_t (H2 generation rate (ft^3/day)) vr_t (DCRT ventilation rate (ft^3/day)) and $hvol_t$ (DCRT headspace volume(ft^3)) are known functions of t
and the initial condition is vol_{H2t} (0 days) = 0

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Initial condition of the ODE ft3 of hydrogen in the tank headspace at time 0 (Set in input section)

$vol_{H2_0} = 0\ 000\,ft^3$

Definition of y' from differential equation

$$input(t) = \left[gr_{sol} + \left[(Awet(t))\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right]\right]$$ [Eqn 29]

$$output(t) = \left[\frac{\left[gr_{sol} + \left[(Awet(t))\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right]\right] + (vr + flow)}{hvol(t)}\right]$$ [Eqn 30]

$$D(t, vol_{H2}) = input(t) - output(t)\ vol_{H2_0}$$ [Eqn 31]

$npoints = \frac{lim}{hr}$ evaluation points within the evaluation interval

$t1 = 0$ beginning of time interval

$t2 = \frac{lim}{sec}$ end of time interval

$Z = rkfixed\left(\frac{vol_{H2}}{ft^3}, t1, t2, npoints\ D\right)$ Z contains the values of vol_{H2} calculated at the evaluation points by the 4th Order Runge-Kutta approximation method for ordinary differential equations expressed as an n column matrix [where n = order of the ordinary differential equation + 1 (2 in this case yielding t & vol_{H2})] [Eqn 32]

$i = 1\ \ npoints$

$t_i = \left[Z^{\langle(0)\rangle}\right]_i sec$ $vol_{H2_i} = \left[Z^{\langle(1)\rangle}\right]_i ft^3$ [Eqn 33, Eqn 34]

$vol'_{H2_i} = input(t_i) - output(t_i)\ vol_{H2_i}$ Definition of vol $_{H2t}$ in terms of t and vol_{H2t} as defined by the differential equation [Eqn 35]

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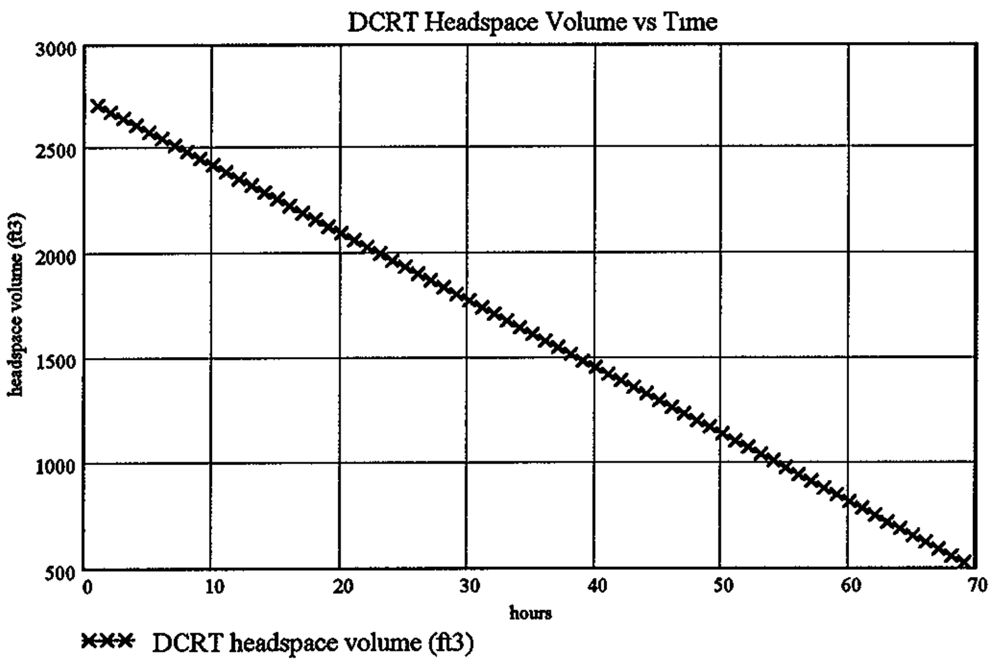

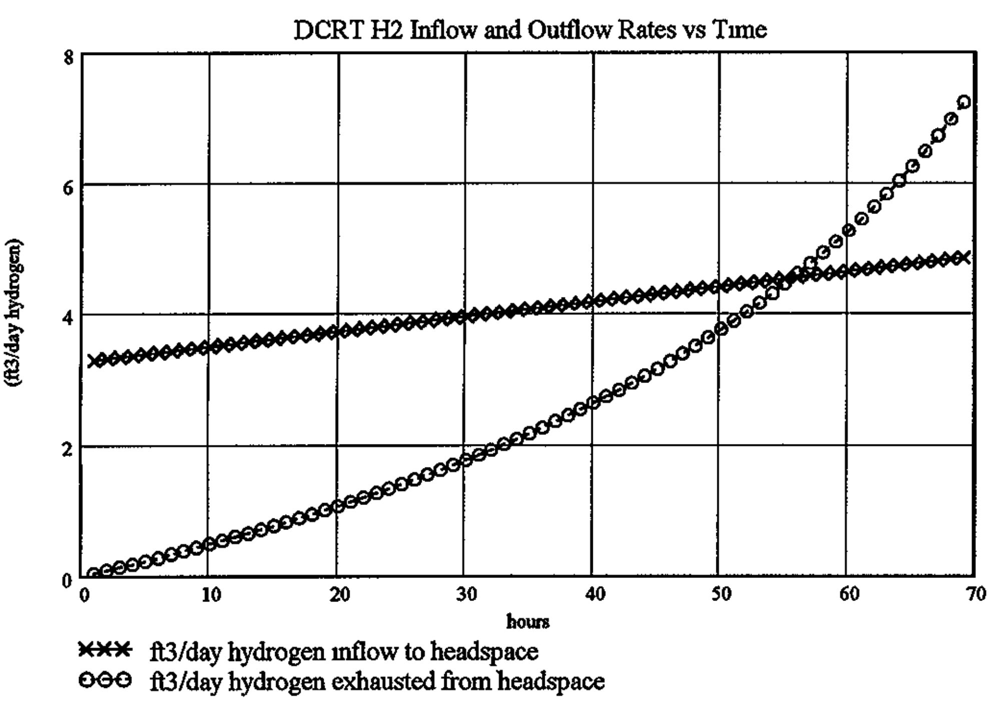

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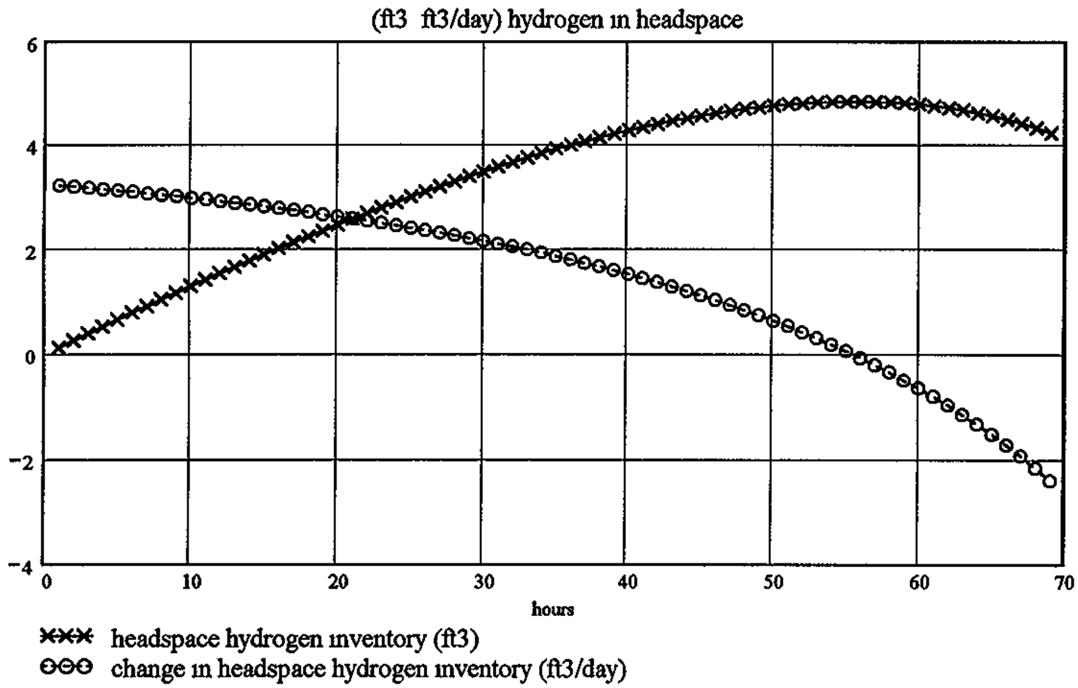

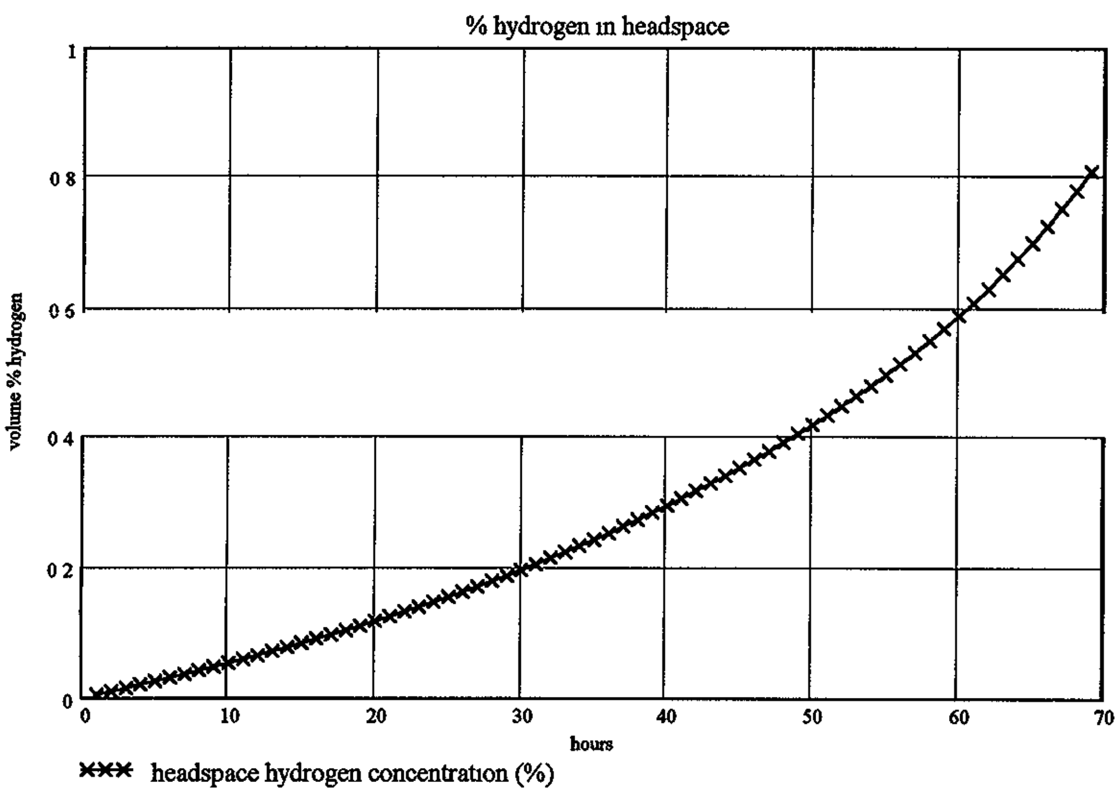

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Display tabulated results for first 24 hours of DCRT fill time

$\iota = 0,8 \ \frac{\text{lim}}{\text{hr}}$

time (hours)	H_2 volume in Headspace (ft^3)	Rate of H_2 volume Increase in Headspace (ft^3/day)	H_2 Concentration in Headspace (volume %)	H_2 Concentration in Headspace (% LFL)	volume of liquid in tank at time (ft^3)
$\frac{t_\iota}{(hr)} =$	$\frac{vol_{H2_\iota}}{(ft^3)} =$	$\frac{vol'_{H2_\iota}}{\left(\frac{ft^3}{day}\right)} =$	$100 \frac{vol_{H2_\iota}}{hvol(t_\iota)} =$	$100 \frac{vol_{H2_\iota}}{hvol(t_\iota)} \frac{100}{4} =$	$\frac{flow\ t_\iota + tvol_{init}}{(ft^3)} =$
0 000	0 000	0 000	0 000	0 000	0 000
8 000	1 059	3 074	0 043	1 067	256 667
16 000	2 043	2 817	0 092	2 294	513 333
24 000	2 929	2 489	0 149	3 719	770 000
32 000	3 692	2 073	0 216	5 390	1 027 10^3
40 000	4 298	1 542	0 295	7 382	1 283 10^3
48 000	4 703	0 857	0 392	9 806	1 540 10^3
56 000	4 845	-0 052	0 514	12 853	1 797 10^3
64 000	4 630	-1 312	0 675	16 880	2 053 10^3

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DCRT headspace hydrogen concentration when the maximum fill level is first achieved

$time = 34\,000\,hr$

$$\%H_{2lim} = \frac{100\ vol_{H2}\left(\frac{time}{hr}\right)}{hvol(time)} \qquad \%H_{2lim} = 0.234$$ volume % hydrogen [Eqn 36]

$$\%LFL_{lim} = 100\,\frac{vol_{H2}\left(\frac{time}{hr}\right)}{hvol(time)}\,\frac{100}{4} \qquad \%LFL_{lim} = 5.855$$ % LFL based on hydrogen [Eqn 37]

Ultimate (steady-state) DCRT headspace hydrogen concentration

$$\%H_{2ss} = \frac{100\,(gr\gamma(time))}{gr\gamma(time) + vr} \qquad \%H_{2ss} = 0.672$$ volume % hydrogen [Eqn 38]

$$\%LFL_{ss} = \%H_{2ss}\,\frac{100}{4} \qquad \%LFL_{ss} = 16.812$$ % LFL based on hydrogen [Eqn 39]

Tank Headspace wolume @ $time = 34\,000\,hr$

$$hvol(time) = 1648\,ft^3 \qquad t1 = \frac{time}{hr}$$

Hydrogen generation rate

$$gr\gamma(time) = 0.812\,\frac{ft^3}{day}$$

Barometric Breathing Rate

$$vent_{bb} = \frac{0.0045}{day}\,hvol(time) \qquad vent_{bb} = 0.309\,\frac{ft^3}{hr}$$

Determine if Steady-State concentration or concentration at end of pumping is limiting

$$flag_{lim} = if(\%LFL_{ss} < \%LFL_{lim}, 0, 1) \qquad flag_{lim} = 1$$

(flag = 0 pumping concentration limiting
flag = 1 steady-state limited)

Hydrogen concentration at loss of ventilation (greater of "end of pumping" or "final steady-state")

$$H_{2\_init} = if\left(flag_{lim} = 0, \frac{vol_{H2_{t1}}}{hvol(t1\ hr)}, \frac{\%H_{2ss}}{100}\right) \qquad H_{2\_init} = 0.672484\,\%$$

Final H2 Concentration to meet 25% (NH3 and CH4 included)

$$H_{2\_25\%} = if\left[flag_{lim} = 0, 0.0004\left(25 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(25 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_25\%} = -1.886\,\%$$

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Final H2 Concentration to meet 50% (NH3 and CH4 included)

$$H_{2\_50\%} = \mathrm{if}\left[\mathrm{flag}_{lim} = 0, 0.0004\left(50 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(50 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_50\%} = -0.886\%$$

Final H2 Concentration to meet 100% (NH3 and CH4 included)

$$H_{2\_100\%} = \mathrm{if}\left[\mathrm{flag}_{lim} = 0, 0.0004\left(100 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(100 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_100\%} = 1.114\%$$

Maximum %LFL with loss of ventilation

$$LFL_{nat\_breathing} = \frac{gr\gamma(time)}{\left(gr\gamma(time) + vent_{bb}\right) .04} + NH_3 \qquad LFL_{nat\_breathing} = 257.621\%$$

Time to Reach 25% LFL with loss of ventilation

$$temp1_{25} = \frac{-hvol(time)}{\left(gr\gamma(time) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_25\%}}{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp1_{25} = -49.147\,day$$

$$Time_{1\_25\%LFL} = \mathrm{if}\left(LFL_{nat\_breathing} > 25\%, \mathrm{if}\left(temp1_{25} < 0\,day, 0\,day, temp1_{25}\right), 999999999\,day\right) \qquad Time_{1\_25\%LFL} = 0.000\,day$$

Time to Reach 50% LFL with loss of ventilation

$$temp1_{50} = \frac{-hvol(time)}{\left(gr\gamma(time) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_50\%}}{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp1_{50} = -31.344\,day$$

$$Time_{1\_50\%LFL} = \mathrm{if}\left(LFL_{nat\_breathing} > 50\%, \mathrm{if}\left(temp1_{50} < 0\,day, 0\,day, temp1_{50}\right), 999999999\,day\right) \qquad Time_{1\_50\%LFL} = 0.000\,day$$

Time to Reach 100% LFL with loss of ventilation

$$temp1_{100} = \frac{-hvol(time)}{\left(gr\gamma(time) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_100\%}}{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp1_{100} = 9.851\,day$$

$$Time_{1\_100\%LFL} = \mathrm{if}\left(LFL_{nat\_breathing} > 100\%, \mathrm{if}\left(temp1_{100} < 0\,day, 0\,day, temp1_{100}\right), 999999999\,day\right) \qquad Time_{1\_100\%LFL} = 9.851\,day$$

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PART 2
Determination of Headspace Gas Concentration in a Horizontally Oriented DCRT

Begin Initialization Section for Part 2

$time = 34\,000\,hr \qquad t1 = \frac{time}{hr}$

Hydrogen volume in headspace

$vol2_{H2_0} = vol_{H2_{t1}}$

$vol2_{H2_0} = 3.8600\,ft^3$

Input Rate at which DCRT fills (flow2)

$flow_2 = 4\,000\,\frac{gal}{min}$

wolume of fill at start of phase 2

$tvol_{init2} = tvol_{init} + flow\cdot time$

$tvol_{init2} = 1091\,ft^3$

Pumping time for phase 2

$lim2 = time_2$

$lim2 = 35\,000\,hr$

Input rate at which saltwell pumping introduces hydrogen to the DCRT (gr_{sol})(mole/liter & convert to ft^3/hr

$gr_{sol2} = gr_{sol}\cdot\frac{flow_2}{flow} \qquad \frac{gr_{sol2}}{\left(\frac{ft^3}{hr}\right)} = 0.135$

$tt = 0\,hr .. lim2$

End Initialization Section for Part 2

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Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$$\text{hvol2(time)} := \text{tvol} - \text{flow}_2 \cdot \text{time} - \text{tvol}_{\text{init2}}$$ hvol2(lim2) = 525 326 ft^3 [Eqn 4]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\, d\,\frac{\text{flow}_2\, t + \text{tvol}_{\text{init2}}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(\text{flow}_2\, t + \text{tvol}_{\text{init2}}\right)}{d}$$ [Eqn 8]

$$\text{Awet(tt2)} := \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(\text{flow}_2\, \text{tt2} + \text{tvol}_{\text{init2}}\right)}{d}$$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) Awet(lim2) = 767 048 ft^2

Awet(0 hr) = 467 603 ft^2 Check the answers

Awet(1 hr) = 476 159 ft^2

Awet(lim2) = 767 048 ft^2

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$$\frac{NO_3}{\left(\frac{\text{mole}}{\text{liter}}\right)} = 2\,660 \quad \frac{NO_2}{\left(\frac{\text{mole}}{\text{liter}}\right)} = 3\,100 \quad \frac{\text{Al}}{\left(\frac{\text{mole}}{\text{liter}}\right)} = 1\,630 \quad \frac{\text{TOC}}{\left(\frac{\text{gm}}{\text{liter}}\right)} = 3\,228$$

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Definition of the hydrogen production by corrosion (ft³ per day)

$$H_{2cr}(t) \equiv R_{corr}\left[Awet(t)\left[\left(22\,4\,\frac{liter}{mole}\right)\left(\frac{T}{273\,15\,K}\right)\right]\right]$$ [Eqn 10]

$$C = R_{corr}\left(22\,4\,\frac{liter}{mole}\right)\left(\frac{T}{273\,15\,K}\right)$$ [Eqn 11]

$$H_{2cr}(t) = (Awet(t)\ C)$$ [Eqn 12]

Maximum hydrogen production rate from corrosion (ft³ per day)

$$\frac{H_{2cr}(lim2)}{\left(\frac{ft^3}{day}\right)} = 0\,169 \qquad H_{2cr}(\,1\ hr) = 0\,1032\,\frac{ft^3}{day}$$

Definition of the hydrogen radiolysis G factor (molecules hydrogen per 100 ew) and the hydrogen production by radiolysis (ft³ per day)

$$G_{H2O} = \left[0\,45 - 0\,43\left[\frac{[NO_2]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}} - 0\,56\left[\frac{[NO_3]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}}\right]\frac{molecules}{100\ eV} \qquad G_{H2O} = -0\,953\,\frac{molecules}{100\ eV}$$ [Eqn 13]

$$G_{H2O} = if\left(G_{H2O} \le G_{H2O\_sat}, G_{H2O\_sat}, G_{H2O}\right) \qquad G_{H2O} = 0\,005\,\frac{molecules}{100\ eV}$$

$$G_{org} = k_{rad}\ exp\left(\frac{-Ea_{rad}}{R_{const}\ T}\right)[TOC]\ E_{toc\_rad} \qquad G_{org} = 0\,049\,\frac{molecules}{100\ eV}$$

$$\left[H_{2rad}(t) \equiv \left(G_{H2O} + G_{org}\right) H_{load}\right] Liq_{wt\_frac}\left(\frac{g\_mol}{6\,02\ 10^{23}\ molecules}\right)\left(tvol_{init2} + flow_2\ t\right)\rho_{liq}$$ [Eqn 14]

$$E = \left(G_{H2O} + G_{org}\right)\left(H_{load}\ flow_2\right)\left(\frac{g\_mol}{6\,02\ 10^{23}\ molecules}\right)$$ [Eqn 15]

$$E_{const} = \left(G_{H2O} + G_{org}\right)\left(H_{load}\ tvol_{init2}\right)\left(\frac{g\_mol}{6\,02\ 10^{23}\ molecules}\right)$$ [Eqn 16]

$$F = \rho_{liq}\ Liq_{wt\_frac}\left(\frac{T}{273\,15\,K}\right)$$ [Eqn 17 Eqn 17b]

$$H_{2rad}(t) = \left(E\ t\ F + E_{const}\ F\right)$$ [Eqn 18]

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Maximum hydrogen production rate from radiolysis (ft³ per day)

$$\frac{H_{2rad}(lim2)}{\left(\frac{ft^3}{day}\right)} = 0\ 0555 \qquad \frac{H_{2rad}(2\ hr)}{\left(\frac{ft^3}{day}\right)} = 0\ 029$$

Definition of the hydrogen production by chemical reaction (ft³ per day) Reference (Hu 1999) [Eqn 19]

$$H_{2ch}(t) = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0\ 4}\,Liq_{wt\_frac}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)\left[\rho_{liq}\left(flow_2\,t + tvol_{init2}\right)\right]$$

$$G = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0\ 4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right) flow_2$$ [Eqn 20]

$$G_{const} = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0\ 4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right) tvol_{init2}$$ [Eqn 20a]

$$H_{2ch}(t) = \left(G \cdot F\,t + G_{const}\,F\right)$$ [Eqn 21]

Maximum hydrogen production rate from chemical reaction (ft³ per day)

$$\frac{H_{2ch}(lim2)}{\left(\frac{ft^3}{day}\right)} = 1\ 3842 \qquad \frac{H_{2ch}(2\ hr)}{\left(\frac{ft^3}{day}\right)} = 0\ 7222$$

Total hydrogen generation rate (ft³ per day)

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)$$ [Eqn 22]

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t) \qquad gr\gamma(lim2) = 0\ 067\,\frac{ft^3}{hr}$$ [Eqn 23]

Maximum total hydrogen production rate (ft³ per day)

$$Sum = gr\gamma(lim2)$$ [Eqn 24]

$$\frac{Sum}{\left(\frac{ft^3}{day}\right)} = 1\ 609$$

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Determine the relative amounts of hydrogen produced by each mechanism in percent

$\text{Corrosion} = 100\left(\text{Awet(lim2)}\ C\ \text{Sum}^{-1}\right)$ Corrosion = 10 502 [Eqn 25]

$\text{Radiolysis} = 100\left(E\ \text{lim2}\ F + E_{const}\ F\right)\text{Sum}^{-1}$ Radiolysis = 3 452 [Eqn 26]

$\text{Chemical} = 100\left(G\ F\ \text{lim2} + G_{const}\ F\right)\text{Sum}^{-1}$ Chemical = 86 046 [Eqn 27]

$\text{Total} = 100\ \text{Sum}\ \text{Sum}^{-1}$ Total = 100 000 [Eqn 28]

Prepare equations for solution of ordinary differential equation

Accumulation = Input - Output

Accumulation ==> $\frac{w}{dt} = w$

Input ==> H2 released by salt well pumping + H2 generated

==> $gr_{sol2} + gr\gamma(t) = grtot = gr_{sol2} + \left(H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)\right)$

==> $gr_{sol2} + \left(\text{Awet}(t)\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right)$

Output ==> H2 vented based on generation rate + vent rate + volume reduction

==> $\left(grtot(t) + vr + flow_2\right)\frac{vol2_{H2}}{hvol2(t)}$

==> $\left[gr_{sol2} + \left(\text{Awet}(t) + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right) + vr + flow_2\right]\frac{vol2_{H2}}{\left(tvol - flow_2\ t - tvol_{init2}\right)}$

Solve (i e find $vol_{H2t} = f(t)$) the following Initial walue problem

$vol_{H2t} - [gr_t - (gr_t + vr_t)(vol_{H2t}/hvol_t)] = 0$ where

vol_{H2t} is the volume of H_2 (ft^3) in the DCRT headspace at time t

$vol'_{H2t} = d(vol_{H2t})/dt$ the rate of change of the hydrogen volume in the tank headspace (ft^3/day)

gr_t (H2 generation rate (ft^3/day)) vr_t (DCRT ventilation rate (ft^3/day)) and $hvol_t$ (DCRT headspace volume(ft^3)) are known functions of t,
and the initial condition is vol_{H2t} (0 days) = 0

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Initial condition of the ODE ft3 of hydrogen in the tank headspace at time 0 (Set in input section)

$vol2_{H2_0} = 3\ 8600\, ft^3$

Definition of y' from differential equation

$$input(t) = \left[gr_{sol2} + \left[(Awet(t))\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right]\right]$$ [Eqn 29]

$$output(t) = \left[\frac{\left[gr_{sol2} + \left[(Awet(t))\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right]\right] + \left(vr + flow_2\right)}{hvol2(t)}\right]$$ [Eqn 30]

$$D(t, vol2_{H2}) = input(t) - output(t)\ vol2_{H2_0}$$ [Eqn 31]

$npoints = roundoff\left(\frac{1}{1}\ \frac{lim2}{hr}\right)$ evaluation points within the evaluation interval

$t1 = 0$ beginning of time interval $t2 = \frac{lim2}{sec}$ end of time interval

$$Z = rkfixed\left(\frac{vol2_{H2}}{ft^3}, t1, t2, npoints, D\right)$$

$i = 1\ \ npoints$

Z contains the values of vol_{H2} calculated at the evaluation points by the 4th Order Runge-Kutta approximation method for ordinary differential equations, expressed as an n column matrix [where n = order of the ordinary differential equation + 1 (2 in this case yielding t & vol_{H2})] [Eqn 32]

$t_i = \left[Z^{\langle 0 \rangle}\right]_i sec \qquad vol2_{H2_i} = \left[Z^{\langle 1 \rangle}\right]_i ft^3$ [Eqn 33 Eqn 34]

$vol2'_{H2_i} = input(t_i) - output(t_i)\ vol2_{H2_i}$ Definition of vol $_{H2t}$ in terms of t and vol_{H2t} as defined by the differential equation [Eqn 35]

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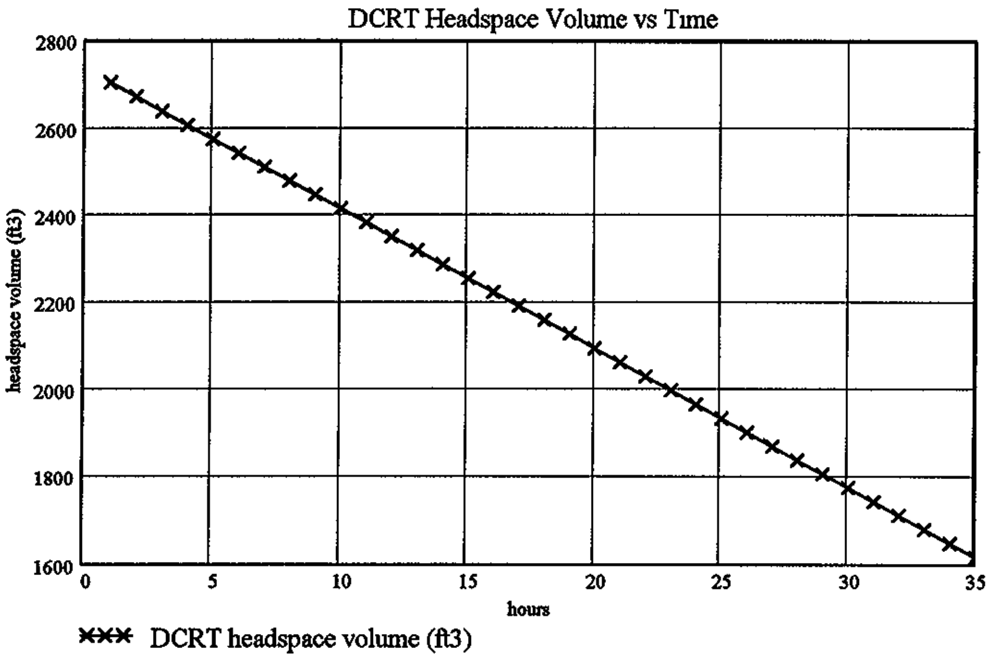

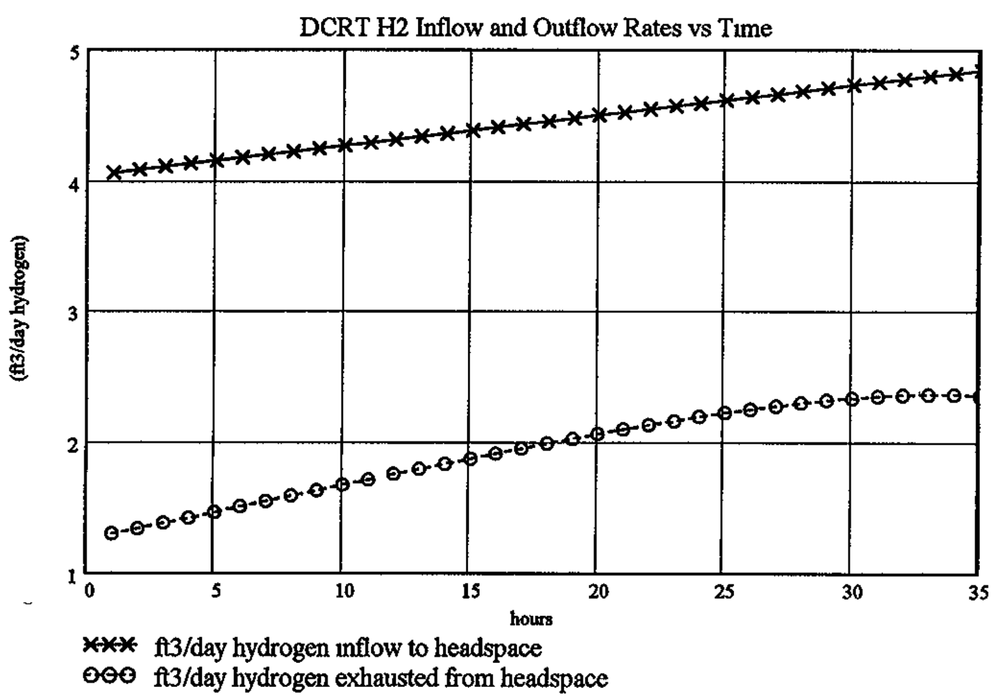

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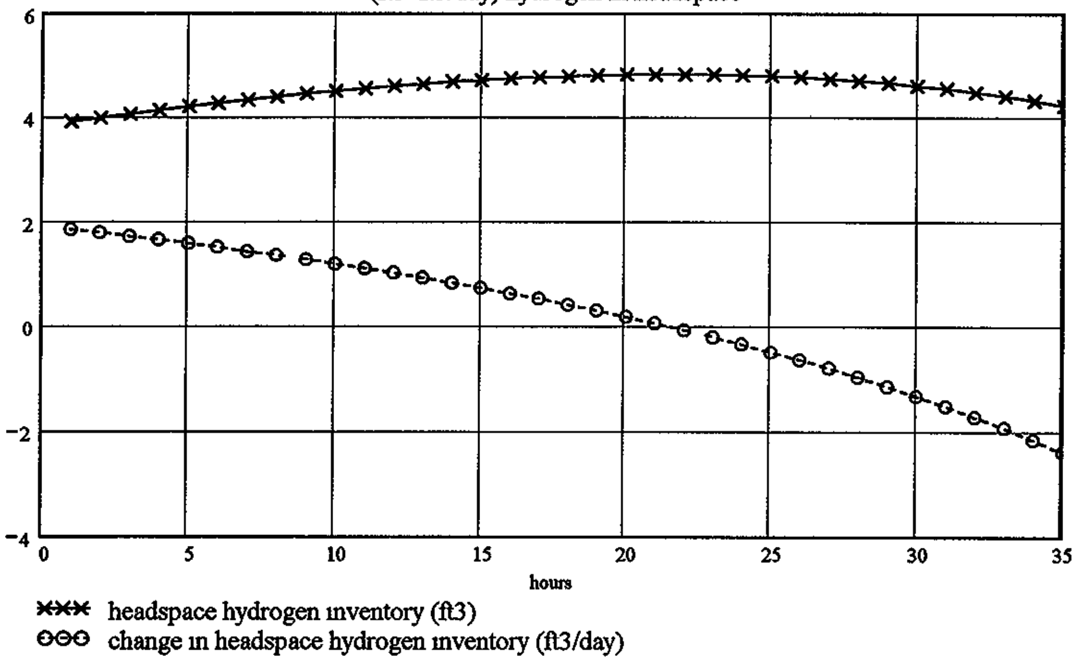
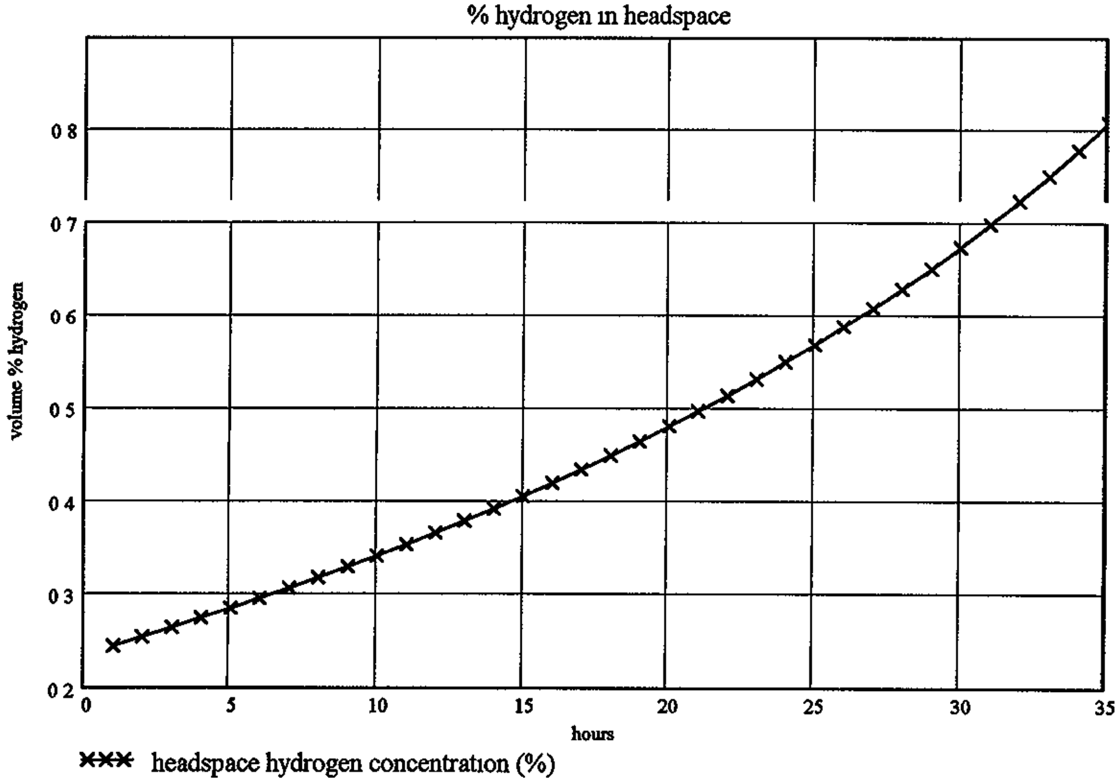
(ft3 ft3/day) hydrogen in headspace



% hydrogen in headspace



Case 3 Worst Case H2 SX-105 & S-107 dissolved H2 and SX-102 NH3 to 244-S hf mcd

Process Engineering
CH2M HILL
Mathcad v2000+

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Display tabulated results for first 24 hours of DCRT fill time

$i = 0, 1 .. \frac{lim2}{hr}$

time (hours)	H_2 volume in Headspace (ft^3)	Rate of H_2 volume Increase in Headspace (ft^3/day)	H_2 Concentration in Headspace (volume %)	H_2 Concentration in Headspace (% LFL)	volume of liquid in tank at time (ft^3)
$\frac{t_i}{(hr)} =$	$\frac{vol2_{H2_i}}{(ft^3)} =$	$\frac{vol2'_{H2_i}}{\left(\frac{ft^3}{day}\right)} =$	$100 \frac{vol2_{H2_i}}{hvol2(t_i)} =$	$100 \frac{vol2_{H2_i}}{hvol2(t_i)} \frac{100}{4} =$	$\frac{flow_2 t_i + tvol_{init2}}{(ft^3)} =$
0 000	3 860	0 000	0 234	5 855	$1\ 091\ 10^3$
1 000	3 940	1 889	0 244	6 095	$1\ 123\ 10^3$
2 000	4 017	1 824	0 254	6 340	$1\ 155\ 10^3$
3 000	4 092	1 757	0 264	6 592	$1\ 187\ 10^3$
4 000	4 164	1 688	0 274	6 849	$1\ 219\ 10^3$
5 000	4 233	1 616	0 284	7 112	$1\ 251\ 10^3$
6 000	4 298	1 542	0 295	7 382	$1\ 283\ 10^3$
7 000	4 361	1 466	0 306	7 658	$1\ 315\ 10^3$
8 000	4 421	1 388	0 318	7 942	$1\ 348\ 10^3$
9 000	4 477	1 306	0 329	8 232	$1\ 380\ 10^3$
10 000	4 529	1 222	0 341	8 531	$1\ 412\ 10^3$
11 000	4 579	1 135	0 353	8 837	$1\ 444\ 10^3$
12 000	4 624	1 046	0 366	9 151	$1\ 476\ 10^3$
13 000	4 666	0 953	0 379	9 474	$1\ 508\ 10^3$
14 000	4 703	0 857	0 392	9 806	$1\ 540\ 10^3$
15 000	4 737	0 757	0 406	10 148	$1\ 572\ 10^3$

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DCRT headspace hydrogen concentration when the maximum fill level is first achieved (end of step 2)

$lim2 = 35\,000\,hr$ $time_2 = 35\,000\,hr$ $lim = 69\,000\,hr$

$$\%H_{2lim} = \frac{100\ vol2_{H2}\left(time_2\ hr^{-1}\right)}{hvol2\left(time_2\right)}$$ $\%H_{2lim} = 0\ 809$ volume % hydrogen [Eqn 36]

$$\%LFL_{lim} = 100\ \frac{vol2_{H2}\left(time_2\ hr^{-1}\right)}{hvol2\left(time_2\right)}\ \frac{100}{4}$$ $\%LFL_{lim} = 20\ 221$ % LFL based on hydrogen [Eqn 37]

Ultimate (steady-state) DCRT headspace hydrogen concentration

$$\%H_{2ss2} = \frac{100\ \left(gr\gamma(lim2)\right)}{gr\gamma(lim2) + vr}$$ $\%H_{2ss2} = 1\ 323$ volume % hydrogen [Eqn 38]

$$\%LFL_{ss2} = \%H_{2ss2}\ \frac{100}{4}$$ $\%LFL_{ss2} = 33\ 072$ % LFL based on hydrogen [Eqn 39]

Tank Headspace wolume

$$t1 = \frac{lim2}{hr}$$

$hvol2(lim2) = 525\,ft^3$

Hydrogen generation rate

$$gr\gamma(lim2) = 1\ 609\ \frac{ft^3}{day}$$

Barometric Breathing Rate

$$vent_{bb} = \frac{0\ 0045}{day}\ hvol2(lim2)$$ $vent_{bb} = 0\ 098\ \frac{ft^3}{hr}$

Determine if Steady-State concentration or concentration at end of pumping is limiting

$$flag_{lim} = if\left(\%LFL_{ss2} < \%LFL_{lim}, 0, 1\right)$$ $flag_{lim} = 1$ (flag = 0 pumping concentration limiting, flag = 1, steady-state limited)

Hydrogen concentration at loss of ventilation (greater of "end of pumping" or "final steady-state")

$$H_{2\_init} = if\left(flag_{lim} = 0, \frac{vol2_{H2_{t1}}}{hvol2(t1\ hr)}, \frac{\%H_{2ss2}}{100}\right)$$ $H_{2\_init} = 1\ 322863\,\%$

Final H2 Concentration to meet 25% (NH3 and CH4 included)

$$H_{2\_25\%} = if\left[flag_{lim} = 0, 0\ 0004\left(25 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0\ 0004\left(25 - \frac{NH_3}{\%LFL_{NH3}}\right)\right]$$ $H_{2\_25\%} = -1\ 88600\,\%$

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Final H2 Concentration to meet 50% (NH3 and CH4 included)

$$H_{2\_50\%} = \mathrm{if}\left[\mathrm{flag}_{lim} = 0, 0\ 0004\left(50 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0\ 0004\left(50 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_50\%} = -0\ 886\,\%$$

Final H2 Concentration to meet 100% (NH3 and CH4 included)

$$H_{2\_100\%} = \mathrm{if}\left[\mathrm{flag}_{lim} = 0, 0\ 0004\left(100 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0\ 0004\left(100 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_100\%} = 1\ 114\,\%$$

Maximum %LFL with loss of ventilation

$$LFL_{nat\_breathing} = \frac{gr\gamma(lim2)}{\left(gr\gamma(lim2) + vent_{bb}\right)\ 04} + NH_3 \qquad LFL_{nat\_breathing} = 1\ 023 \times 10^{3}\,\%$$

Time to Reach 25% LFL with loss of ventilation

$$temp2_{25} = \frac{-hvol2(lim2)}{\left(gr\gamma(lim2) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(lim2) - \left(gr\gamma(lim2) + vent_{bb}\right) H_{2\_25\%}}{gr\gamma(lim2) - \left(gr\gamma(lim2) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp2_{25} = -10\ 412\ day$$

$$Time_{2\_25\%LFL} = \mathrm{if}\left(LFL_{nat\_breathing} > 25\%, \mathrm{if}\left(temp2_{25} < 0\ day, 0\ day, temp2_{25}\right), 999999999\ day\right) \qquad Time_{2\_25\%LFL} = 0\ 000\ day$$

Time to Reach 50% LFL with loss of ventilation

$$temp2_{50} = \frac{-hvol2(lim2)}{\left(gr\gamma(lim2) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(lim2) - \left(gr\gamma(lim2) + vent_{bb}\right) H_{2\_50\%}}{gr\gamma(lim2) - \left(gr\gamma(lim2) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp2_{50} = -7\ 254\ day$$

$$Time_{2\_50\%LFL} = \mathrm{if}\left(LFL_{nat\_breathing} > 50\%, \mathrm{if}\left(temp2_{50} < 0\ day, 0\ day, temp2_{50}\right), 999999999\ day\right) \qquad Time_{2\_50\%LFL} = 0\ 000\ day$$

Time to Reach 100% LFL with loss of ventilation

$$temp2_{100} = \frac{-hvol2(lim2)}{\left(gr\gamma(lim2) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(lim2) - \left(gr\gamma(lim2) + vent_{bb}\right) H_{2\_100\%}}{gr\gamma(lim2) - \left(gr\gamma(lim2) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp2_{100} = -0\ 703\ day$$

$$Time_{2\_100\%LFL} = \mathrm{if}\left(LFL_{nat\_breathing} > 100\%, \mathrm{if}\left(temp2_{100} < 0\ day, 0\ day, temp2_{100}\right), 999999999\ day\right) \qquad Time_{2\_100\%LFL} = 0\ 000\ day$$

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SUMMARY: DCRT 244-S CASE 3

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh) includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\,660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,468$	Nitrite Concentration	$NO_2 = 3\,100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,218\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 3\,228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 72\,150\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 1\,890\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\,471 \times 10^{-4}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,135\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time pumped at Second flow rate $tim2 = 35\,000\,hr$

Hydrogen Carryover Rate' $gr_{sol2} = 0\,135\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39.825\,\%$

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OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 39\ 825\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8160\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 5\ 855\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 79\ 895\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\ 812\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 88\ 962\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$

Time pumped at Second Flow Rate $lim2 = 35\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\,\%$

Final Fill Factor $fff2 = 80\ 821\,\%$

Initial Fill Volume $tvol_{init2} = 8160\,gal$

Final Fill Volume $ffv2 = 16560\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\ 855\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 20\ 221\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 94\ 261\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\ 072\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 105\ 222\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\ 023 \times 10^3\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\ 000\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0\ 000\,day$

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Determination of Headspace Gas Concentration in a Horizontally Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d) DCRT 244-U CASE 3

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

$d := 12\,ft$

Input length of DCRT (L)

$L := 35\,ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10^{-6})

$flow := 4\cdot\frac{gal}{min}$ $\qquad flow = 8\,912\times 10^{-3}\,ft^3\,sec^{-1}$ $\qquad \frac{flow}{\left(\frac{ft^3}{hr}\right)} = 32\,083$

Higher Input flow rate

$flow_2 := 4\cdot\frac{gal}{min}$ $\qquad flow_2 = 8\,912\times 10^{-3}\,ft^3\,sec^{-1}$ $\qquad \frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 32\,083$

Calculate total DCRT volume (tvol)

$tvol := 4146\cdot ft^3$ $\qquad$ (Reference HNF-SD-WM-CN-118) $\qquad$ [Eqn 1]

Volume of fill at start of pumping

$tvol_{init} := 0\,0\cdot tvol + 0\cdot hr\cdot 0\cdot\frac{gal}{min}$ $\qquad tvol_{init} = 0\,000\,ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 52\cdot hr$

Time at pumping rate 2

$time_2 := 52\cdot hr$

Volume of fill at start of pumping rate 2

$tvol_2 = tvol_{init} + time\cdot flow$ $\qquad tvol_2 = 1668\,ft^3$

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Calculate hours of fill time for the DCRT (t)

$\%full := 80$ Input percentage of tank fill

$$time_{fill} := \left(\frac{\%full}{100} tvol - tvol_{init}\right) flow^{-1}$$ $time_{fill} = 103\ 381\ hr$ [Eqn 2]

$mantissa(x) := x - floor(x)$

Rounding Off at the Halfway Point

$roundoff(x) := if(mantissa(x) < 0\ 5, floor(x), ceil(x))$

Rounding Off at Arbitrary Point

$RoundOff(x, t) := if(mantissa(x) < t, floor(x), ceil(x))$

'Time to fill is rounded to allow use as an integer counter Roundoff functions are not built-in MathCad functions

$lim := roundoff\left(time_{fill}\ hr^{-1}\right) hr$ $lim = 103\ 000\ hr$

$$lim := \begin{cases} 2\ 4\ 10^3\ hr & if\ lim > 2\ 4\ 10^3\ hr \\ lim & otherwise \end{cases}$$

$t := 0\ hr\ \ lim$

A time limit greater than 2400 hrs creates very large arrays and the solver equation becomes very slow The solver cannot handle array sizes greater than ~1,000 000

Input DCRT waste temperature (K)

$T := (273.15 + 31.1) \cdot K$ $T = 304\ 250\ K$ (Reference)

Input rate at which saltwell pumping introduces hydrogen to the DCRT ($gr_{sol\ molar}$)(mole/liter) & convert to ft^3/hr

$gr_{sol\_molar} := 3.297 \cdot 10^{-5} \cdot \frac{mole}{liter}$

$$gr_{sol} := gr_{sol\_molar}\ 22\ 4\ \frac{liter}{mole}\ flow\ \frac{T}{273\ 15\ K}$$ $\frac{gr_{sol}}{\left(\frac{ft^3}{hr}\right)} = 0\ 026$ [Eqn 3]

(Reference)

Input DCRT ventilation rate (vr)

$vr := 0.05 \cdot \frac{ft^3}{min}$ $\frac{vr}{\left(\frac{ft^3}{hr}\right)} = 3\ 000$

Input saltwell waste specific gravity (r)

$\rho := 1.41$ (Reference)

Input saltwell waste nitrate concentration (molar)

$NO_3 := 3.18 \cdot \frac{mole}{liter}$ (Reference)

Input saltwell waste nitrite concentration (molar)

$NO_2 := 3.02 \cdot \frac{mole}{liter}$ (Reference)

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Input saltwell waste aluminum concentrations (molar)

$Al := 1.20 \left(\frac{mole}{liter}\right)$ (Reference)

Input saltwell waste TOC concentrations (grams carbon per liter)

$TOC := 12.781 \left(\frac{gm}{liter}\right)$ (Reference)

Input radiolytic power from waste (Ci/mL) and then calculate DCRT radiolytic power (power generation per cubic foot of waste)

$decays = 1$ define decays as a unit of measure

$Ci = 3.7 \cdot 10^{10} \frac{decays}{sec}$ define Curies (Ci) as a unit of measure in decays/sec

$wastepower := \left(467 \cdot 10^{-6} \frac{Ci}{mL}\right)\left(1.61 \cdot 10^{-2} \frac{BTU \cdot hr^{-1}}{Ci}\right)$ [Eqn 5]

$wastepower = 7.519 \times 10^{-6} \frac{BTU}{hr \cdot mL}$

Conversion based on 137Cs - 137Ba pair Ref Kirkpatrick T D and Brown, R C , 1984, Basis and Values for Specific Activity and Decay Heat Generation Rates for Selected Radionuclides, RHO-SD-RE-TI-131, Rockwell Hanford Operations Richland Washington

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Input source of waste, DST or SST

tank_type := "SST" Tank type must be in quotes

Constants and other input for H_2 generation by radiolysis

Hu, T A, 1999, Empirical Rate Equation Model of Hydrogen Generation for Hanford Tank Waste, HNF-3851, Rev 0, Lockheed Martin Hanford Inc , Richland Washington

$K_{rad} := 2.49 \cdot 10^{6} \frac{molecules}{100 \cdot eV}$ Pre-exponential factor of G in organic radiolysis (Hu 1999 - eqn 4-16)

$Ea_{rad} := 44.32 \frac{kilo \cdot joule}{g\_mol}$ Activation energy of G in organic radiolysis (Hu 1999 - eqn 4-16)

$Liq_{wt\_frac} := 1$ Weight fraction liquid in material

$E_{toc\_rad} = \begin{cases} 0.4 & \text{if tank\_type = "SST"} \\ 0.7 & \text{otherwise} \end{cases}$ Reactivity coefficient of TOC (0 7 for DSTs 0 4 for SSts) (Hu 1999 - eqn 4-16)

$E_{toc\_rad} = 0.400$

Constants and other input for H_2 generation by chemical reaction

Hu T A 1999 Empirical Rate Equation Model of Hydrogen Generation for Hanford Tank Waste, HNF-3851 Rev 0 Lockheed Martin Hanford Inc Richland, Washington

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$k_{thm} := 2.76 \cdot 10^{9} \cdot \frac{g\_mol}{kg \cdot day}$ Thermolysis pre-exponential factor (Hu, 1999 - eqn 4-8)

$Ea_{thm} := 89.33 \cdot \frac{kilo\_joule}{g\_mol}$ Activation energy of H_2 generation (Hu 1999 - eqn 4-8)

$E_{toc\_thm} = \begin{cases} 0.4 & \text{if } tank\_type = \text{"SST"} \\ 0.7 & \text{otherwise} \end{cases}$

[TOC] efficiency coefficient, 0 70 for DSTs 0 40 for SSTs (Hu, 1999 - eqn 4-8)

$E_{toc\_thm} = 0.400$

Define unit rate of <u>corrosion</u> hydrogen production (R)

$R_{corr} = \begin{cases} 1.2 \cdot 10^{-7} \frac{ft^3}{ft^2\, min} \cdot \frac{mole}{22.4\, liter} & \text{if } tank\_type = \text{"SST"} \\ 6.0 \cdot 10^{-8} \frac{ft^3}{ft^2\, min} \cdot \frac{mole}{22.4\, liter} & \text{otherwise} \end{cases}$

eference 6 0E-08 for DSTs and 1 2E-07 for SSTs ³/min/ft²) (Hu 1999)

$R_{corr} = 1.200 \times 10^{-7} \frac{ft^3}{ft^2\, min} \cdot \frac{mole}{22.4\, liter}$

Initial condition of the ODE ft3 of hydrogen in the tank headspace at time t=0

$vol_{H2_0} := 0 \cdot ft^3$ (Reference)

If there is a combustion gas moniter (cgm) measurement, calculate the H_2 concentration

$flag_{cgm} := \text{"no"}$ <=== User inputs "yes" or "no" to indicate if a cgm measurement is available

$conc_{LFL\_cgm0} := 0\%LFL$ $conc_{LFL\_cgm0} = 0\, ppm$ (Reference)

Adjust H2 cgm reading for minimum detection limit (1220 ppm (3%LFL) combustable gas per WHC-SD-WM-TRP-256)

$conc_{LFL\_cgm} = if(conc_{LFL\_cgm0} < 3\ \%LFL, 1220\, ppm, conc_{LFL\_cgm0})$ $conc_{LFL\_cgm} = 1.220 \times 10^{3}\, ppm$

$conc_{NH3\_cgm} := 0 \cdot ppm$ $conc_{NH3\_cgm} = 0.000\, \%LFL_{NH3}$

Calculation H2 concentration in the dome space based on the CGM measurement

$$conc_{H2\_cgm} = \left(\frac{conc_{LFL\_cgm}}{\frac{1220\, ppm}{.03}} - \frac{conc_{NH3\_cgm}}{150000\, ppm} \right) 40000\, ppm$$

$conc_{H2\_cgm} = 3.000\, \%LFL_{H2}$ $conc_{H2\_cgm} = 1200\, ppm$

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$vol_{H2_0} = if[flag_{cgm} = yes", conc_{H2\_cgm} (tvol - tvol_{init}), vol_{H2_0}]$

$vol_{H2_0} = 0\ 000\ ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 14.85\ \%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 0.30\ \%LFL_{CH4}$ (Reference)

End of Input Section

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow\ t - tvol_{init}$ $hvol(lim) = 841\ 417\ ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft²) $2\ \pi \left(\frac{d}{2}\right)^2 + \pi\ d\ L = 1546\ ft^2$ [Eqn 8]

Wetted area of horizontally oriented DCRT (ft²)

$Vol = flow\ time + tvol_{init} = L\left(\frac{d}{2}\right)^2 (\alpha - \sin(\alpha)\cos(\alpha))$ Reference Perry's Chemical Engineers Handbook 5th Ed (a = 0 5* the overall angle) [Eqn 9]

$angle = 2\ root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow\ tt + tvol_{init}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]$ The MathCad Ver 6 0 formula to solve for the angle [Eqn 9b]

$\alpha := 0\ deg$ Set the initial value for a [Eqn 10]

$$Awet(tt) := L\frac{d}{2}\left[2\left[root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow\ tt + tvol_{init}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]\right]\right] + 2\left[\frac{1}{2}\left(\frac{d}{2}\right)^2\left[2\left[root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow\ tt + tvol_{init}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]\right] + -\sin\left[2\left[root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow\ tt + tvol_{init}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]\right]\right]\right]\right]$$

calculate the wetted surface (modified for initial condition)

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$Awet(0\ hr) = 0\ 000\ ft^2$

$Awet(1\ hr) = 144\ 508\ ft^2$

Check the answers

$Awet(lim) = 1\ 096 \times 10^3\ ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 3\ 180 \qquad \frac{NO_2}{\left(\frac{mole}{liter}\right)} = 3\ 020 \qquad \frac{Al}{\left(\frac{mole}{liter}\right)} = 1\ 200 \qquad \frac{TOC}{\left(\frac{gm}{liter}\right)} = 12\ 781$$

Definition of the hydrogen production by corrosion (ft^3 per day)

$$H_{2cr}(t) \equiv R_{corr}\left[Awet(t)\left[\left(22\ 4\ \frac{liter}{mole}\right)\left(\frac{T}{273\ 15\ K}\right)\right]\right] \qquad \text{[Eqn 10]}$$

$$C = R_{corr}\left(22\ 4\ \frac{liter}{mole}\right)\left(\frac{T}{273\ 15\ K}\right) \qquad \text{[Eqn 11]}$$

$$H_{2cr}(t) = (Awet(t)\ C) \qquad \text{[Eqn 12]}$$

Maximum hydrogen production rate from corrosion (ft^3 per day)

$$\frac{H_{2cr}(lim)}{\left(\frac{ft^3}{day}\right)} = 0\ 211 \qquad H_{2cr}(1\ hr) = 0\ 0111\ \frac{ft^3}{day}$$

Definition of the hydrogen radiolysis G factor (molecules hydrogen per 100 eV) and the hydrogen production by radiolysis (ft^3 per day)

$G_{H2O\_sat} = 0.005\ \frac{molecules}{100 \cdot eV}$ Default water radiolysis value for saturated salts waste

Add units back into definition of density

$sp\_g = \rho$

$\rho_{liq} = sp\_g\ 1\ \frac{gm}{mL} \qquad \rho_{liq} = 1\ 410\ \frac{gm}{mL}$

$TOC = 0\ 013\ \frac{kg}{liter}$ Redefine [TOC] as weight percent

$$[TOC] = \frac{TOC}{\rho_{liq}}\ 100$$

$$[TOC] = 0\ 906$$

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$Al = 1\ 200\ \frac{mole}{liter}$ $mw_{Al} = 26\ 9815\ \frac{gm}{mole}$ **Redefine [Al] as weight percent**

$$[Al] = \frac{Al\ mw_{Al}}{\rho_{liq}}\ 100$$

$$[Al] = 2\ 296$$

$NO_2 = 3\ 020\ \frac{mole}{liter}$ $[NO_2] = NO_2$ **Change of nomenclature**

$NO_3 = 3\ 180\ \frac{mole}{liter}$ $[NO_3] = NO_3$ **Change of nomenclature**

$wastepower = 2\ 203 \times 10^{-3}\ \frac{watt}{liter}$ **Convert wastepower** $\left(\frac{watt}{liter}\right)$ **to Heat Load** $\left(\frac{watt}{kg}\right)$

$$H_{load} = \frac{wastepower}{\rho_{liq}}$$

$$H_{load} = 1\ 563 \times 10^{-3}\ \frac{watt}{kg}$$

Reference (Hu, 1999) **[Eqn 13]**

$$G_{H2O} = \left[0\ 45 - 0\ 43\left[\frac{[NO_2]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}} - 0\ 56\left[\frac{[NO_3]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}}\right]\frac{molecules}{100\ eV} \qquad G_{H2O} = -0\ 995\ \frac{molecules}{100\ eV}$$

$$G_{H2O} = if\left(G_{H2O} \le G_{H2O\_sat}, G_{H2O\_sat}, G_{H2O}\right) \qquad G_{H2O} = 0\ 005\ \frac{molecules}{100\ eV}$$

$$G_{org} = k_{rad}\ \exp\left(\frac{-Ea_{rad}}{R_{const}\ T}\right)[TOC]\ E_{toc\_rad} \qquad G_{org} = 0\ 022\ \frac{molecules}{100\ eV}$$

$$\left[H_{2rad}(t) = \left(G_{H2O} + G_{org}\right) H_{load}\right] Liq_{wt\_frac}\left(\frac{g\_mol}{6\ 02\ 10^{23}\ molecules}\right)\left(tvol_{init} + flow\ t\right)\rho_{liq}$$ **[Eqn 14]**

$$E = \left(G_{H2O} + G_{org}\right)\left(H_{load}\ flow\right)\left(\frac{g\_mol}{6\ 02\ 10^{23}\ molecules}\right)$$ **[Eqn 15]**

$$E_{const} = \left(G_{H2O} + G_{org}\right)\left(H_{load}\ tvol_{init}\right)\left(\frac{g\_mol}{6\ 02\ 10^{23}\ molecules}\right)$$ **[Eqn 16]**

$$F = \rho_{liq}\ Liq_{wt\_frac}\left(\frac{T}{273\ 15\ K}\right)$$ **[Eqn 17, Eqn 17b]**

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$$H_{2rad}(t) = E\,t\,F + E_{const}\,F$$ [Eqn 18]

Maximum hydrogen production rate from radiolysis (ft³ per day)

$$\frac{H_{2rad}(\lim)}{\left(\frac{ft^3}{day}\right)} = 0.0443 \qquad \frac{H_{2rad}(1\ hr)}{\left(\frac{ft^3}{day}\right)} = 4.304 \times 10^{-4}$$

Definition of the hydrogen production by chemical reaction (ft³ per day) Reference (Hu 1999) [Eqn 19]

$$H_{2ch}(t) \equiv k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0.4}\,Liq_{wt\_frac}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)\left[\rho_{liq}\left(flow\,t + tvol_{init}\right)\right]$$

$$G = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0.4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)flow$$ [Eqn 20]

$$G_{const} = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0.4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)tvol_{init}$$ [Eqn 20a]

$$H_{2ch}(t) = G\,F\,t + G_{const}\,F$$ [Eqn 21]

Maximum hydrogen production rate from chemical reaction (ft³ per day)

$$\frac{H_{2ch}(\lim)}{\left(\frac{ft^3}{day}\right)} = 0.0749 \qquad \frac{H_{2ch}(1\ hr)}{\left(\frac{ft^3}{day}\right)} = 7.2682 \times 10^{-4}$$

Total hydrogen generation rate (ft³ per day)

$$gr\gamma(t) \equiv H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)$$ [Eqn 22]

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t) \qquad gr\gamma(\lim) = 0.330\,ft^3\,day^{-1}$$ [Eqn 23]

Maximum total hydrogen production rate (ft³ per day)

$$Sum = gr\gamma(\lim)$$ [Eqn 24]

$$\frac{Sum}{\left(\frac{ft^3}{day}\right)} = 0.330$$

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Determine the relative amounts of hydrogen produced by each mechanism in percent

$\text{Corrosion} = 100\left(\text{Awet(lim)}\ C\ \text{Sum}^{-1}\right)$	$\text{Corrosion} = 63\ 905$	[Eqn 25]
$\text{Radiolysis} = 100\left(E\ \text{lim}\ F + E_{const}\ F\right)\text{Sum}^{-1}$	$\text{Radiolysis} = 13\ 425$	[Eqn 26]
$\text{Chemical} = 100\left(G\ F\ \text{lim} + G_{const}\ F\right)\text{Sum}^{-1}$	$\text{Chemical} = 22\ 670$	[Eqn 27]
$\text{Total} = 100\ \text{Sum}\ \text{Sum}^{-1}$	$\text{Total} = 100\ 000$	[Eqn 28]

Prepare equations for solution of ordinary differential equation

Accumulation = Input - Output

Accumulation ==> $\frac{dVol_{H2}}{dt} = Vol_{H2}$

Input ==> H2 released by salt well pumping + H2 generated

==> $gr_{sol} + gr\gamma(t) = grtot = gr_{sol} + \left(H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)\right)$

==> $gr_{sol} + \left(\text{Awet}(t)\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right)$

Output ==> H2 vented based on generation rate + vent rate + volume reduction

==> $(grtot(t) + vr + flow)\ \frac{vol_{H2}}{hvol(t)}$

==> $\left[gr_{sol} + \left(\text{Awet}(t) + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right) + vr + flow\right]\frac{vol_{H2}}{\left(tvol - flow\ t - tvol_{init}\right)}$

Solve (i e , find $vol_{H2t} = f(t)$) the following Initial Value problem

$vol_{H2t} - [gr_t - (gr_t + vr_t)(vol_{H2t}/hvol_t)] = 0$ where

vol_{H2t} is the volume of H_2 (ft^3) in the DCRT headspace at time t

$vol_{H2t} = d(vol_{H2t})/dt$, the rate of change of the hydrogen volume in the tank headspace (ft^3/day)
gr_t (H2 generation rate (ft^3/day)) vr_t (DCRT ventilation rate (ft^3/day)) and $hvol_t$ (DCRT headspace volume(ft^3)) are known functions of t,
and the initial condition is vol_{H2t} (0 days) = 0

Author D C Hedengren Date 1/26/00 Checked by J D Bjorn Date 1/27/00

Initial condition of the ODE ft3 of hydrogen in the tank headspace at time 0 (Set in input section)

$$vol_{H2_0} = 0.000\,ft^3$$

Definition of y' from differential equation

$$input(t) = \left[gr_{sol} + \left[(Awet(t))\,C + E\,t\,F + E_{const}\,F + G\,F\,t + G_{const}\,F\right]\right]$$ [Eqn 29]

$$output(t) = \left[\frac{\left[gr_{sol} + \left[(Awet(t))\,C + E\,t\,F + E_{const}\,F + G\,F\,t + G_{const}\,F\right]\right] + (vr + flow)}{hvol(t)}\right]$$ [Eqn 30]

$$D(t, vol_{H2}) = input(t) - output(t)\,vol_{H2_0}$$ [Eqn 31]

$$npoints = \frac{lim}{hr}$$ evaluation points within the evaluation interval

$$t1 = 0$$ beginning of time interval

$$t2 = \frac{lim}{sec}$$ end of time interval

$$Z = rkfixed\left(\frac{vol_{H2}}{ft^3}, t1, t2, npoints, D\right)$$

Z contains the values of vol_{H2} calculated at the evaluation points by the 4th Order Runge-Kutta approximation method for ordinary differential equations expressed as an n column matrix [where n = order of the ordinary differential equation + 1 (2 in this case yielding t & vol_{H2})] [Eqn 32]

$$i = 1 .. npoints$$

$$t_i = \left[Z^{\langle 0 \rangle}\right]_i sec \qquad vol_{H2_i} = \left[Z^{\langle 1 \rangle}\right]_i ft^3$$ [Eqn 33 Eqn 34]

$$vol'_{H2_i} = input(t_i) - output(t_i)\,vol_{H2_i}$$

Definition of vol $_{H2t}$ in terms of t and vol_{H2t} as defined by the differential equation [Eqn 35]

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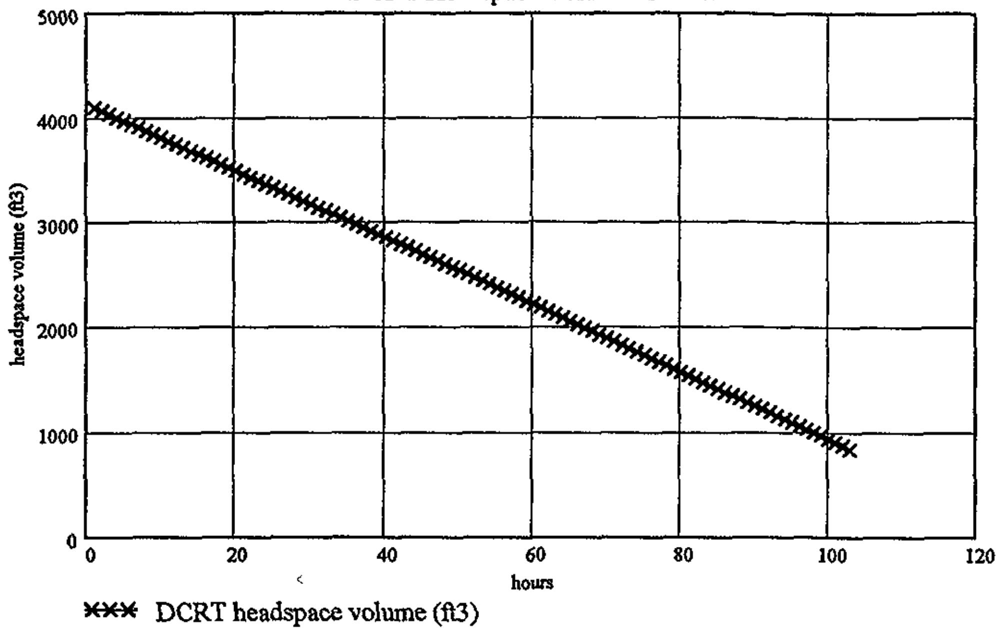
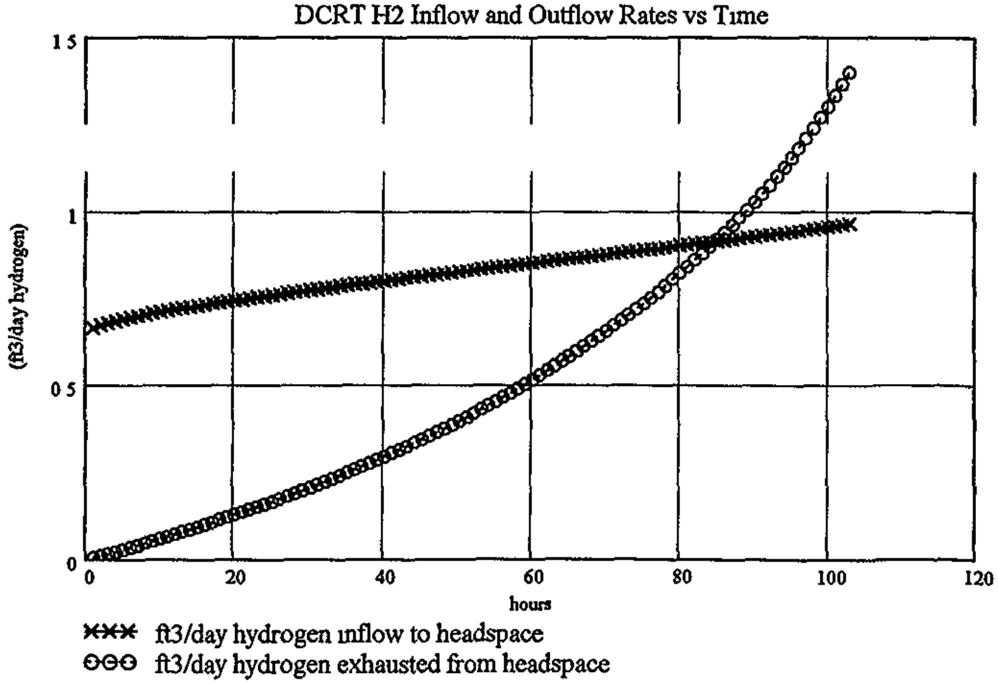
DCRT Headspace Volume vs Time



DCRT H2 Inflow and Outflow Rates vs Time



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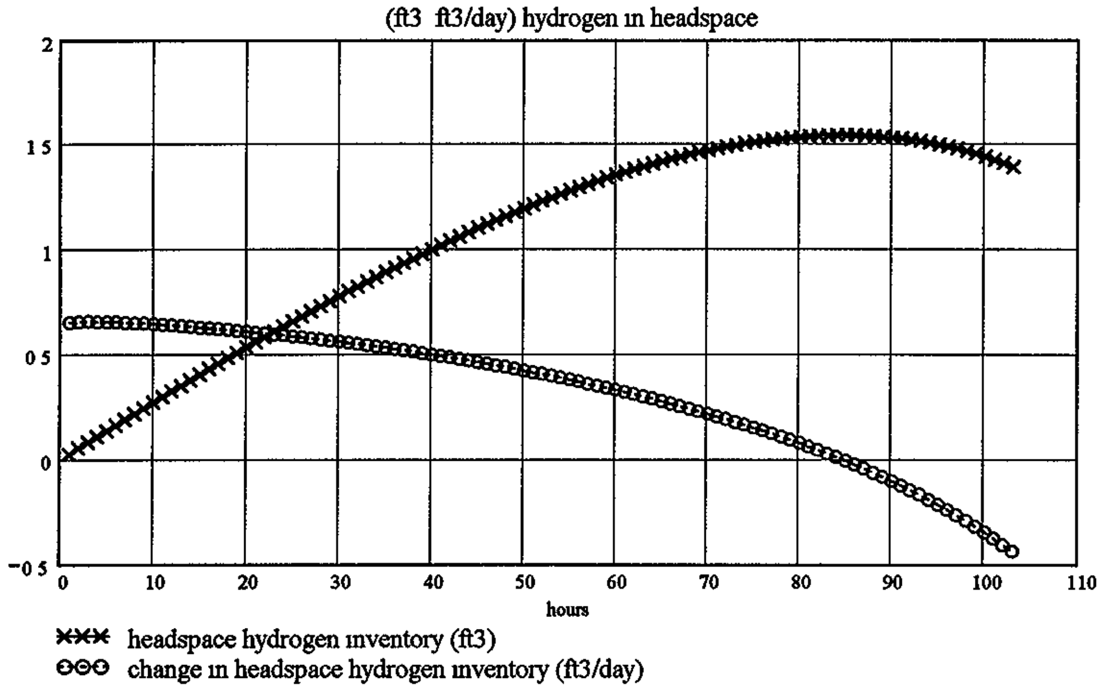

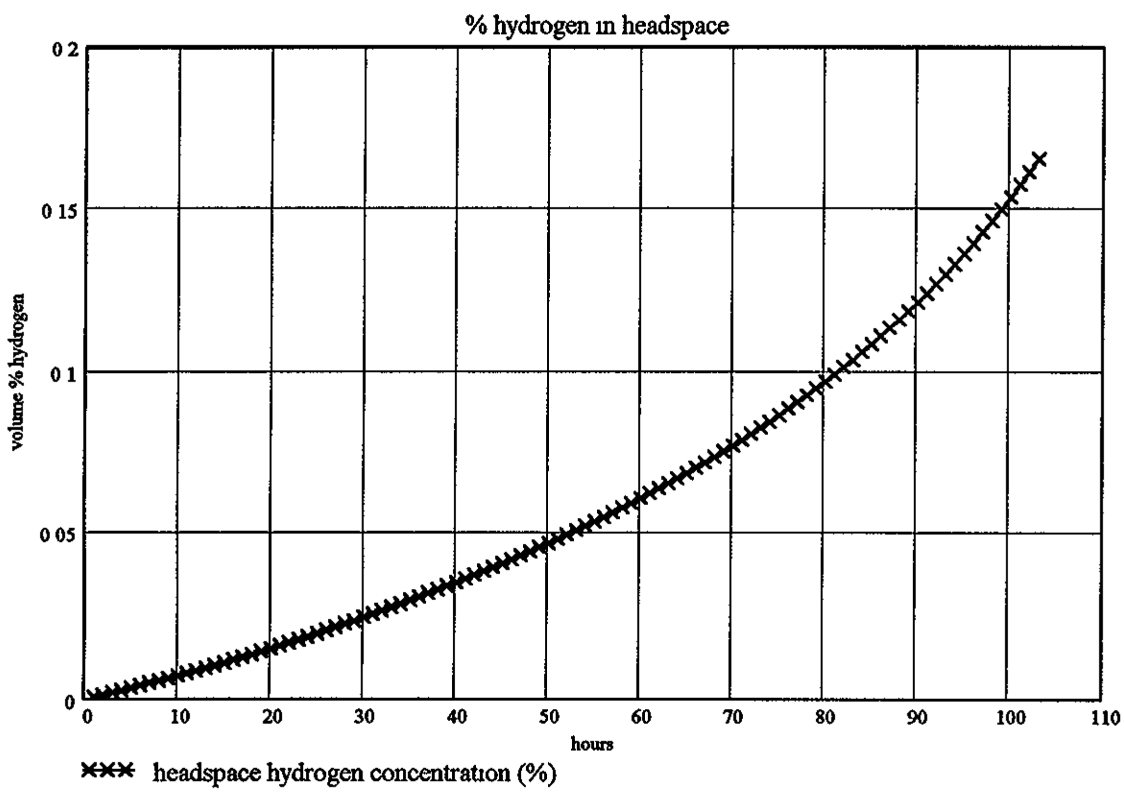

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Display tabulated results for first 24 hours of DCRT fill time

$\iota = 0,8 \ \frac{lm}{hr}$

time (hours)	H_2 volume in Headspace (ft^3)	Rate of H_2 Volume Increase in Headspace (ft^3/day)	H_2 Concentration in Headspace (volume %)	H_2 Concentration in Headspace (% LFL)	Volume of liquid in tank at time (ft^3)
$\frac{t_\iota}{(hr)} =$	$\frac{vol_{H2_\iota}}{(ft^3)} =$	$\frac{vol_{H2_\iota}}{\left(\frac{ft^3}{day}\right)} =$	$100\ \frac{vol_{H2_\iota}}{hvol(t_\iota)} =$	$100\ \frac{vol_{H2_\iota}}{hvol(t_\iota)}\ \frac{100}{4} =$	$\frac{flow\ t_\iota + tvol_{init}}{(ft^3)} =$
0 000	0 000	0 000	0 000	0 000	0 000
8 000	0 219	0 654	$5\ 637\ 10^{-3}$	0 141	256 667
16 000	0 434	0 629	0 012	0 298	513 333
24 000	0 638	0 595	0 019	0 472	770 000
32 000	0 829	0 552	0 027	0 665	$1\ 027\ 10^3$
40 000	1 005	0 502	0 035	0 878	$1\ 283\ 10^3$
48 000	1 163	0 443	0 045	1 116	$1\ 540\ 10^3$
56 000	1 299	0 373	0 055	1 382	$1\ 797\ 10^3$
64 000	1 410	0 291	0 067	1 685	$2\ 053\ 10^3$
72 000	1 492	0 195	0 081	2 031	$2\ 310\ 10^3$
80 000	1 538	0 080	0 097	2 435	$2\ 567\ 10^3$
88 000	1 542	0 061	0 117	2 915	$2\ 823\ 10^3$
96 000	1 493	-0 238	0 140	3 502	$3\ 080\ 10^3$

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DCRT headspace hydrogen concentration when the maximum fill level is first achieved

$time = 52\,000\,hr$

$\%H_{2lim} = \frac{100\ vol_{H2}\left(\frac{time}{hr}\right)}{hvol(time)}$ $\%H_{2lim} = 0\,050$ volume % hydrogen [Eqn 36]

$\%LFL_{lim} = 100\,\frac{vol_{H2}\left(\frac{time}{hr}\right)}{hvol(time)}\,\frac{100}{4}$ $\%LFL_{lim} = 1\,245$ % LFL based on hydrogen [Eqn 37]

Ultimate (steady-state) DCRT headspace hydrogen concentration

$\%H_{2ss} = \frac{100\,(gr\gamma(time))}{gr\gamma(time) + vr}$ $\%H_{2ss} = 0\,271$ volume % hydrogen [Eqn 38]

$\%LFL_{ss} = \%H_{2ss}\,\frac{100}{4}$ $\%LFL_{ss} = 6\,769$ % LFL based on hydrogen [Eqn 39]

Tank Headspace Volume @ $time = 52\,000\,hr$

$hvol(time) = 2478\,ft^3$ $t1 = \frac{time}{hr}$

Hydrogen generation rate

$gr\gamma(time) = 0\,195\,\frac{ft^3}{day}$

Barometric Breathing Rate

$vent_{bb} = \frac{0\,0045}{day}\,hvol(time)$ $vent_{bb} = 0\,465\,\frac{ft^3}{hr}$

Determine if Steady-State concentration or concentration at end of pumping is limiting

$flag_{lim} = if(\%LFL_{ss} < \%LFL_{lim}, 0, 1)$ $flag_{lim} = 1$ (flag = 0 pumping concentration limiting flag = 1, steady-state limited)

Hydrogen concentration at loss of ventilation (greater of "end of pumping" or "final steady-state")

$H_{2\_init} = if\left(flag_{lim} = 0, \frac{vol_{H2_{t1}}}{hvol(t1\ hr)}, \frac{\%H_{2ss}}{100}\right)$ $H_{2\_init} = 0\,270768\,\%$

Final H2 Concentration to meet 25% (NH3 and CH4 included)

$H_{2\_25\%} = if\left[flag_{lim} = 0, 0\,0004\left(25 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0\,0004\left(25 - \frac{NH_3}{\%LFL_{NH3}}\right)\right]$ $H_{2\_25\%} = 0\,406\,\%$

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Final H2 Concentration to meet 50% (NH3 and CH4 included)

$$H_{2\_50\%} = \text{if}\left[\text{flag}_{\text{lim}} = 0, 0.0004\left(50 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(50 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_50\%} = 1.406\%$$

Final H2 Concentration to meet 100% (NH3 and CH4 included)

$$H_{2\_100\%} = \text{if}\left[\text{flag}_{\text{lim}} = 0, 0.0004\left(100 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(100 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_100\%} = 3.406\%$$

Maximum %LFL with loss of ventilation

$$LFL_{nat\_breathing} = \frac{gr\gamma(time)}{\left(gr\gamma(time) + vent_{bb}\right) .04} + NH_3 \qquad LFL_{nat\_breathing} = 45.304\%$$

Time to Reach 25% LFL with loss of ventilation

$$temp1_{25} = \frac{-hvol(time)}{\left(gr\gamma(time) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_25\%}}{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp1_{25} = 21.346\,day$$

$$Time_{1\_25\%LFL} = \text{if}\left(LFL_{nat\_breathing} > 25\%, \text{if}\left(temp1_{25} < 0\ day, 0\ day, temp1_{25}\right), 999999999\ day\right) \qquad Time_{1\_25\%LFL} = 21.346\,day$$

Time to Reach 50% LFL with loss of ventilation

$$temp1_{50} = \frac{-hvol(time)}{\left(gr\gamma(time) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_50\%}}{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp1_{50} = 332.346\,day$$

$$Time_{1\_50\%LFL} = \text{if}\left(LFL_{nat\_breathing} > 50\%, \text{if}\left(temp1_{50} < 0\ day, 0\ day, temp1_{50}\right), 999999999\ day\right) \qquad Time_{1\_50\%LFL} = 10.000 \times 10^{8}\,day$$

Time to Reach 100% LFL with loss of ventilation

$$temp1_{100} = \frac{-hvol(time)}{\left(gr\gamma(time) + vent_{bb}\right)} \ln\left[\frac{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_100\%}}{gr\gamma(time) - \left(gr\gamma(time) + vent_{bb}\right) H_{2\_init}}\right] \qquad temp1_{100} = -32.188 - 686.102i\,day$$

$$Time_{1\_100\%LFL} = \text{if}\left(LFL_{nat\_breathing} > 100\%, \text{if}\left(temp1_{100} < 0\ day, 0\ day, temp1_{100}\right), 999999999\ day\right) \qquad Time_{1\_100\%LFL} = 10.000 \times 10^{8}\,day$$

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PART 2
Determination of Headspace Gas Concentration in a Horizontally Oriented DCRT

Begin Initialization Section for Part 2

$time = 52\,000\,hr \qquad t1 = \frac{time}{hr}$

Hydrogen volume in headspace

$vol2_{H2_0} = vol_{H2_{t1}}$

$vol2_{H2_0} = 1.2339\,ft^3$

Input Rate at which DCRT fills (flow2)

$flow_2 = 4\,000\,\frac{gal}{min}$

Volume of fill at start of phase 2

$tvol_{init2} = tvol_{init} + flow\ time$

$tvol_{init2} = 1668\,ft^3$

Pumping time for phase 2

$lim2 = time_2$

$lim2 = 52\,000\,hr$

Input rate at which saltwell pumping introduces hydrogen to the DCRT (gr_{sol})(mole/liter & convert to ft^3/hr

$gr_{sol2} = gr_{sol}\frac{flow_2}{flow} \qquad \frac{gr_{sol2}}{\left(\frac{ft^3}{hr}\right)} = 0.026$

$tt = 0\,hr\ \ lim2$

End Initialization Section for Part 2

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Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$$hvol2(time) := tvol - flow_2 \cdot time - tvol_{init2} \qquad hvol2(lim2) = 809\,333\ ft^3$$ [Eqn 4]

Wetted area of full DCRT (ft^2)

$$2\,\pi\left(\frac{d}{2}\right)^2 + \pi\, d\, L = 1\,546 \times 10^3\ ft^2$$ [Eqn 8]

Wetted area of horizontally oriented DCRT (ft^2)

$$Vol = flow_2\, time + tvol_{init2} = L\left(\frac{d}{2}\right)^2 (\alpha - \sin(\alpha)\cos(\alpha))$$

Reference Perry's Chemical Engineers Handbook 5th Ed (a = 0 5* the overall angle) [Eqn 9]

$$angle := 2\,root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow_2\, tt + tvol_{init2}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]$$

The MathCad Ver 6 0 formula to solve for the angle [Eqn 9b]

$\alpha := 0\ deg$ Set the initial value for a

[Eqn 10]

$$Awet(tt2) := L\cdot\frac{d}{2}\left[2\left[root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow_2\, tt2 + tvol_{init2}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]\right]\right] + 2\left[\frac{1}{2}\left(\frac{d}{2}\right)^2\left[2\left[root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow_2\, tt2 + tvol_{init2}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]\right] + -\sin\left[2\left[root\left[\alpha - \sin(\alpha)\cos(\alpha) - \frac{flow_2\, tt2 + tvol_{init2}}{L\left(\frac{d}{2}\right)^2}, \alpha\right]\right]\right]\right]\right]$$

calculate the wetted surface (modified for initial condition)

$Awet(0\ hr) = 702\,980\ ft^2$ Check the answers

$Awet(1\ hr) = 710\,240\ ft^2$

$Awet(lim2) = 1105\,926\ ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 3\,180 \qquad \frac{NO_2}{\left(\frac{mole}{liter}\right)} = 3\,020 \qquad \frac{Al}{\left(\frac{mole}{liter}\right)} = 1\,200 \qquad \frac{TOC}{\left(\frac{gm}{liter}\right)} = 12\,781$$

Author DC Hedengren Date 1/26/00 Checked by J.D. Rogers Date 1/27/00

Definition of the hydrogen production by corrosion (ft³ per day)

$$H_{2cr}(t) = R_{corr}\left[Awet(t)\left[\left(22.4\,\frac{liter}{mole}\right)\left(\frac{T}{273.15\,K}\right)\right]\right]$$ [Eqn 10]

$$C = R_{corr}\left(22.4\,\frac{liter}{mole}\right)\left(\frac{T}{273.15\,K}\right)$$ [Eqn 11]

$$H_{2cr}(t) = (Awet(t)\,C)$$ [Eqn 12]

Maximum hydrogen production rate from corrosion (ft³ per day)

$$\frac{H_{2cr}(lim2)}{\left(\frac{ft^3}{day}\right)} = 0.213 \qquad H_{2cr}(1\,hr) = 0.1354\,\frac{ft^3}{day}$$

Definition of the hydrogen radiolysis G factor (molecules hydrogen per 100 eV) and the hydrogen production by radiolysis (ft³ per day)

$$G_{H2O} = \left[0.45 - 0.43\left[\frac{[NO_2]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}} - 0.56\left[\frac{[NO_3]}{\left(\frac{mole}{liter}\right)}\right]^{\frac{1}{3}}\right]\frac{molecules}{100\,eV} \qquad G_{H2O} = -0.995\,\frac{molecules}{100\,eV}$$ [Eqn 13]

$$G_{H2O} = if\left(G_{H2O} \le G_{H2O\_sat}, G_{H2O\_sat}, G_{H2O}\right) \qquad G_{H2O} = 0.005\,\frac{molecules}{100\,eV}$$

$$G_{org} = k_{rad}\,exp\left(\frac{-Ea_{rad}}{R_{const}\,T}\right)[TOC]\,E_{toc\_rad} \qquad G_{org} = 0.022\,\frac{molecules}{100\,eV}$$

$$\left[H_{2rad}(t) = \left(G_{H2O} + G_{org}\right)H_{load}\right]Liq_{wt\_frac}\left(\frac{g\_mol}{6.02\,10^{23}\,molecules}\right)\left(tvol_{init2} + flow_2\,t\right)\rho_{liq}$$ [Eqn 14]

$$E = \left(G_{H2O} + G_{org}\right)\left(H_{load}\,flow_2\right)\left(\frac{g\_mol}{6.02\,10^{23}\,molecules}\right)$$ [Eqn 15]

$$E_{const} = \left(G_{H2O} + G_{org}\right)\left(H_{load}\,tvol_{init2}\right)\left(\frac{g\_mol}{6.02\,10^{23}\,molecules}\right)$$ [Eqn 16]

$$F = \rho_{liq}\,Liq_{wt\_frac}\left(\frac{T}{273.15\,K}\right)$$ [Eqn 17 Eqn 17b]

$$H_{2rad}(t) = E\,t\,F + E_{const}\,F$$ [Eqn 18]

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Maximum hydrogen production rate from radiolysis (ft³ per day)

$$\frac{H_{2rad}(lim2)}{\left(\frac{ft^3}{day}\right)} = 0\,0448 \qquad \frac{H_{2rad}(2\ hr)}{\left(\frac{ft^3}{day}\right)} = 0\,0232$$

Definition of the hydrogen production by chemical reaction (ft³ per day) Reference (Hu 1999) [Eqn 19]

$$H_{2ch}(t) = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0\,4}\,Liq_{wt\_frac}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)\left[\rho_{liq}\left(flow_2\,t + tvol_{init2}\right)\right]$$

$$G = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0\,4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)flow_2$$ [Eqn 20]

$$G_{const} = k_{thm}\,[TOC]\,E_{toc\_thm}\,([Al])^{0\,4}\,\exp\left(\frac{-Ea_{thm}}{R_{const}\,T}\right)tvol_{init2}$$ [Eqn 20a]

$$H_{2ch}(t) = G\,F\,t + G_{const}\,F$$ [Eqn 21]

Maximum hydrogen production rate from chemical reaction (ft³ per day)

$$\frac{H_{2ch}(lim2)}{\left(\frac{ft^3}{day}\right)} = 0\,0756 \qquad \frac{H_{2ch}(2\ hr)}{\left(\frac{ft^3}{day}\right)} = 0\,0392$$

Total hydrogen generation rate (ft³ per day)

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)$$ [Eqn 22]

$$gr\gamma(t) = H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t) \qquad gr\gamma(lim2) = 0\,014\,\frac{ft^3}{hr}$$ [Eqn 23]

Maximum total hydrogen production rate (ft³ per day)

$$Sum = gr\gamma(lim2)$$ [Eqn 24]

$$\frac{Sum}{\left(\frac{ft^3}{day}\right)} = 0\,333$$

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Determine the relative amounts of hydrogen produced by each mechanism in percent

$Corrosion = 100\left(Awet(lim2)\ C\ Sum^{-1}\right)$	$Corrosion = 63.881$	[Eqn 25]
$Radiolysis = 100\left(E\ lim2\ F + E_{const}\ F\right) Sum^{-1}$	$Radiolysis = 13.434$	[Eqn 26]
$Chemical = 100\left(G\ F\ lim2 + G_{const}\ F\right) Sum^{-1}$	$Chemical = 22.685$	[Eqn 27]
$Total = 100\ Sum\ Sum^{-1}$	$Total = 100.000$	[Eqn 28]

Prepare equations for solution of ordinary differential equation

Accumulation = Input - Output

Accumulation ==> $\frac{dVol2_{H2}}{dt} = Vol2'_{H2}$

Input ==> H2 released by salt well pumping + H2 generated

==> $gr_{sol2} + gr\gamma(t) = grtot = gr_{sol2} + \left(H_{2cr}(t) + H_{2rad}(t) + H_{2ch}(t)\right)$

==> $gr_{sol2} + \left(Awet(t)\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right)$

Output ==> H2 vented based on generation rate + vent rate + volume reduction

==> $\left(grtot(t) + vr + flow_2\right)\frac{vol2_{H2}}{hvol2(t)}$

==> $\left[gr_{sol2} + \left(Awet(t) + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right) + vr + flow_2\right]\frac{vol2_{H2}}{\left(tvol - flow_2\ t - tvol_{init2}\right)}$

Solve (i e , find $vol_{H2t} = f(t)$) the following Initial Value problem

$vol'_{H2t} - [gr_t - (gr_t + vr_t)(vol_{H2t}/hvol_t)] = 0$ where

vol_{H2t} is the volume of H_2 (ft^3) in the DCRT headspace at time t

vol_{H2t} = $d(vol_{H2t})/dt$, the rate of change of the hydrogen volume in the tank headspace (ft^3/day),
gr_t (H2 generation rate (ft^3/day)) vr_t (DCRT ventilation rate (ft^3/day)) and $hvol_t$ (DCRT headspace volume(ft^3)) are known functions of t
and the initial condition is vol_{H2t} (0 days) = 0

Author *D C Hedengren* Date *1/26/00* Checked by *J D Bogen* Date *1/27/00*

Initial condition of the ODE ft3 of hydrogen in the tank headspace at time 0 (Set in input section)

$vol2_{H2_0} = 1\ 2339\,ft^3$

Definition of y' from differential equation

$$input(t) = \left[gr_{sol2} + \left[(Awet(t))\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right]\right]$$ [Eqn 29]

$$output(t) = \left[\frac{\left[gr_{sol2} + \left[(Awet(t))\ C + E\ t\ F + E_{const}\ F + G\ F\ t + G_{const}\ F\right]\right] + (vr + flow_2)}{hvol2(t)}\right]$$ [Eqn 30]

$$D(t, vol2_{H2}) = input(t) - output(t)\ vol2_{H2_0}$$ [Eqn 31]

$npoints = roundoff\left(\frac{1}{1}\ \frac{lim2}{hr}\right)$ evaluation points within the evaluation interval

$t1 = 0$ beginning of time interval $t2 = \frac{lim2}{sec}$ end of time interval

$$Z = rkfixed\left(\frac{vol2_{H2}}{ft^3}, t1, t2, npoints, D\right)$$

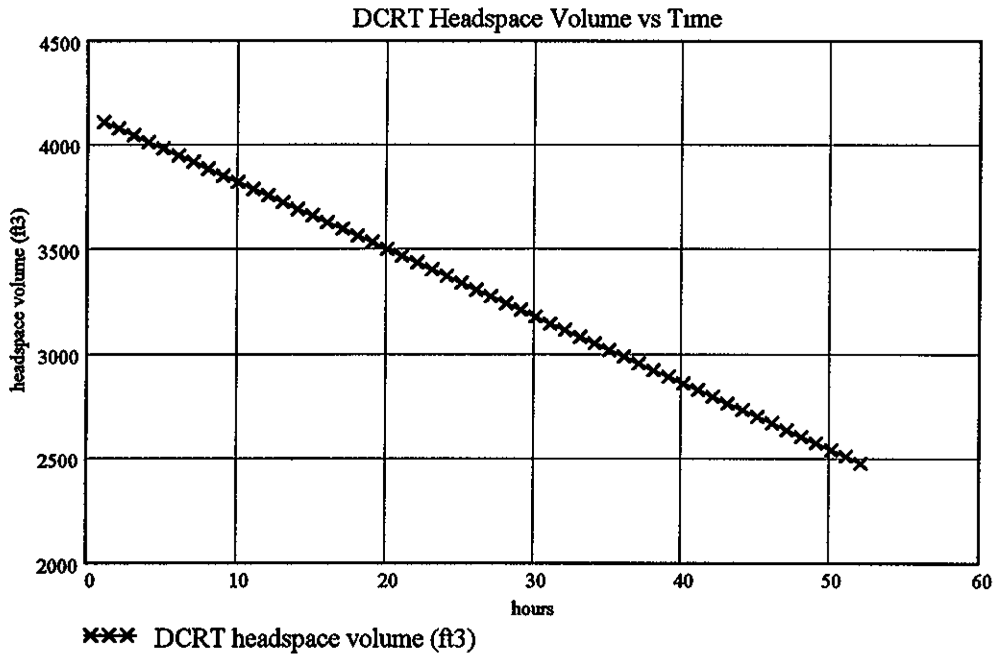
Z contains the values of vol_{H2} calculated at the evaluation points by the 4th Order Runge-Kutta approximation method for ordinary differential equations, expressed as an n column matrix [where n = order of the ordinary differential equation + 1 (2 in this case yielding t & vol_{H2})] [Eqn 32]

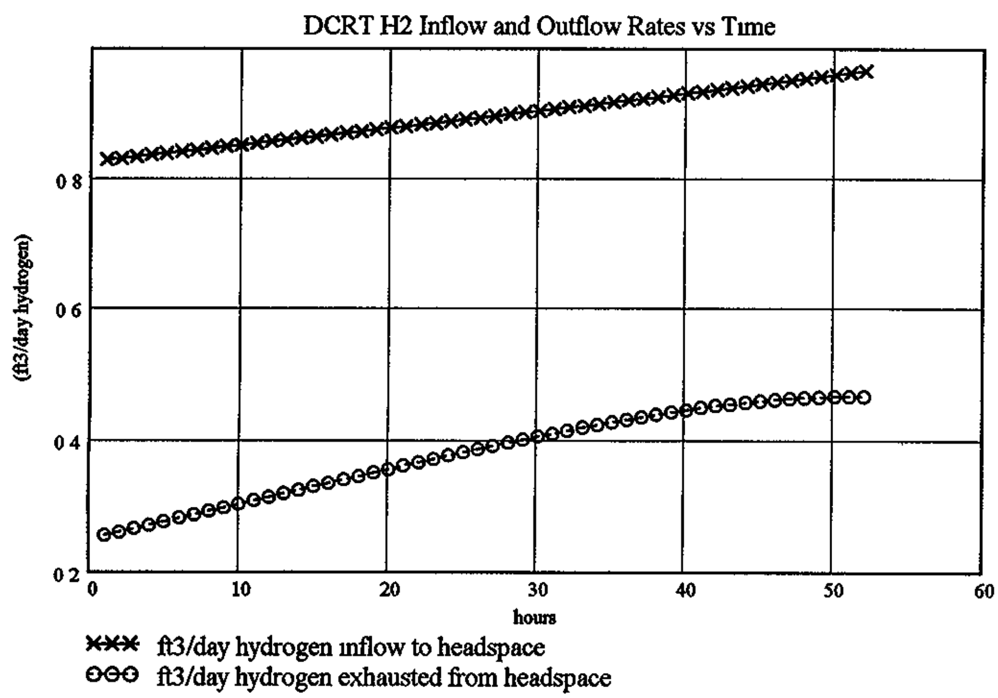
$i = 1\ \ npoints$

$t_i = \left[Z^{\langle 0\rangle}\right]_i\ sec \qquad vol2_{H2_i} = \left[Z^{\langle 1\rangle}\right]_i\ ft^3$ [Eqn 33, Eqn 34]

$vol2'_{H2_i} = input(t_i) - output(t_i)\ vol2_{H2_i}$ Definition of vol_{H2t} in terms of t and vol_{H2t} as defined by the differential equation [Eqn 35]

Author DC Helderson Date 1/26/00 Checked by JD Byrne Date 1/27/00





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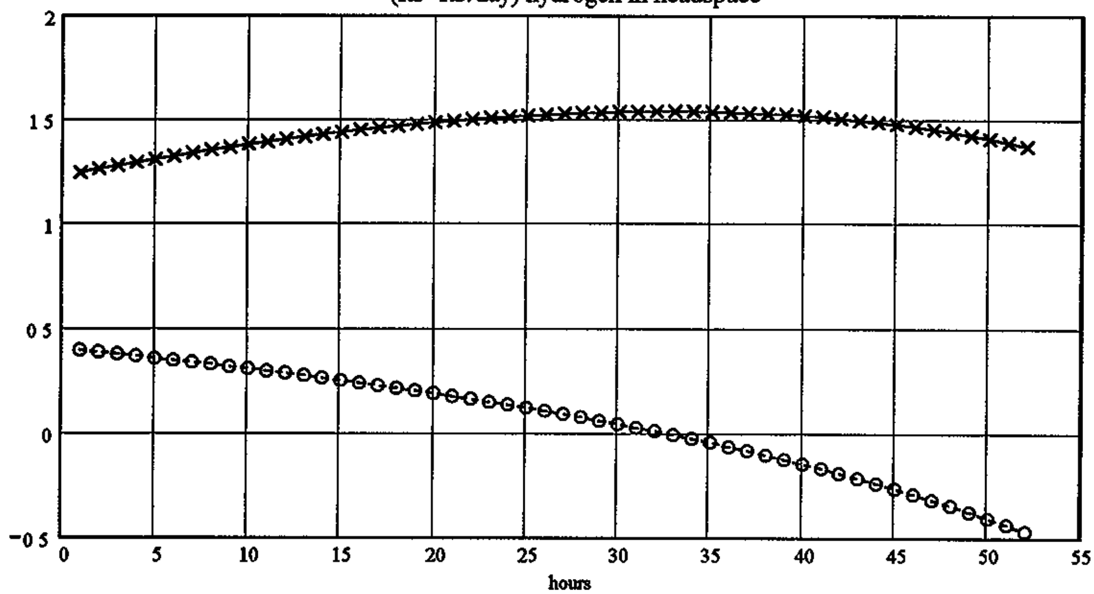
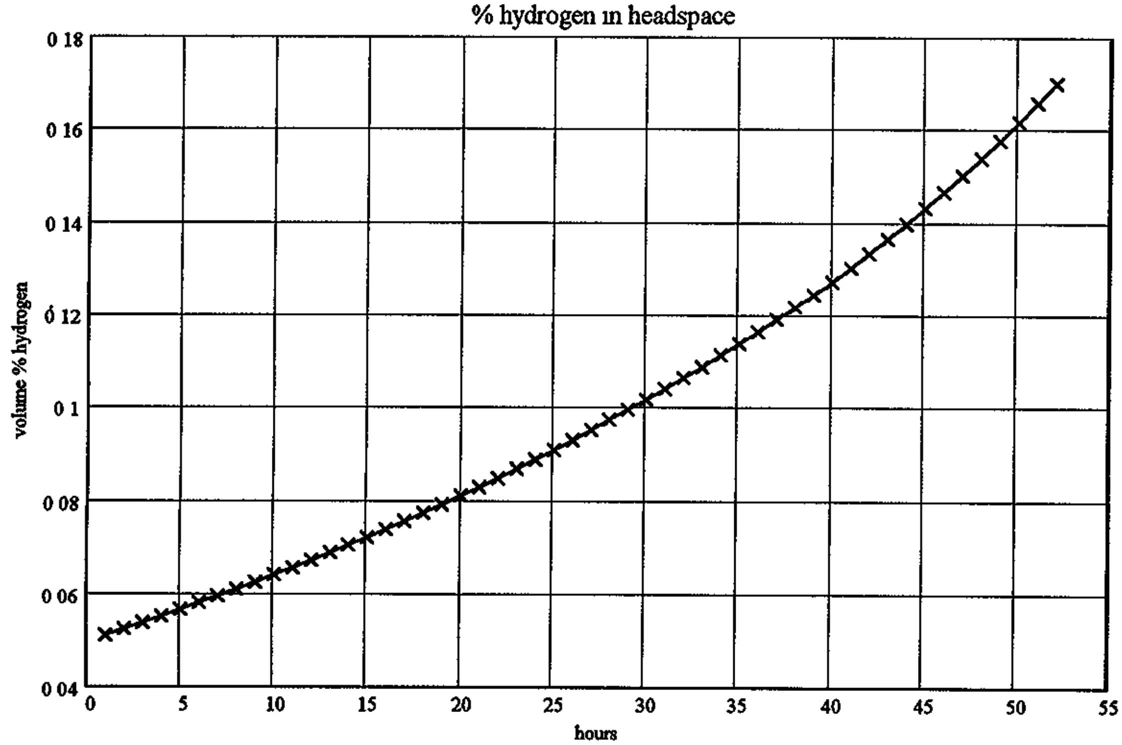
(ft3 ft3/day) hydrogen in headspace



xxx headspace hydrogen inventory (ft3)
ooo change in headspace hydrogen inventory (ft3/day)

% hydrogen in headspace



xxx headspace hydrogen concentration (%)

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Display tabulated results for first 24 hours of DCRT fill time

$i = 0, 1 .. \frac{lim2}{hr}$

time (hours)	H_2 volume in Headspace (ft^3)	Rate of H_2 Volume Increase in Headspace (ft^3/day)	H_2 Concentration in Headspace (volume %)	H_2 Concentration in Headspace (% LFL)	Volume of liquid in tank at time (ft^3)
$\frac{t_i}{(hr)} =$	$\frac{vol2_{H2_i}}{(ft^3)} =$	$\frac{vol2'_{H2_i}}{\left(\frac{ft^3}{day}\right)} =$	$100\frac{vol2_{H2_i}}{hvol2(t_i)} =$	$100\frac{vol2_{H2_i}}{hvol2(t_i)}\frac{100}{4} =$	$\frac{flow_2 t_i + tvol_{init2}}{(ft^3)} =$
0 000	1 234	0 000	0 050	1 245	1 668 10^3
1 000	1 251	0 400	0 051	1 279	1 700 10^3
2 000	1 267	0 391	0 053	1 313	1 733 10^3
3 000	1 283	0 382	0 054	1 347	1 765 10^3
4 000	1 299	0 373	0 055	1 382	1 797 10^3
5 000	1 314	0 364	0 057	1 418	1 829 10^3
6 000	1 329	0 354	0 058	1 454	1 861 10^3
7 000	1 344	0 344	0 060	1 491	1 893 10^3
8 000	1 358	0 334	0 061	1 529	1 925 10^3
9 000	1 372	0 324	0 063	1 567	1 957 10^3
10 000	1 385	0 313	0 064	1 605	1 989 10^3
11 000	1 398	0 302	0 066	1 645	2 021 10^3
12 000	1 410	0 291	0 067	1 685	2 053 10^3
13 000	1 422	0 280	0 069	1 725	2 085 10^3
14 000	1 434	0 269	0 071	1 767	2 118 10^3
15 000	1 445	0 257	0 072	1 809	2 150 10^3

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DCRT headspace hydrogen concentration when the maximum fill level is first achieved

$lim2 = 52\,000\,hr \qquad time_2 = 52\,000\,hr \qquad lim = 103\,000\,hr$

$$\%H_{2lim} = \frac{100\ vol2_{H2}\left(time_2 \cdot hr^{-1}\right)}{hvol2\left(time_2\right)} \qquad \%H_{2lim} = 0.170$$ volume % hydrogen [Eqn 36]

$$\%LFL_{lim} = 100\ \frac{vol2_{H2}\left(time_2 \cdot hr^{-1}\right)}{hvol2\left(time_2\right)} \cdot \frac{100}{4} \qquad \%LFL_{lim} = 4.255$$ % LFL based on hydrogen [Eqn 37]

Ultimate (steady-state) DCRT headspace hydrogen concentration

$$\%H_{2ss2} = \frac{100\ (gr\gamma(lim2))}{gr\gamma(lim2) + vr} \qquad \%H_{2ss2} = 0.461$$ volume % hydrogen [Eqn 38]

$$\%LFL_{ss2} = \%H_{2ss2} \cdot \frac{100}{4} \qquad \%LFL_{ss2} = 11.517$$ % LFL based on hydrogen [Eqn 39]

Tank Headspace Volume

$$t1 = \frac{lim2}{hr}$$

$hvol2(lim2) = 809\,ft^3$

Hydrogen generation rate

$$gr\gamma(lim2) = 0.333\,\frac{ft^3}{day}$$

Barometric Breathing Rate

$$vent_{bb} = \frac{0.0045}{day} \cdot hvol2(lim2) \qquad vent_{bb} = 0.152\,\frac{ft^3}{hr}$$

Determine if Steady-State concentration or concentration at end of pumping is limiting

$$flag_{lim} = if\left(\%LFL_{ss2} < \%LFL_{lim}, 0, 1\right) \qquad flag_{lim} = 1$$

(flag = 0 pumping concentration limiting
flag = 1 steady-state limited)

Hydrogen concentration at loss of ventilation (greater of "end of pumping" or "final steady-state")

$$H_{2\_init} = if\left(flag_{lim} = 0, \frac{vol2_{H2_{t1}}}{hvol2(t1\ hr)}, \frac{\%H_{2ss2}}{100}\right) \qquad H_{2\_init} = 0.460667\,\%$$

Final H2 Concentration to meet 25% (NH3 and CH4 included)

$$H_{2\_25\%} = if\left[flag_{lim} = 0, 0.0004\left(25 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(25 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \qquad H_{2\_25\%} = 0.406\,\%$$

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Final H2 Concentration to meet 50% (NH3 and CH4 included)

$$H_{2\_50\%} = if\left[flag_{lim} = 0, 0.0004\left(50 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(50 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \quad H_{2\_50\%} = 1.406\%$$

Final H2 Concentration to meet 100% (NH3 and CH4 included)

$$H_{2\_100\%} = if\left[flag_{lim} = 0, 0.0004\left(100 - \frac{NH_3}{\%LFL_{NH3}} - \frac{CH_4}{\%LFL_{CH4}}\right), 0.0004\left(100 - \frac{NH_3}{\%LFL_{NH3}}\right)\right] \quad H_{2\_100\%} = 3.406\%$$

Maximum %LFL with loss of ventilation

$$LFL_{nat\_breathing} = \frac{gr\gamma(lim2)}{(gr\gamma(lim2) + vent_{bb}) \cdot 04} + NH_3 \qquad LFL_{nat\_breathing} = 211.786\%$$

Time to Reach 25% LFL with loss of ventilation

$$temp2_{25} = \frac{-hvol2(lim2)}{(gr\gamma(lim2) + vent_{bb})} \ln\left[\frac{gr\gamma(lim2) - (gr\gamma(lim2) + vent_{bb}) H_{2\_25\%}}{gr\gamma(lim2) - (gr\gamma(lim2) + vent_{bb}) H_{2\_init}}\right] \qquad temp2_{25} = -1.400\,day$$

$$Time_{2\_25\%LFL} = if(LFL_{nat\_breathing} > 25\%, if(temp2_{25} < 0\,day, 0\,day, temp2_{25}), 999999999\,day) \qquad Time_{2\_25\%LFL} = 0.000\,day$$

Time to Reach 50% LFL with loss of ventilation

$$temp2_{50} = \frac{-hvol2(lim2)}{(gr\gamma(lim2) + vent_{bb})} \ln\left[\frac{gr\gamma(lim2) - (gr\gamma(lim2) + vent_{bb}) H_{2\_50\%}}{gr\gamma(lim2) - (gr\gamma(lim2) + vent_{bb}) H_{2\_init}}\right] \qquad temp2_{50} = 25.872\,day$$

$$Time_{2\_50\%LFL} = if(LFL_{nat\_breathing} > 50\%, if(temp2_{50} < 0\,day, 0\,day, temp2_{50}), 999999999\,day) \qquad Time_{2\_50\%LFL} = 25.872\,day$$

Time to Reach 100% LFL with loss of ventilation

$$temp2_{100} = \frac{-hvol2(lim2)}{(gr\gamma(lim2) + vent_{bb})} \ln\left[\frac{gr\gamma(lim2) - (gr\gamma(lim2) + vent_{bb}) H_{2\_100\%}}{gr\gamma(lim2) - (gr\gamma(lim2) + vent_{bb}) H_{2\_init}}\right] \qquad temp2_{100} = 94.653\,day$$

$$Time_{2\_100\%LFL} = if(LFL_{nat\_breathing} > 100\%, if(temp2_{100} < 0\,day, 0\,day, temp2_{100}), 999999999\,day) \qquad Time_{2\_100\%LFL} = 94.653\,day$$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/27/00

SUMMARY:

DCRT 244-U
CASE 3

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106

- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 12\ 781\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 14\ 850\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 300\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\,K$		

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 026\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 026\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

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OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,245\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\,395\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\,619\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,245\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4\,255\,\%$

Final Flammable Gas Concentration $ffgc2 = 19\,405\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\,517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 26\,367\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 211\,786\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 25\,872\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 94\,653\,day$

DRAFT PROC 021, section 13 0, dated 12/21/99

APPENDIX A
CHECKLIST FOR INDEPENDENT REVIEW

Document RPP-4941 Rev 0 Appendix E
Author D C Hedengren, et al
Scope of Review
Appendix E Hydrogen Generation Rates

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

Steven A. Barker [signature]
Reviewer (Printed Name and Signature

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

Results compared to
Hu, T A, 1999, "Empirical Rate Equation Model and Rate Equations of Hydrogen Generation for Hanford Tank Waste," HNF-3851, Rev 0, Lockheed Martin Hanford, Corp, Richland, WA

APPENDIX F

Determination of Ammonia Solubility in High Salt Solutions

Washington State University – Tri-Cities

Class Project

Class Project for CE-515

Washington State University--Tri-Cities

Determination of Ammonia Solubility in High Salt Solutions

by

David C Hedengren

May 5, 1999

Table of Contents

1 0 Background

The solubilities of gases in electrolyte (salt) solutions are important in chemical and biochemical reaction engineering For example, the estimation of gas-liquid mass transfer rate requires not only the volumetric mass-transfer coefficient but also the equilibrium liquid phase concentration to be known With increasing salt concentration, gas solubility is nearly always found to decrease ("salting-out' effect) Schumpe (Reference 1 and Attachment A) has suggested a model that can sometimes be used to predict gas solubilities in salt solutions in excess of 5 moles/L However, there are significant concerns in extrapolating the Schumpe model to saturated or near saturated salt solutions

An environmental and industrial safety issue of storing radioactive chemical wastes in the 177 underground waste storage tanks is the presence of ammonia in many of these tanks Ammonia has an IDLH (immediately dangerous to life and health) limit of 300 ppm and an LFL (lower flammability limit) of 15 5% Therefore, it is important to understand the relationships between ammonia in the liquid phase and the gaseous phase This information is needed to predict levels of ammonia which can exist in the vapor spaces of tanks and which can be discharged from storage tanks in exhaust ventilation air

Ammonia gas is very soluble in water and its solubility as a function of temperature is well documented in the literature Some ammonia solubility data are available for dilute salt solutions However, very little data exist for saturated or near saturated salt solutions, which are similar to some of the waste in Hanford underground storage tanks The results of a literature search is given in Attachment C The existing data indicate that ammonia solubility decreases as salt solutions become more concentrated and ammonia solubility decreases with increases with temperature (Reference 2) The measurements of Reference 2 made use of a fairly complex, modified isoteniscope This piece of equipment relied upon taking vapor samples to determine the partial pressures of both ammonia and water and to calculate ammonia solubilities in various salt solutions

More direct measurements of ammonia solubilities in high salt solutions are needed to validate or correct the vapor pressure model and coefficients presented in Reference 1 and the Schumpe model s use for mixed salt solutions above 5 molar concentrations

Henry's Law states that the ratio of the equilibrium ratio of the concentration of a gas in solution to its vapor pressure above that solution is given by a constant, Henry's Law constant The Henry's Law constant, per the Schumpe model, is a function of temperature and the ionic composition of a water solution A discussion of this is given in Reference 3 (Attachment B)

2 0 Purpose

The purpose of this project is to measure the solubility of ammonia in a concentrated salt solution at room temperature A saturated salt solution which simulates the waste in the Hanford underground waste tank 241-SY-101 was used The composition of this simulant approximates that of simulant SY1-SIM-91A, which is given in Table 1 of Reference 2 This heterogenous (slurry) is reported to have the following composition

Component	Molarity (moles/L)	Weight %
NaOH	2 3	6 4
$NaAlO_2$	2 2	12 2
$NaNO_3$	3 7	22 0
$NaNO_2$	3 2	15 4
Na_2CO_3	0 6	4 4
H_2O		39.6
Total		100 0

This slurry, after being mixed for a period of time, was filtered to obtain a saturated solution without solids Ammonia solubility data from this experiment can be used to validate or adjust the Schumpe model (Reference 1) for predicting ammonia solubilities in high salt solutions Comparisons to ammonia solubilities and/or ammonia vapor pressure obtained by vapor phase measurements of Norton and Pederson (Reference 2) are also made to check for consistency with the results of this experiment

3 0 Methods

Methodology

A closed system consisting of three interconnected, 500 ml filter flasks was used (See Figure 1) Each of two of the primary filter flasks was filled to approximately the same volume (between 300 and 400 ml) of water or saturated salt solution A third filter flask contained concentrated ammonium hydroxide solution was connected to the other two flasks as needed as a source of ammonia vapor When not needed, the two primary flasks were isolated from the third flask and the atmosphere by use of a plug

Prior to the taking of data for the saturated salt solution described above, the system was checked, along with analytical methods, using only water with dissolved ammonia or ammonium hydroxide, which was added to one of two flasks of water In all tests, electric stirrers were used to maximize mass transfer of ammonia between the liquid and vapor phases

It can be shown (Reference 3) that, for a system with a common equilibrium ammonia concentration, the ratio of equilibrium concentrations of ammonia in two water based solutions at the same temperature is equal to the ratio of their respective Henry's Law constants In the case of this experiment, the two water based solutions were water and a saturated salt solution. Knowing from the literature the temperature dependent Henry's Law constants for ammonia in water, a Henry's Law constant for ammonia in a saturated salt solution was calculated (Reference 3) This Henry's Law constant can then be used to relate the equilibrium liquid concentration of ammonia in the saturated salt solution to its equilibrium vapor pressure of ammonia above this solution

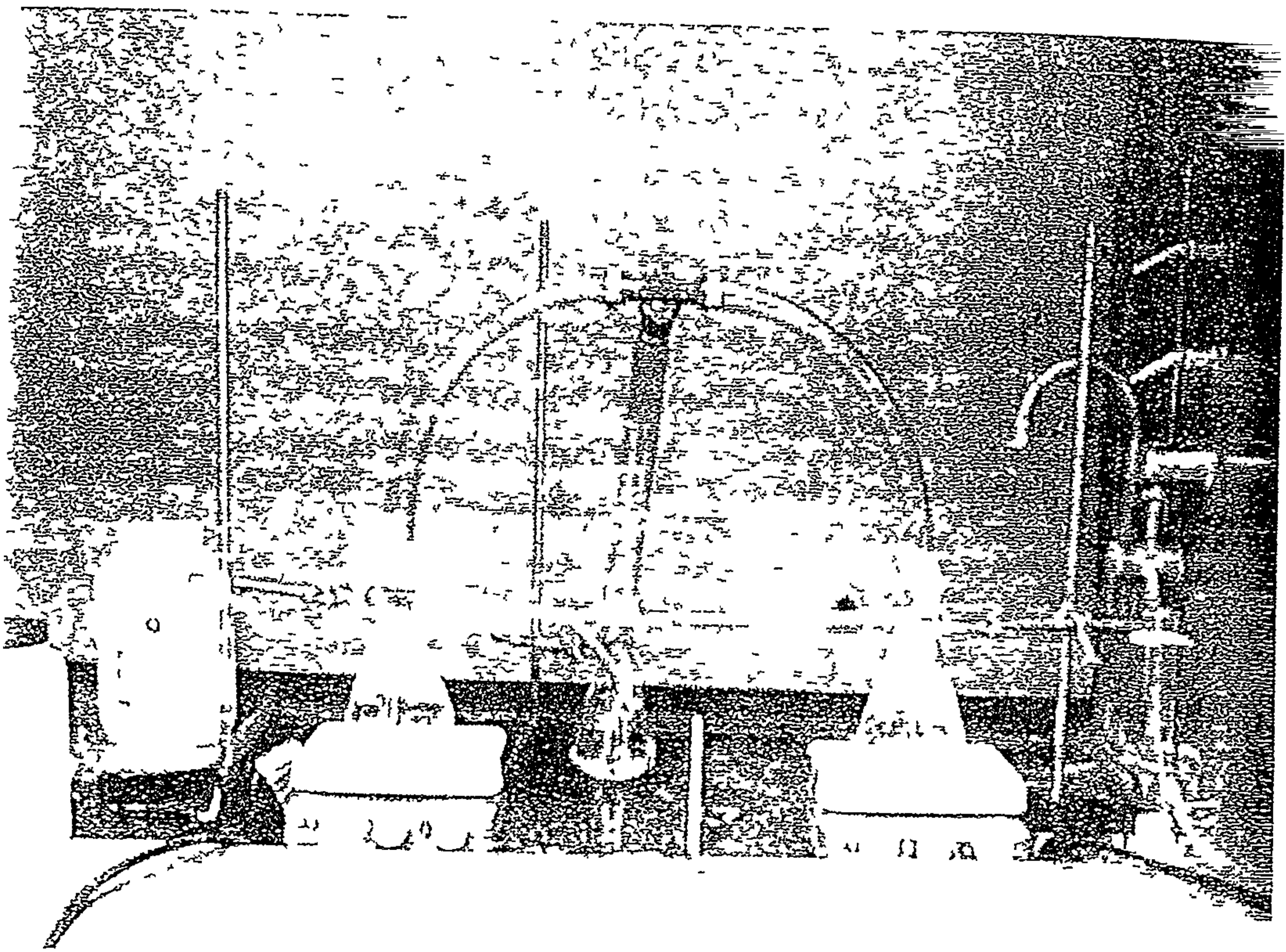
Analytical Methods

The analytes measured in this experiment and the analytical methods used include the following

Analyte	Methods of Analysis
ammonia	spectrophotometry
hydroxide ion	pH meter
sodium ion	inductively coupled plasma (ICP)
aluminate ion	inductively coupled plasma (ICP)
nitrate ion	spectrophotometry
nitrite ion	spectrophotometry
carbonate ion	material balance

Samples were diluted with distilled water to obtain the required range of concentration(s) for the analytical method(s) used For a given dilution, the original concentration of an analyte and was then back calculated

Figure 1



4 0 Calculations

Data and other information associated with this project were kept in a laboratory notebook This information forms the basis for this lab report Output from various instruments have been referenced and applicable data reproduced in the laboratory notebook On-the-spot descriptions, original spectra, computer outputs, and observations have been recorded in the laboratory notebook

The composition of the salt solution used in this experiment is as follows

Analyte	Molarity, (Moles/L)
Ammonia	4 64×10^{-5} (maximum)
Hydroxide Ion	3 16
Sodium Ion	10 40
Aluminate Ion	0 69
Nitrate Ion	3 70
Nitrite Ion	2 86
Carbonate Ion	0 60

Table 1 presents the calculations of the ratios of concentrations of ammonia in water to ammonia in the salt solution A plot of these data is given in Figure 2 The calculation of the ammonia Henry's Law constant for the salt solution using the Schumpe model is given in Table 2 The calculation of the ammonia Henry's Law constant for the salt solution using the measured "steady state" ratio of ammonia concentration in water to that in the salt solution is given in Table 3

Table 1

Table 1 Calculation of Results for Water/Water and Water/Salt Cases								
Water on Both Sides					Note	*NH$_3$ as N corrected from		
						1/10 000 dilution		
	Left Side	Left Side	Right Side	Right Side	Ratio of NH$_3$ on Left		Ratio of pH on Left	
Date/Time	pH	NH3, mg/L*	pH	NH3, mg/L*	to NH$_3$ on Right		to pH on Right	
3/8/99 1605	11 01	0 06	10 95	0 065	0 92		1 01	
3/12/99 1010	11 29	0 38	11 20	0 35	1 09		1 01	
3/20/99 1540	11 24	0 35	11 22	0 3	1 17		1 00	
3/24/99 2000	11 18	0 31	11 13	0 28	1 11		1 00	
				Average	1 07		1 00	
Water on Left Side and Salt Solution on Right Side					Note	*NH$_3$ as N corrected from		
						**One sample 1/10 000 and		
						one sample 1/20 000		
	Left Side	Left Side	Right Side	Right Side	Ratio of NH$_3$ on Left			
Date/Time	Dilution	NH3, mg/L*	Dilution	NH3, mg/L*	to NH$_3$ on Right		Notes	
3/24/99 2030	1/1	0 00	1/1	0 00	n/a		NH$_3$ Installed	
3/26/99 1730	1/10 000	0 085	1/10 000	0 095	0 89			
3/31/99 2030	1/10 000	0 27	1/10 000	0 30	0 90			
4/5/99 1600	1/10 000	0 47	1/20 000	0 65	0 72			
4/5/99 2045							NH$_3$ Removed	
4/7/99 2030	1/10 000	0 445	1/10 000	0 39	1 14			
4/8/99 1930	1/10 000	0 485	1/10 000	0 36	1 35		T=23°C	
4/9/99 1630	1/10 000**	0 525	1/10 000	0 395	1 33		T=24°C	
4/10/99 1600	1/10 000	0 465	1/10 000	0 36	1 29		T=23°C	
4/12/99 2000	1/10 000	0 52	1/10 000	0 4075	1 28		T=23°C	

Figure 2

Ratios of Concentration of Ammonia in Water to Concentration of Ammonia in Salt Solution

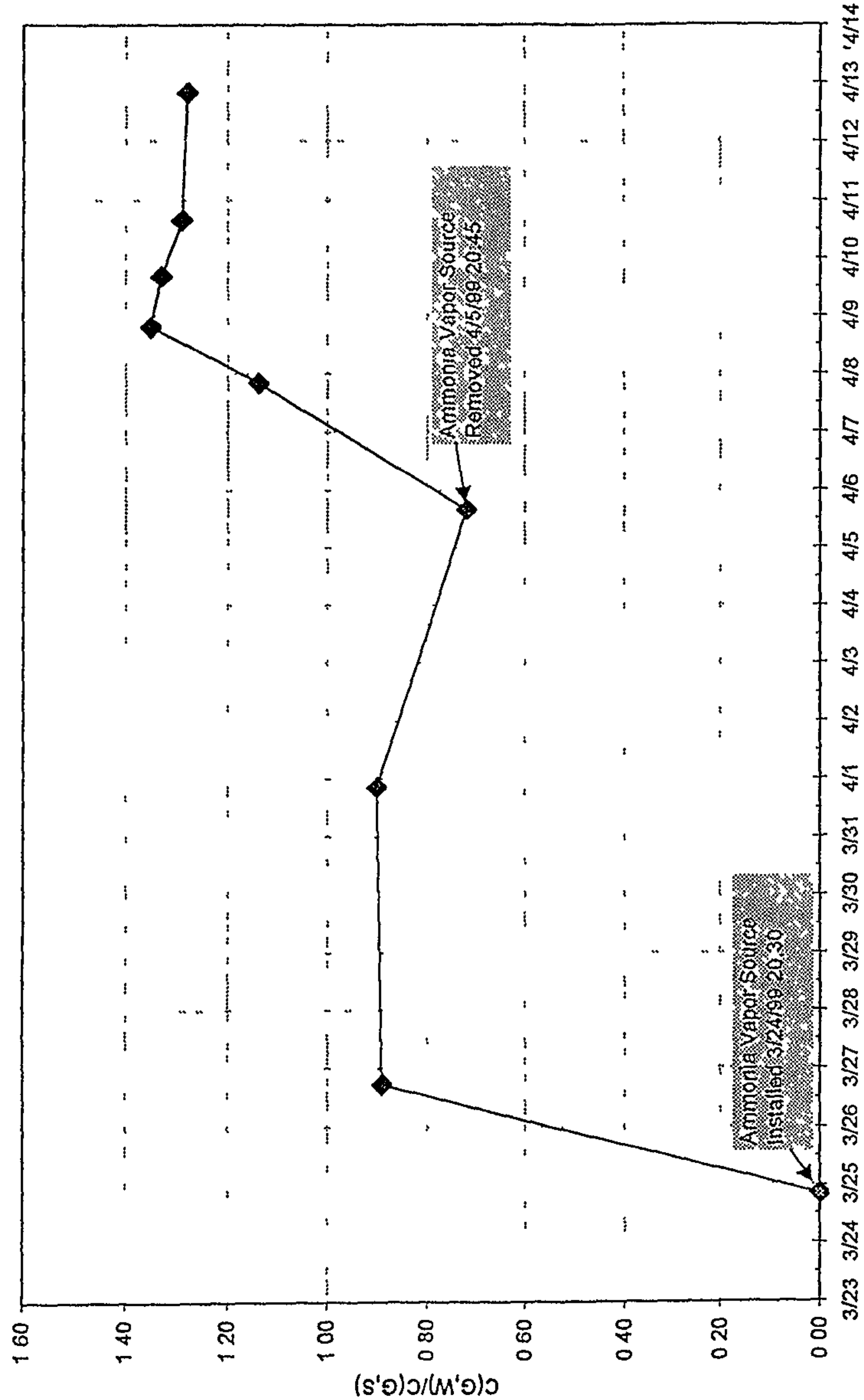


Table 2 Schumpe Model

	A	B	C	D	E	F	G	H
1	Tank SY 101 Sim 91 A		INPUT DATA	Date				
2	Ion	M W			05/04/99		Revision	0
3			ci (moles/L)	hi	hi*ci			
4	Na+1	22 99						
5	Al+3	26 98	10 40	0 1143	1 189	From Weisenberger & Schumpe (1996)		
6	Fe+3	55 85	0 69	0 2174	0 150			
7	Cr+3	52	0 00	0 1161	0 000			
8	Ni+2	58 71	0 00	0 0648	0 000	Gas	h (T)	h (G,0)
9	K+1	39 09	0 00	0 1654	0 000			
10	OH-1	17 0074	0 00	0 0922	0 000	Ammonia	0	-0 0481
11	NO3 1	62 0049	3 16	0 0839	0 265	Hydrogen	-0 000299	0 0218
12	NO2-1	46 0055	3 70	0 0128	0 047	Methane	0 000524	0 0022
13	CO3 2	60 0092	2 86	0 0795	0 227			
14	PO4-3	94 9676	0 60	0 1423	0 085			
15	SO4-2	96 0576	0 00	0 2119	0 000			
16	F-1	19	0 00	0 1117	0 000			
17	Cl 1	35 453	0 00	0 092	0 000			
18	Li+1	6 94	0 00	0 0318	0 000			
19	Br 1	79 916	0 00	0 0754	0 000			
20			0 00	0 0269	0 000			
21								
22			21 41		1 964			
23	Mass fraction water in liq		0 522					
24	Liquid density (kg/m3)		1320					
25	T (C)		23 0					
26								
27								
28								
29								
30						PNL-10785		
31				Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3
32	Ammonia		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm
33	Hydrogen		2 781E-01	4 810E-02	8 591E+00	6 681E+01	5 358E+00	5 190E 02
34	Methane			-2 120E 02	3 235E+01	7 931E 04	1 689E 05	0 000E+00
				3 248E-03	1 080E+02	1 483E 03	9 464E 06	0 000E+00

Table 3 Laboratory Measurements

	A	B	C	D	E	F	G	H
1	Tank SY 101 Sim -91 A		INPUT DATA	Date	05/04/99			
2	Ion	M W	ci (moles/L)				Revision	0
3				hi	hi*ci			
4	Na+1	22 99	10 40	0 1143	1 189	From Weisenberger & Schumpe (1996)		
5	Al+3	26 98	0 69	0 2174	0 150			
6	Fe+3	55 85	0 00	0 1161	0 000			
7	Cr+3	52	0 00	0 0648	0 000	Gas	h (T)	h (G 0)
8	Ni+2	58 71	0 00	0 1654	0 000			
9	K+1	39 09	0 00	0 0922	0 000	Ammonia	0	0 0481
10	OH 1	17 0074	3 16	0 0839	0 265	Hydrogen	0 000299	-0 0218
11	NO3 1	62 0049	3 70	0 0128	0 047	Methane	0 000524	0 0022
12	NO2-1	46 0055	2 86	0 0795	0 227			
13	CO3 2	60 0092	0 60	0 1423	0 085			
14	PO4 3	94 9676	0 00	0 2119	0 000			
15	SO4-2	96 0576	0 00	0 1117	0 000			
16	F-1	19	0 00	0 092	0 000			
17	Cl 1	35 453	0 00	0 0318	0 000			
18	Li+1	6 94	0 00	0 0754	0 000			
19	Br 1	79 916	0 00	0 0269	0 000			
20								
21			21 41		1 964			
22								
23	Mass fraction water in liq		0 522					
24	Liquid density (kg/m3)		1320					
25	T (C)		23 0					
26								
27								
28								
29								
30						PNL-10785		
31				Schumpe	Cwater/Csalt =	pure water K	mol/L(liq) atm	NH3
32			gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm
32	Ammonia		2 781E 01	4 810E 02	1 400E+00	6 681E+01	3 288E+01	8 458E 03
33	Hydrogen			-2 120E 02	3 236E+01	7 931E 04	1 689E 05	0 000E+00
34	Methane			3 248E 03	1 080E+02	1 483E 03	9 459E-06	0 000E+00

5 0 Results

The Henry's Law constants for ammonia dissolved in the concentrated salt solution are

Laboratory Measurements.
$K_{h(Ammonia,Salt)} = \underline{32.9}$ moles/(L-atm)

Calculated using Schumpe Model.

$K_{h(Ammonia,Salt)} = \underline{5.4}$ moles/(L-atm)

Therefore, the Schumpe Model under predicts the solubility of ammonia dissolved in the highly concentrated salt solution by a factor of 6 based on the measurements made in this project

6 0 Error Analysis

Knowing when equilibrium or near equilibrium conditions were achieved is difficult to determine Once the source of ammonia (concentrated ammonium hydroxide) is isolated from the system, ammonia measurements will be taken every few days of the water and concentrated salt solutions to determine rate of change of concentrations of the two solutions This would be complicated by any potential paths of leakage of ammonia from the system As equilibrium conditions are approached, replicate samples will be taken and analyzed for ammonia to provide statistical measures of the accuracy of the dilution and analytical methods used Mean values of results are reported

7 0 Discussion/Conclusions

The results of this study show that the Schumpe model significantly under predicts the solubility of ammonia in high salt solutions For a given concentration ammonia in a high salt solution, the resulting equilibrium vapor pressure is over predicted proportionally The result of over prediction of ammonia in a vapor space would drive excessive and likely expensive measures to prevent flammable gas mixtures and/or releases with are harmful to humans For high salt solutions, actual liquid phase measurements are needed for a given common vapor phase concentration of ammonia to obtain an accurate prediction of an ammonia Henry's Law constant for a given temperature The Schumpe model should not be used for high salt solutions Additional measurements should be made for various high salt solutions of interest at a selected range of temperatures

8 0 References

1 Weisenberger, S and Schumpe, A , "Estimation of Gas Solubilities in Salt Solutions at Temperatures from 273 K to 363 K," January 1996, AIChE Journal, Vol 42, pp 298-300

2 Norton, J D and Pederson, L R , "Ammonia in Simulated Hanford Double-Shell Tank Wastes Solubility and Effects on Surface Tension," PNL-10173, September 1994, Pacific Northwest Laboratory, Richland, Washington

3 Hedengren, D C , et al , "Predicting Flammable Gas Mixtures in Hanford Double-Contained Receiver Tanks," September 13-18, Proceedings of SPECTRUM '98 International Conference on Decommissioning and Decontamination and on Nuclear and Hazardous Waste Management, Denver, Colorado

APPENDIX G

SELECTED CALCULATIONS FOR SAFETY ANALYSIS

General Assumptions

1 Maximum ammonia concentration found is used including RGS values If no value is available for ammonia concentration in the liquid waste, 1 ug/mL is used to avoid division by zero problems in the calculations
2 Best basis data are used if they are available
3 If best basis data are not available then average tank characterization data are used
4 Lithium and bromide data not used since they are added during some core sampling of tank waste
5 Unless ventilation rate in a DCRT exceeds 1 cfm, equilibrium ammonia concentrations in the DCRT vapor space can be used in place of that predicted by the dynamic model for ammonia
6 For diffusion limited transfer of ammonia from a liquid into a vapor space, caustic addition will not increase the vapor space ammonia above the equilibrium concentration in the vapor space based on the solubility of ammonia at a particular set of waste conditions

General

The Schumpe model is used for the calculations of hydrogen, ammonia, and methane solubility in tank waste Some preliminary measurements by the author at Washington State University-Tri-Cities conclude that the Schumpe under predicts the solubility (and therefore over predicts the vapor space ammonia) of highly concentrated wastes (above 5 molar total ionic species) Therefore, where the WSU model is identified, a correction factor to the Schumpe model has been applied to the Schumpe model Additional work is being performed to define more accurately these correction factors When they are available, these correction factors will be applied as applicable to ammonia solubility and the corresponding vapor space predictions

DCRT 244-A

Case 1 Initially, consider the 244-A DCRT 33% full of 1 to 1 diluted waste from

241-SY-101 via 241-SY-102 This waste has a greater hydrogen generation rate and a larger equilibrium ammonia vapor pressure than other wastes considered for cross-site transfer These other wastes include feed to the 244-BX DCRT from 241-BY-105 and 241-BY-106 Also included is the feed to 241-SY-102 from 241-SX-103 and 241-SX-105 which have been diluted 1 volume part water to 2 volume parts waste and cooled to at least 126° F, the maximum temperature of 241-SY-101 waste during 1999

The 244-A DCRT is then filled to 80% (an additional 8400 gallons) at 20 gpm and a ventilation rate of 3 cfh The end of fill % LFL contributions using the Schumpe model for case 1 are

0 21% LFL hydrogen, 0 0% LFL methane, 18 9% LFL ammonia for a total of

19 1% LFL The end of fill % LFL contributions using the WSU model for case 1 are

0 21% LFL hydrogen, 0 0% LFL methane, 7 0% LFL ammonia for a total of

7 2% LFL

The steady state % LFL contributions using the Schumpe model for case 1 are 11 75% LFL hydrogen, 0 0% LFL methane, 18 9% LFL ammonia for a total of 30 7% LFL The steady state % LFL contributions using the WSU model for case 1 are 11 75% LFL hydrogen, 0 0% LFL methane, 7 0% LFL ammonia for a total of 18 8% LFL

Case 2 Without considering ammonia in the 1 to 1 diluted waste from 241-SY-101 via 241-SY-102, the time from 25% to 100% LFL following the loss of ventilation is 51 days Considering ammonia in the 1 to 1 diluted waste from 241-SY-101 via 241-SY-102, the time from 31% to 100% LFL following the loss of ventilation is 45 days

Case 3 If the 244-A DCRT were 80% full of 1 to 1 diluted waste from 241-SY-101 via 241-SY-102 and it leaked near its bottom to its cell, the maximum concentration of flammable gases in the vault following loss of ventilation but continuation of natural breathing would be 59 1% LFL from hydrogen and ammonia

DCRT 244-BX

Case 1 For a saltwell pumping rate of 4 gpm to fill the DCRT from empty to 80% full with the higher hydrogen generation rate from 241-BY-106 than from 241-BY-105 for a ventilation rate of 3 cfh, the % LFL hydrogen for end of fill is 7 0% LFL and the % LFL hydrogen for steady state is 12 2% The time from end of fill to 95% of steady state % LFL hydrogen is 577 hours Since hydrogen generation rate within the waste dominates the dissolved hydrogen contribution from the entering waste, increasing the waste feed rate does not increase the vapor space hydrogen concentration in the DCRT

Case 2 Upon loss of ventilation, the time from 25% LFL hydrogen to 100% LFL hydrogen is 97 7 days

Case 3 The end of fill % LFL contributions using the Schumpe model for case 1 are 7 0% LFL hydrogen, 0 55% LFL methane, 14 7% LFL ammonia for a total of 22 2% LFL The end of fill % LFL contributions using the WSU model for case 1 are 7 0% LFL hydrogen, 0 55% LFL methane, 3 7% LFL ammonia for a total of 11 3% LFL

The steady state % LFL contributions using the Schumpe model for case 1 are 12 2% LFL hydrogen, 0 0% LFL methane, 14 7% LFL ammonia for a total of 26 9% LFL The steady state % LFL contributions using the WSU model for case 1 are

12 2% LFL hydrogen, 0 0% LFL methane, 3 7% LFL ammonia for a total of

15 9% LFL

Case 4 The end of fill % LFL contributions using the Schumpe model for case 3, except for a saltwell pumping rate of 8 gpm, are

6 6% LFL hydrogen, 0 55% LFL methane, 14 7% LFL ammonia for a total of

21 8% LFL

The steady state % LFL contributions using the Schumpe model for case 3, except for a saltwell pumping rate of 8 gpm, are

12 2% LFL hydrogen, 0 0% LFL methane, 14 7% LFL ammonia for a total of

26 9% LFL

Case 5 The bounding case for the maximum concentration of dissolved hydrogen in waste that could be transferred at 4 gpm to 244-BX DCRT was determined to be BY-106 The calculated DCRT post fill and steady state hydrogen concentrations are

Transfer Route	Vent Rate	Post Fill H2, %LFL	Steady State H2, %LFL
BY-106 to 244-BX	3 cfh	7 0	12 2

Case 6 If the 244-BX DCRT were 80% full of 241-BY-106 waste with the ammonia concentration of the 241-BY-105 waste and it leaked near its bottom to its cell, the maximum concentration of flammable gases in the vault following loss of ventilation but continuation of natural breathing would be 29 0% LFL from hydrogen and ammonia

DCRT 244-S

Case 1 The base case considered is the saltwell pumping rate of 4 gpm to fill the DCRT from empty to 80% full with the highest hydrogen generation rate from 241-SX-105 of those S and SX tanks to be saltwell pumped and the greatest dissolved hydrogen from 241-S-107 For a ventilation rate of 5 cfh, the % LFL hydrogen for end of fill is 20 2% LFL and the % LFL hydrogen for steady state is 33 1% The time from end of fill to 95% of steady state % LFL hydrogen is 212 hours

Case 2 Upon loss of ventilation, the time from 33 1% LFL hydrogen to 100% LFL hydrogen is 9 4 days

Case 3 The vapor phase equilibrium ammonia concentration from 241-SX-103 waste in the 244-S DCRT is calculated using the Schumpe model to be 138% LFL The vapor phase equilibrium ammonia concentration from 241-SX-105 waste in the 244-S DCRT is calculated using the Schumpe model to be 110% LFL The vapor phase equilibrium ammonia concentration from 241-SX-102 waste in the 244-S DCRT is calculated using the Schumpe model to be 72% LFL Therefore, the third highest vapor phase ammonia from 241-SX-102 is used This excludes the saltwell pumping of 241-SX-103 and

241-SX-105 without better modeling of the ammonia in these wastes Using the ammonia from 241-SX-102, the dissolved hydrogen from 241-SY-107, and the hydrogen generation from 241-SX-105, the end of fill % LFL contributions using the Schumpe model for case 1 (ventilation rate of 5 cfh) are

20 2% LFL hydrogen, 1 89% LFL methane, 72 15% LFL ammonia for a total of

94 3% LFL The end of fill % LFL contributions using the WSU model for case 1 are

20 2% LFL hydrogen, 1 89% LFL methane, 12 0 % LFL ammonia for a total of

34 1% LFL

The steady state % LFL contributions using the Schumpe model for case 1 are

33 07% LFL hydrogen, 0 0% LFL methane, 72 15% LFL ammonia for a total of

105 2% LFL The steady state % LFL contributions using the WSU model for case 1 are

33 07% LFL hydrogen, 0 0% LFL methane, 12 0% LFL ammonia for a total of

45 1% LFL

Case 4 Since hydrogen generation rate within the waste dominates the dissolved hydrogen contribution from the entering waste, increasing the waste feed rate does not increase the vapor space hydrogen concentration in the DCRT at end of fill This can be seen from the cases for 4, 8, 12, 16, and 20 gpm feed rates to the 244-S DCRT (ventilation rate of 5 cfh)

Case 5 The defined 222-S Lab waste (defined on page B-5 of Lockheed Martin Hanford interoffice memo 74B50-99-002, March 3, 1999) is considered added at 115 gpm to the 244-S DCRT (ventilation rate of 3 cfh), which is initially 13% full of the same waste The end of fill % LFL contributions using the Schumpe model for this 222-S Lab waste case are

0 02% LFL hydrogen, 0 0% LFL methane, 0 48% LFL ammonia for a total of

0 5% LFL

The steady state % LFL contributions using the Schumpe model for this 222-S Lab waste case are

4 91% LFL hydrogen, 0 0% LFL methane, 0 48% LFL ammonia for a total of

5 4% LFL

Case 6 The defined wastes from the Active Catch Tanks (defined in Lockheed Martin Hanford interoffice memo 74B50-99-105, December 3, 1999) is considered added at 120 gpm to the 244-S DCRT (ventilation rate of 3 cfh), which is initially 10% full of the same waste The end of fill % LFL contributions using the Schumpe model for this waste from the Active Catch Tanks case are

0 02% LFL hydrogen, 0 0% LFL methane, 0 0025% LFL ammonia for a total of

0 02% LFL

The steady state % LFL contributions using the Schumpe model for this waste from the Active Catch Tanks case are

5 0% LFL hydrogen, 0 0% LFL methane, 0 0025% LFL ammonia for a total of

5 0% LFL

Case 7 Waste like the current heel in 244-S DCRT (defined in an e-mail message from Paul Kison to Mike Grigsby et al , November 29, 1999) is considered added at 4 gpm to an empty 244-S DCRT until it is 80% full (ventilation rate of 3 cfh) The end of fill % LFL contributions using the Schumpe model for this 244-S DCRT heel waste case are

0 56% LFL hydrogen, 0 0% LFL methane, 0 29% LFL ammonia for a total of

0 85% LFL

The steady state % LFL contributions using the Schumpe model for this 244-S DCRT heel waste case are

5 37% LFL hydrogen, 0 0% LFL methane, 0 29% LFL ammonia for a total of

5 7% LFL

The time to go from 25% LFL to 100% LFL upon loss of ventilation with the bounding case of 244-S DCRT heel waste is 181 days

Case 8 Henry's Law Constants were calculated for each of the wastes to be saltwell pumped to the 244-S DCRT These include S-101, S-102, S-103, S-106, S-107, S-109, S-111, SX-101, SX-102, SX-103, SX-104, SX-105, and SX-106 No best basis or tank characterization data exist for S-112 Vapor phase ammonia in the 244-S DCRT containing waste from 241-SX-105 over the range of temperatures from 70 to 170 degrees Fahrenheit at the ventilation rate of 3 cfh are given in Table S8-1 for the Schumpe model and in Table S8-2 for the WSU model Tank 241-SX-105 was selected because its waste has the lowest ammonia solubility In other words, its ammonia vapor pressure is greatest for a given ammonia concentration

Case 9 The bounding case for the maximum concentration of dissolved hydrogen in waste that could be transferred at 4 gpm to 244-S DCRT was determined to be S-107 The calculated DCRT post fill and steady state hydrogen concentrations are

Transfer Route	Vent Rate	Post Fill H2, %LFL	Steady State H2, %LFL
S-107 to 244-S	3 cfh	15 0	5 3
S-107 to 244-S	5 cfh	14 3	3 2

Case 10 If the 244-S DCRT were 80% full of 241-SX-105 waste with the ammonia concentration of the 241-SX-102 waste and it leaked near its bottom to its cell, the maximum concentration of flammable gases in the vault following loss of ventilation but continuation of natural breathing would be 109 2% LFL from hydrogen and ammonia
If the 244-S DCRT were 80% full of its current heel waste and it leaked near its bottom to its cell, the maximum concentration of flammable gases in the vault following loss of ventilation but continuation of natural breathing would be 43 9% LFL from hydrogen and ammonia

DCRT 244-TX

Case 1 For a saltwell pumping rate of 4 gpm to fill the DCRT from empty to 80% full with a ventilation rate of 3 cfh, the % LFL hydrogen for end of fill is 43 0% LFL and the % LFL hydrogen for steady state is 7 1% The time from end of fill to the lower value of 105% of steady state % LFL hydrogen is 1242 hours

Case 2 Upon loss of ventilation at end of fill, the time from 43% LFL hydrogen to 100% LFL hydrogen is 210 days

Case 3 The end of fill % LFL contributions using the Schumpe model for case 1 are

43 0% LFL hydrogen, 9 9% LFL methane, 0 0% LFL ammonia for a total of

52 9% LFL

The steady state % LFL contributions using the Schumpe model for case 1 are

7 1% LFL hydrogen, 0 0% LFL methane, 0 0% LFL ammonia for a total of

7 1% LFL

Case 4 The defined PFP waste (defined in Table 4 of letter 15530-99-DRH-002 from

D R Hirzel to J N Strode, January 6, 1999) contains the ions of sodium, hydroxide, nitrate, and nitrite but no ammonia, cesium-137 or total organic carbon Therefore, this waste can be modeled as water since water is conservative for wastes with corrosion as the exclusive mechanism for the generation of hydrogen The end of fill % LFL contributions using the Schumpe model for this PFP waste case are

0 1% LFL hydrogen, 0 0% LFL methane, 0 0% LFL ammonia for a total of

0 1% LFL

The steady state % LFL contributions using the Schumpe model for this PFP waste case are

7 1% LFL hydrogen, 0 0% LFL methane, 0 0% LFL ammonia for a total of

7 1% LFL

Case 5 The steady state % LFL contributions from loss of ventilation using the Schumpe model for a 10% waste heel from 241-T-110 in the 244_TX DCRT are

10 2% LFL hydrogen, 0 0% LFL methane, 0 0% LFL ammonia for a total of

10 2% LFL

Case 6 The bounding case for the maximum concentration of dissolved hydrogen in waste that could be transferred at 4 gpm to 244-TX DCRT was determined to be T-110 The calculated DCRT post fill and steady state hydrogen concentrations are

Transfer Route	Vent Rate	Post Fill H2, %LFL	Steady State H2, %LFL
T-110 to 244-TX	3 cfh	43 0	7 1

Case 7 If the 244-TX DCRT were 80% full of 241-T-110 waste and it leaked near its bottom to its cell, the maximum concentration of flammable gases in the vault following loss of ventilation but continuation of natural breathing would be 32 5% LFL from hydrogen

DCRT 244-U

Case 1 The base case considered is the saltwell pumping rate of 4 gpm to fill the DCRT from empty to 80% full with the highest hydrogen generation rate from 241-U-103 of those U tanks to be saltwell pumped and the greatest dissolved hydrogen from

241-U-106 For a ventilation rate of 3 cfh, the % LFL hydrogen for end of fill is

4 3% LFL and the % LFL hydrogen for steady state is 11 5% The time from end of fill to 95% of steady state % LFL hydrogen is 680 hours

Since hydrogen generation rate within the waste dominates the dissolved hydrogen contribution from the entering waste, increasing the waste feed rate does not increase the vapor space hydrogen concentration in the DCRT This can be seen from the cases for 4, 8, 12, 16, 20, and 30 gpm feed rates to the 244-U DCRT (ventilation rate of 3 cfh)

Case 2 Upon loss of ventilation, the time from 25% LFL hydrogen to 100% LFL hydrogen is 106 days

Case 3 The vapor phase equilibrium ammonia concentration from 241-U-103 waste in the 244-S DCRT is calculated using the Schumpe model to be 14 85% LFL Using the dissolved hydrogen from 241-U-106, and the hydrogen generation from 241-U-103, the end of fill % LFL contributions using the Schumpe model for case 1 (ventilation rate of 3 cfh) are

4 26% LFL hydrogen, 0 3% LFL methane, 14 85% LFL ammonia for a total of

19 4% LFL The end of fill % LFL contributions using the WSU model for case 1 are

4 26% LFL hydrogen, 0 3% LFL methane, 2 48 % LFL ammonia for a total of

7 0% LFL

The steady state % LFL contributions using the Schumpe model for case 1 are

11 52% LFL hydrogen, 0 0% LFL methane, 14 85% LFL ammonia for a total of

26 4% LFL The steady state % LFL contributions using the WSU model for case 1 are

11 52% LFL hydrogen, 0 0% LFL methane, 2 48% LFL ammonia for a total of

14 0% LFL

Case 4 Since hydrogen generation rate within the waste dominates the dissolved hydrogen contribution from the entering waste, increasing the waste feed rate does not increase the vapor space hydrogen concentration in the DCRT at end of fill This can be seen from the cases for 4, 8, 12, 16, 20, and 30 gpm feed rates to the 244-U DCRT (ventilation rate of 3 cfh)

Case 5 Henry's Law Constants were calculated for each of the wastes to be saltwell pumped to the 244-U DCRT These include U-102, U-103, U-105, U-106, U-107, U-108, and U-109 No best basis or tank characterization data exist for U-111 Vapor phase ammonia in the 244-U DCRT containing waste from 241-U-108 over the range of temperatures from 70 to 170 degrees Fahrenheit at the ventilation rate of 3 cfh are given in Table U5-1 for the Schumpe model Tank 241-U-108 was selected because its waste has the lowest ammonia solubility of these tanks In other words, its ammonia vapor pressure is greatest for a given ammonia concentration and temperature

Case 6 The bounding case for the maximum concentration of dissolved hydrogen in waste that could be transferred at 4 gpm to 244-U DCRT was determined to be U-106 The calculated DCRT post fill and steady state hydrogen concentrations are

Transfer Route	Vent Rate	Post Fill H2, %LFL	Steady State H2, %LFL
U-106 to 244-U	3 cfh	4 1	10 7

Case 7 If the 244-U DCRT were 80% full of 241-U-103 waste with the ammonia concentration of the 241-U-103 waste and it leaked near its bottom to its cell, the maximum concentration of flammable gases in the vault following loss of ventilation but continuation of natural breathing would be 27 5% LFL from hydrogen and ammonia

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Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

Table G 1 Summary of Input Data

Tank	Density (g/mL)	*NH_3 (µg/mL)	Na (µg/mL)	Al^{+3} (µg/mL)	Fe^{+3} (µg/mL)	Cr^{+3} (µg/mL)	Ni^{+2} (µg/mL)	K^{+1} (µg/mL)	OH^{-1} (µg/mL)	NO_3^{-1} (µg/mL)	NO_2^{-1} (µg/mL)	CO_3^{-2} (µg/mL)	PO_4^{-3} (µg/mL)	SO_4^{-2} (µg/mL)	F^{-1} (µg/mL)	Cl^{-1} (µg/mL)	Water (/)	Density (g/mL)	TOC (g/L)	Cs^{137} (µCi/mL)	Temperature (°F)
A 101	1 4	1800 0	217000	44600	27 2	51	10 9	6580	39358	136000	137000	12700	3330	1290	79	7980	53 42	1 4	3 370	353	148
AX 101	1 475	4100 0	253999	53600	27 0	87	10 8	7980	38950	149000	162001	11050	3060	2200	85	9560	47 93	1 475	3 591	395	130
BY 105	1 44	1030 0	207999	39200	40 0	1380	12 0	4480	36112	198999	68800	22950	1358	2553	229	4920	51 62	1 44	2 292	199	108
BY 106	1 312	1030 0	164800	39810	32 2	354	28 0	8925	35750	110260	78130	6600	1988	2023	293	4652	59 39	1 312	2 630	207	118
C 103	1 078	1 0	35284	12	5 4	79	78 5	310	0	4302	24298	34250	4590	3226	1162	405	86 44	1 078	6 848	0	116
S 101	1 36	1 0	215000	24500	20 1	813	8 0	2360	0	181000	94000	5300	3861	5650	106	7450	62 66	1 36	0 267	0	116
S 102	1 39	1700 0	231999	43500	38 4	97	15 7	3190	40950	158999	112000	26410	4880	4610	314	10200	50 00	1 39	3 906	324	105
S 103	1 36	1410 0	215000	24500	20 1	269	8 0	2360	36467	181000	94000	22279	3861	5650	106	7450	49 80	1 36	4 679	365	86
S 106	1 45	430 0	244000	37967	30 1	9410	12 0	1840	54865	240000	109000	15750	6380	5730	140	11100	51 28	1 45	1 525	267	80
S 107	1 238	1 0	126749	7731	20 0	1220	8 4	1285	0	93425	46735	0	3854	3642	327	3542	68 21	1 238	0 000	0	106
S 109	1 463	1550 0	211750	34499	29 6	7241	11 0	1780	81883	237288	64455	9800	1836	2502	89	7147	52 94	1 463	1 115	315	85
S 111	1 39	1500 0	217000	25500	20 1	4380	8 0	1560	47250	190000	64600	29200	2540	4650	112	6020	52 46	1 39	1 423	275	90
S 112	N/A	1 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	84
SX 101	1 499	132 0	242000	75600	35 6	12100	12 0	2520	48660	105000	78000	8050	5180	1830	71	16700	49 10	1 499	0 335	403	133
SX 102	1 45	1370 0	235000	45600	36 5	2770	14 5	3550	50050	158001	151000	8800	3490	3330	78	10200	48 03	1 45	1 510	438	142
SX 103	1 47	1800 0	237393	44121	32 1	84	12 8	4242	41517	158629	158479	12750	3329	2014	101	10996	46 95	1 47	3 051	440	161
SX 104	1 47	793 0	249900	35574	33 8	939	13 5	2881	34150	291060	117306	24770	12730	3896	187	8232	50 76	1 47	2 195	283	144
SX 105	1 468	1210 0	235679	44040	30 1	338	12 0	3375	40939	164776	142805	14131	3266	4194	104	8998	42 87	1 468	3 228	384	167
SX 106	1 42	2500 0	245000	25887	30 1	130	12 0	3891	33117	209656	132044	25594	3514	7202	311	11732	45 79	1 42	3 951	377	105
T 104	1 1	1 0	55400	3160	1520 0	316	1 6	75	0	97650	6085	0	32806	4260	4195	1515	83 55	1 1	0 451	0 0783	66
T 110	1 06	1 0	36950	5	5 0	35	2 0	327	0	18300	59	0	17000	4360	4220	958	86 78	1 06	0 045	0 00336	68
U 102	1 38	745 0	243000	18000	20 1	279	126 0	3770	26630	244001	104000	46800	3800	7050	706	8810	47 85	1 38	12 750	436	86
U 103	1 41	1400 0	224000	32500	28 1	190	180 0	4320	34613	197000	139000	17200	3430	3840	1730	10900	48 67	1 41	12 781	467	88
U 105	1 46	1600 0	226999	29800	31 0	201	248 0	3980	20933	181001	108000	27850	3923	8010	1310	8920	62 56	1 46	11 441	386	90
U 106	1 35	1 0	210001	11300	50 1	393	496 0	1810	0	233001	92800	46500	3708	8130	60	5070	48 60	1 35	37 470	0	82
U 107	1 41	403 0	221001	26400	37 7	575	17 2	3270	27597	227000	111000	26450	3440	6630	167	8990	52 14	1 41	3 907	352	79
U 108	1 4	1 0	242999	32900	33 3	1280	31 3	4010	49150	181000	130000	22000	3126	4230	790	8940	50 02	1 4	8 950	416	88
U 109	1 47	1100 0	228000	29200	100 0	2610	45 5	3330	44150	185000	128000	18700	3370	5170	396	8690	51 93	1 47	4 433	366	84
U 111	N/A	1 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	81

N/A Data Not Available

For tanks without measured ammonia concentrations a value of 1 is used as a mathematical place holder Tank BY 106 using measured value from BY 105 (no ammonia data available for BY 106)

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Author D C Hedengren Date 1/26/00 Checked by J D Berglin Date 1/26/00

Table G-2 Henry s Law Constants and the Ammonia and Methane Contribution to the Total %LFL

1/24/00

Tank	K (NH3)	PP (NH3)	K (H2)	K (CH4)	Pt (atm)	65% of Pt Liquid Concentration H2 (mol/L)	5% of Pt Liquid Concentration CH4 (mol/L)	Liquid Concentration NH3 (ug/ml)	(At 1 atm) Equilibrium Vapor Concentration NH3 (%)	vol % (CH4)	% LFL (CH4)	% LFL (NH3)
BY-105	2 637	2 293E 02	2 868E 05	1 887E-05	1 574	2 934E-05	1 485E 06	1030	2 293	1 212E 02	0 24	14 79
BY-106	2 661	2 273E 02	4 495E 05	3 424E-05	1 978	5 779E 05	3 386E 06	1030	2 273	2 764E 02	0 55	14 66
S 101	3 511	1 672E 05	5 372E-05	3 929E 05	1 458	5 091E 05	2 864E 06	1	0 002	2 338E 02	0 47	0 01
S 102	1 801	5 542E 02	1 623E 05	9 723E 06	1 722	1 817E 05	8 372E 07	1700	5 542	6 835E 03	0 14	35 75
S 103	4 547	1 821E 02	2 565E 05	1 698E 05	1 348	2 248E 05	1 145E-06	1410	1 821	9 346E 03	0 19	11 75
S 106	3 863	6 537E 03	1 410E 05	7 439E 06	1 501	1 376E 05	5 583E-07	430	0 654	4 558E 03	0 09	4 22
S 107	9 848	5 963E-06	1 613E 04	1 655E-04	1 403	1 471E 04	1 161E 05	1	0 001	9 474E 02	1 89	0 00
S 109	4 505	2 020E-02	2 075E 05	1 172E-05	1 319	1 779E-05	7 729E 07	1550	2 020	6 311E 03	0 13	13 03
S 111	4 240	2 077E 02	2 640E 05	1 708E-05	1 668	2 862E-05	1 425E 06	1500	2 077	1 163E 02	0 23	13 40
SX 101	0 602	1 287E 02	1 229E 05	7 453E-06	1 574	1 258E-05	5 866E 07	132	1 287	4 789E 03	0 10	8 31
SX 102	0 719	1 118E 01	1 867E 05	1 120E 05	1 668	2 024E-05	9 344E 07	1370	11 183	7 629E-03	0 15	72 15
SX 103	0 494	2 139E 01	2 273E 05	1 446E 05	1 825	2 697E 05	1 320E 06	1800	21 394	1 077E 02	0 22	138 03
SX 104	0 954	4 881E 02	2 537E 05	1 474E 05	1 762	2 906E 05	1 299E 06	793	4 881	1 061E 02	0 21	31 49
SX-105	0 416	1 707E 01	2 308E 05	1 511E-05	1 836	2 754E 05	1 387E 06	1210	17 074	1 133E 02	0 23	110 15
SX 106	2 154	6 815E 02	1 869E 05	1 079E 05	1 686	2 048E 05	9 100E 07	2500	6 815	7 430E 03	0 15	43 97
T-104	47 454	1 237E 06	3 447E 04	5 103E 04	1 317	2 951E 04	3 360E 05	1	0 000	2 739E 01	5 48	0 00
T-110	51 6963	1 1358E 06	4 6458E 04	7 8677E 04	1 55	4 681E 04	6 097E-05	1	0 000	4 965E 01	9 93	0 00
U-102	4 1180	1 0623E 02	2 0534E 05	1 2131E 05	1 451	1 937E 05	8 801E-07	745	1 062	7 186E 03	0 14	6 85
U-103	3 571	2 302E 02	1 917E 05	1 145E 05	1 618	2 016E 05	9 262E 07	1400	2 302	7 562E 03	0 15	14 85
U-105	4 833	1 944E 02	3 009E 05	1 947E 05	1 51	2 953E-05	1 470E 06	1600	1 944	1 200E 02	0 24	12 54
U-106	7 111	8 257E 06	3 929E 05	2 861E 05	1 291	3 297E-05	1 847E 06	1	0 001	1 508E 02	0 30	0 01
U-107	5 869	4 032E 03	2 518E 05	1 586E-05	1 537	2 515E-05	1 219E 06	403	0 403	9 950E 03	0 20	2 60
U-108	2 918	2 012E 05	1 462E 05	8 188E-06	1 616	1 535E-05	6 616E 07	1	0 002	5 402E-03	0 11	0 01
U-109	4 290	1 506E 02	2 025E 05	1 205E 05	1 607	2 115E-05	9 682E 07	1100	1 506	7 905E 03	0 16	9 71

244-A-DCRT

CASE 1

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

SUMMARY:

DCRT 244-A
CASE 1

Modified for 244-A DCRT Calculations based on worst case hydrogen generation and ammonia tank 241-SY-101 diluted 1 1
- the initial condition of the tank is 33% full
- this model calulates the remainder until filled to 80% full with pumping rate of 20 gpm (Ventilation rate of 3 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 400\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 300$	Nitrite Concentration	$NO_2 = 1\ 680\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 579\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 710\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 4\ 140\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ "no	Ammonia Concentration	$NH_3 = 18\ 910\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 325\ 350\,K$		

Period 1

Initial Flow Rate $flow = 20\ 000\,\frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 4\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 20\ 000\,\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 3\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\ 893\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20.000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 4.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33.000\,\%$

Final Fill Factor $fff = 59.893\,\%$

Initial Fill Volume $tvol_{init} = 5890\,gal$

Final Fill Volume $ffv = 10690\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0.069\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 18.979\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 8.939\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 27.849\,\%$

Period 2

Second Flow Rate $flow_2 = 20.000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 3.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59.893\,\%$

Final Fill Factor $fff2 = 80.062\,\%$

Initial Fill Volume $tvol_{init2} = 10690\,gal$

Final Fill Volume $ffv2 = 14290\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0.069\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0.205\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 19.115\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11.751\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 30.661\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 345.497\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0.000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 11.548\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 45.091\,day$

Author D C Hedengren Date 1/26/00 Checked by Michael Kupfell Date 1/26/00

SUMMARY:

DCRT 244-A CASE 1 — Modified for 244-A DCRT Calculations based on worst case hydrogen generation and ammonia tank 241-SY-101 diluted 1 1 WSU model for ammonia
- the initial condition of the tank is 33% full
- this model calulates the remainder until filled to 80% full with pumping rate of 20 gpm (Ventilation rate of 3 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 400\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 300$	Nitrite Concentration	$NO_2 = 1\ 680\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 579\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 710\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 4\ 140\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 7\ 010\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 325\ 350\,K$		

Period 1

Initial Flow Rate $flow = 20\ 000\,\frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 4\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 20\ 000\,\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 3\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\ 893\,\%$

Author D C Hedengren Date 1/26/00 Checked by Michael Kyhl Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 4\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\,000\,\%$

Final Fill Factor $fff = 59\,893\,\%$

Initial Fill Volume $tvol_{init} = 5890\,gal$

Final Fill Volume $ffv = 10690\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0\,069\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 7\,079\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 8\,939\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 15\,949\,\%$

Period 2

Second Flow Rate $flow_2 = 20\,000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 3\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\,893\,\%$

Final Fill Factor $fff2 = 80\,062\,\%$

Initial Fill Volume $tvol_{init2} = 10690\,gal$

Final Fill Volume $ffv2 = 14290\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0\,069\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0\,205\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 7\,215\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\,751\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 18\,761\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 343\,712\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 3\,650\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 19\,015\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 54\,020\,day$

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244-A-DCRT

CASE 2

Author D C [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

	A	B	C	D	E	F	G	H	I
1	Tank	SY-101	INPUT DATA	Date	03/11/99		Revision	0	NH3
2	Ion	M W	ci (moles/L)	hi	hi*ci				ug/ml
3			1 1 dilution						2125
4	Na+1	22 99	5 45	0 1143	0 623	From Weisenberger & Schumpe (1996)			moles/L
5	Al+3	26 98	0 71	0 2174	0 154				0 12477467
6	Fe+3	55 85	1 235E 03	0 1161	0 000				
7	Cr+3	52	1 608E 02	0 0648	0 001	Gas	h (T)	h (G 0)	
8	Ni+2	58 71	8 772E 04	0 1654	0 000				
9	K+1	39 09	0 06	0 0922	0 006	Ammonia	0	0 0481	
10	OH 1	17 0074	0 84	0 0839	0 070	Hydrogen	0 000299	0 0218	
11	NO3 1	62 0049	1 40	0 0128	0 018	Methane	0 000524	0 0022	
12	NO2 1	46 0055	1 68	0 0795	0 133				
13	CO3 2	60 0092	0 27	0 1423	0 039				
14	PO4 3	94 9676	3 365E 02	0 2119	0 007				
15	SO4 2	96 0576	7 162E 03	0 1117	0 001				
16	F 1	19	0 000E+00	0 092	0 000				
17	Cl 1	35 453	0 15	0 0318	0 005				
18	Li+1	6 94	0 000E+00	0 0754	0 000				
19	Br-1	79 916	0 000E+00	0 0269	0 000				
20									Average
21			10 63		1 058				
22									
23	Mass fraction water in liq		0 620						Temperature
24	Liquid density (kg/m3)		1300						deg F
25	T (C)		54 8						130 6
26									Temperature
27									deg C
28									54 7777778
29						PNL 10785			
30				Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
31			gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P , atm	
32	Ammonia		1 248E 01	4 810E 02	3 523E+00	1 678E+01	3 839E+00	3 250E 02	
33	Hydrogen			3 070E 02	5 393E+00	7 267E 04	1 086E 04	0 000E+00	
34	Methane			-1 340E 02	8 235E+00	9 949E 04	9 737E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by [illegible] Date 1/26/00

SUMMARY:

DCRT 244-A
CASE 2
Reactivity Coef 0 7

Modified for 244-A DCRT Calculations based on worst case hydrogen generation and ammonia tank 241-SY-101 diluted 1 1

- the initial condition of the tank is 33% full
- this model calulates the remainder until filled to 80% full with pumping rate of 20 gpm (Ventilation rate of 3 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 300$

Radiolytic Power of Waste $wastepower = 1\ 579 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm}$ = "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 325\ 350\ K$

Nitrate Concentration $NO_3 = 1\ 400 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1\ 680 \frac{mole}{liter}$

Aluminum Concentration $Al = 0\ 710 \frac{mole}{liter}$

TOC Concentration $TOC = 4\ 140 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\ 000\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 20\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000 \frac{mole}{liter}$

or $gr_{sol} = 0\ 000 \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 4\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 20\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000 \frac{ft^3}{hr}$

Time pumped at Second flow rate $lim2 = 3\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\ 893\ \%$

Author D C Hedengren Date 1/26/00 Checked by Michael Kuffel Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 4\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\,000\,\%$

Final Fill Factor $fff = 59\,893\,\%$

Initial Fill Volume $tvol_{init} = 5890\,gal$

Final Fill Volume $ffv = 10690\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0\,069\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 0\,069\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 8\,939\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 8\,939\,\%$

Period 2

Second Flow Rate $flow_2 = 20\,000\,\frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 3\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\,893\,\%$

Final Fill Factor $fff2 = 80\,062\,\%$

Initial Fill Volume $tvol_{init2} = 10690\,gal$

Final Fill Volume $ffv2 = 14290\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0\,069\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0\,205\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 0\,205\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\,751\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 11\,751\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 342\,660\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 7\,836\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 23\,555\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 59\,481\,day$

Author D C Hedengren Date 1/26/00 Checked by Michael Kyhl Date 1/26/00

SUMMARY:

DCRT 244-A
CASE 2
Reactivity Coef 0 7

Modified for 244-A DCRT Calculations based on worst case hydrogen generation and ammonia tank 241-SY-101 diluted 1 1
- the initial condition of the tank is 33% full
- this model calulates the remainder until filled to 80% full with pumping rate of 20 gpm (Ventilation rate of 3 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000\ \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 300$

Radiolytic Power of Waste $wastepower = 1\ 579\ \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = $ "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 325\ 350\ K$

Nitrate Concentration $NO_3 = 1\ 400\ \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1\ 680\ \frac{mole}{liter}$

Aluminum Concentration $Al = 0\ 710\ \frac{mole}{liter}$

TOC Concentration $TOC = 4\ 140\ \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 18\ 910\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 20\ 000\ \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\ \frac{mole}{liter}$

or $gr_{sol} = 0\ 000\ \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 4\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 20\ 000\ \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\ \frac{ft^3}{hr}$

Time pumped at Second flow rate $tim2 = 3\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\ 893\ \%$

Author D C Hedengren Date 1/26/00 Checked by [illegible signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 4\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\ 000\ \%$

Final Fill Factor $fff = 59\ 893\ \%$

Initial Fill Volume $tvol_{init} = 5890\ gal$

Final Fill Volume $ffv = 10690\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 0\ 069\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 18\ 979\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 8\ 939\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 27\ 849\ \%$

Period 2

Second Flow Rate $flow_2 = 20\ 000\ \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 3\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 59\ 893\ \%$

Final Fill Factor $fff2 = 80\ 062\ \%$

Initial Fill Volume $tvol_{init2} = 10690\ gal$

Final Fill Volume $ffv2 = 14290\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0\ 069\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 0\ 205\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 19\ 115\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\ 751\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 30\ 661\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 345\ 497\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 11\ 548\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 45\ 091\ day$

244-A-DCRT

CASE 3

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

CH2MHILL
Hanford Group, Inc.

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d) DCRT 244-A CASE 3 — Modified for 244-A DCRT Vault Case (Ventilation rate of 3 cfh) 1 to 1 dilution of SY-101

$d := 14\,ft$

Input length of DCRT (L)

$L := 40.29\,ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10⁻⁶)

$flow := 1 \cdot 10^{-6} \cdot \frac{gal}{min}$ $flow = 2.228 \times 10^{-9} ft^3 sec^{-1}$ $\frac{flow}{\left(\frac{ft^3}{hr}\right)} = 8.021 \times 10^{-6}$

Higher Input flow rate

$flow_2 := 1 \cdot 10^{-6} \cdot \frac{gal}{min}$ $flow_2 = 2.228 \times 10^{-9} ft^3 sec^{-1}$ $\frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 8.021 \times 10^{-6}$

Calculate total DCRT volume (tvol)

$tvol := L\,\pi \left(\frac{d}{2}\right)^2$ Assume DCRT has flat ends [Eqn 1]

$tvol = 6202\,ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.308 \cdot tvol + 0 \cdot hr \cdot 0 \cdot \frac{gal}{min}$ $tvol_{init} = 1.910 \times 10^3 ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 1 \cdot hr$

Time at pumping rate 2

$time_2 := 1 \cdot hr$

Volume of fill at start of pumping rate 2

$tvol_2 := tvol_{init} + time \cdot flow$ $tvol_2 = 1910\,ft^3$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

$vol_{H2_0} = if\left[flag_{cgm} = \text{"yes"}, conc_{H2\_cgm}\,(tvol - tvol_{init}), vol_{H2_0}\right]$

$vol_{H2_0} = 0\ 000\,ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 18.91\cdot\%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 0\ 0\cdot\%LFL_{CH4}$ (Reference)

<u>End of Input Section</u>

<u>Calculations:</u>

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow\cdot t - tvol_{init}$ $hvol(lim) = 4\ 292 \times 10^3\,ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft²) $2\,\pi\left(\frac{d}{2}\right)^2 + \pi\, d\, L = 2080\,ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft²)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\, d\,\frac{flow\cdot t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\,(flow\cdot t + tvol_{init})}{d}$$ [Eqn 8]

$Awet(t) := 1715\,ft^2$

[Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft²) $Awet(lim) = 1\ 715 \times 10^3\,ft^2$

$Awet(0\,hr) = 1\ 715 \times 10^3\,ft^2$

$Awet(1\,hr) = 1\ 715 \times 10^3\,ft^2$

Check the answers

$Awet(lim) = 1\ 715 \times 10^3\,ft^2$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$\text{hvol2(time)} = \text{tvol} - \text{flow}_2\ \text{time} - \text{tvol}_{\text{init2}}$ $\text{hvol2(lim2)} = 4.292 \times 10^3\ \text{ft}^3$ [Eqn 4]

Wetted area of vertically oriented DCRT (ft²)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\ d\ \frac{\text{flow}_2\ t + \text{tvol}_{\text{init2}}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(\text{flow}_2\ t + \text{tvol}_{\text{init2}}\right)}{d}$$ [Eqn 8]

$\text{Awet(t)} = 1715\ \text{ft}^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft²) $\text{Awet(lim2)} = 1.715 \times 10^3\ \text{ft}^2$

$\text{Awet(0 hr)} = 1.715 \times 10^3\ \text{ft}^2$ Check the answers

$\text{Awet(1 hr)} = 1.715 \times 10^3\ \text{ft}^2$

$\text{Awet(lim2)} = 1715.000\ \text{ft}^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$\frac{NO_3}{\left(\frac{\text{mole}}{\text{liter}}\right)} = 1.400$ $\frac{NO_2}{\left(\frac{\text{mole}}{\text{liter}}\right)} = 1.680$ $\frac{\text{Al}}{\left(\frac{\text{mole}}{\text{liter}}\right)} = 0.710$ $\frac{\text{TOC}}{\left(\frac{\text{gm}}{\text{liter}}\right)} = 4.140$

Author D C Hedengren Date 1/26/00 Checked by Michael Kapfl Date 1/26/00

SUMMARY:

DCRT 244-A Modified for 244-A DCRT Vault Case
CASE 3 (Ventilation rate of 3 cfh) 1 to 1 dilution of SY-101

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 400 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 300$	Nitrite Concentration	$NO_2 = 1\ 680 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 579 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 710 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000 ft^3$	TOC Concentration	$TOC = 4\ 140 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 18\ 910\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 0\ 000\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 325\ 350 K$		

Period 1

Initial Flow Rate $flow = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 1\ 000 hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000 \frac{mole}{liter}$ or $gr_{sol} = 0\ 000 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 30\ 800\ \%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time pumped at Second flow rate $tim2 = 1\ 000 hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 30\ 800\ \%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 1.000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 30.800\,\%$

Final Fill Factor $fff = 30.800\,\%$

Initial Fill Volume $tvol_{init} = 14290\,gal$

Final Fill Volume $ffv = 14290\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0.011\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 18.921\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 15.340\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 34.250\,\%$

Period 2

Second Flow Rate $flow_2 = 1.000 \times 10^{-6} \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 30.800\,\%$

Final Fill Factor $fff2 = 30.800\,\%$

Initial Fill Volume $tvol_{init2} = 14290\,gal$

Final Fill Volume $ffv2 = 14290\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0.011\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0.022\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 18.932\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 15.340\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 34.250\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 59.080\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0.000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 105.619\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 10.000 \times 10^{8}\,day$

244-BX-DCRT

CASE 1

Author D C Hedengren Date 1/26/00 Checked by J D Bigham Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 1

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate of 4 gpm

No ammonia nor methane is considered

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\,000\,\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\,312$

Radiolytic Power of Waste $wastepower = 0\,656\,\frac{lb}{ft\,sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\,000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ no"

CGM Measurement $conc_{LFL\_cgm0} = 0\,000\,\%LFL$

DCRT Waste Temperature $T = 320\,950\,K$

Nitrate Concentration $NO_3 = 1\,780\,\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1\,700\,\frac{mole}{liter}$

Aluminum Concentration $Al = 1\,480\,\frac{mole}{liter}$

TOC Concentration $TOC = 2\,630\,\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\,000\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\,000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\,779 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D Bergh Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 2\,134\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 2\,134\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7\,168\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 7\,168\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 2\,134\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 6\,962\,\%$

Final Flammable Gas Concentration $ffgc2 = 6\,962\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 12\,202\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 12\,202\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 220\,979\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 12\,815\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 40\,461\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 110\,538\,day$

Author D C Hedengren Date 1/26/00 Checked by J D Byrne Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 1

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate of 4 gpm

No ammonia nor methane is considered
Time to 95% of steady state after fill
Starting point is "BY-106 to 244-BX-no NH3 nor CH4 mcd

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 780\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 312$	Nitrite Concentration	$NO_2 = 1\ 700\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 656\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 480\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 2\ 630\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} = $ "no"	Ammonia Concentration	$NH_3 = 0\ 000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 320\ 950\,K$		

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 104\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\ 779 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\ 049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6}\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 577\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 1\ 220 \times 10^{-8}\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 479\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D B Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4.000\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 104.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\%$

Final Fill Factor $fff = 80.479\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\%$

Final H2 Concentration (%LFL) $fh2c = 6.962\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 6.962\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 12.202\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 12.202\%$

Period 2

Second Flow Rate $flow_2 = 1.000 \times 10^{-6}\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 577.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80.479\%$

Final Fill Factor $fff2 = 80.479\%$

Initial Fill Volume $tvol_{init2} = 24960\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 6.962\%$

Final H2 Concentration (%LFL) $fh2c2 = 11.591\%$

Final Flammable Gas Concentration $ffgc2 = 11.591\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 12.202\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 12.202\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 220.980\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 12.815\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 40.460\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 110.537\,day$

Author D. C Hedengren Date 1/26/00 Checked by J D B[illegible] Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 1

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate of 8 gpm

No ammonia nor methane is considered
Time to 95% of steady state after fill
Input from end of initial fill-"BY-106 to 244-BX-no NH3 nor CH4 mcd"

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 780 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 312$	Nitrite Concentration	$NO_2 = 1\ 700 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 656 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 480 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\ ft^3$	TOC Concentration	$TOC = 2\ 630 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} = $ "no"	Ammonia Concentration	$NH_3 = 0\ 000\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 0\ 000\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 320\ 950\ K$		

Period 1

Initial Flow Rate $flow = 8\ 000 \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 52\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\ 779 \times 10^{-5} \frac{mole}{liter}$

or $gr_{sol} = 0\ 098 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 595\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol2} = 1\ 220 \times 10^{-8} \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 479\ \%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 8\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\%$

Final Fill Factor $fff = 80\ 479\%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\%$

Final H2 Concentration (%LFL) $fh2c = 6\ 596\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 6\ 596\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 12\ 202\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 12\ 202\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6}\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 595\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 479\%$

Final Fill Factor $fff2 = 80\ 479\%$

Initial Fill Volume $tvol_{init2} = 24960\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 6\ 596\%$

Final H2 Concentration (%LFL) $fh2c2 = 11\ 591\%$

Final Flammable Gas Concentration $ffgc2 = 11\ 591\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 12\ 202\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 12\ 202\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 220\ 980\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 12\ 815\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 40\ 460\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 110\ 537\ day$

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244-BX-DCRT

CASE 2

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 2

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 gpm

No ammonia nor methane is considered

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 780 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 312$	Nitrite Concentration	$NO_2 = 1\ 700 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 656 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 480 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 2\ 630 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\ 000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 320\ 950\,K$		

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\ 779 \times 10^{-5} \frac{mole}{liter}$ or $gr_{sol} = 0\ 049 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 049 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D B[illegible] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4.000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\,\%$

Final Fill Factor $fff = 40.240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 2.134\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 2.134\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7.168\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 7.168\,\%$

Period 2

Second Flow Rate $flow_2 = 4.000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40.240\,\%$

Final Fill Factor $fff2 = 80.479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 2.134\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 6.962\,\%$

Final Flammable Gas Concentration $ffgc2 = 6.962\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 12.202\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 12.202\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 220.979\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 12.815\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 40.461\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 110.538\,day$

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244-BX-DCRT

CASE 3

Author D C Hedengren Date 1/26/06 Checked by J D Bj... Date 1/26/07

DCRT 244-BX
Case 3

Table BX-1 BY-106 Ammonia Calculations for Worst Case (3 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-BX		
Source Tank	BY-106				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-BX		During Addition of Waste		
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1030	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	164800	Volume of Vapor Space	L	58700
Al^{+3}	μg/ml	39810	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	32	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	354	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	28	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	8925	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	35750	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	110260	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	78130	Temperature of Air in Vapor Space	°F	119 8
CO_3^{2}	μg/ml	6600	Stream Diameter	inches	1
PO_4^{-3}	μg/ml	1988	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	2023	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{-1}	μg/ml	293	Surface Area of Still Waste	m²	39 02
Cl^{1}	μg/ml	4652	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	59 39			
Specific Gravity	unitless	1 312			
Total Organic Carbon	g/l	2 63			
Cs-137	μCi/ml	207			
Temperature	°F	118			

Author D C Hedengren Date 1/26/00 Checked by J D Berglin Date 1/26/00

DCRT **244 BX**
Case **3**

Table BX-1 (Cont'd) BY-106 Ammonia Calculations for Worst Case (3 pages)

Source Tank	BY-106	INPUT DATA	Date	36546 35139		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1030
Na^{+1}	22 99	7 1683341	0 1143	0 819340583	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 48	0 2174	0 320781838				0 060479017
Fe^{+3}	55 85	0 00	0 1161	6 68329E-05				
Cr^{+3}	52	6 798E 03	0 0648	0 000440515	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	4 769E 04	0 1654	7 88826E-05				
K^{+1}	39 09	2 283E 01	0 0922	0 021051036	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 10	0 0839	0 176359996	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	1 78	0 0128	0 022761556	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	1 70	0 0795	0 135012879				
CO_3^{2}	60 0092	0 11	0 1423	0 0156506				
PO_4^{-3}	94 9676	0 02	0 2119	0 004435576				
SO_4^{2}	96 0576	2 106E 02	0 1117	0 002352433				
F^{-1}	19	1 541E 02	0 092	0 001418059				
Cl^{1}	35 453	1 312E 01	0 0318	0 004172399				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		14 75718636		1 523923187				
Mass fraction water in liq		0 59						Temperature
Liquid density (kg/m3)		1312 000						deg F
T (C)		48						118
								Temperature
								deg C
								47 77777778
					PNL-10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part. P atm	
Ammonia		0 060479017	-0 0481	6 517822405	22 25758937	2 660864524	0 022729086	
Hydrogen			-2 861E-02	1 264E+01	7 291E-04	4 495E-05	0 000E+00	
Methane			-9 736E-03	2 400E+01	1 055E-03	3 424E-05	0 000E+00	

Author DCHedengren Date 1/26/00 Checked by JD Bjor Date 1/26/00

DCRT 244-BX
Case 3

Table BX-1 (Cont'd) BY 106 Ammonia Calculations for Worst Case (3 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	2 27	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	9 457E-03	0 02	0 16	
0 0183	66	1 726E-02	0 05	0 29	
0 0333	120	3 112E-02	0 08	0 53	
0 0617	222	5 668E-02	0 15	0 97	
0 1033	372	9 285E-02	0 25	1 58	
0 1750	630	1 513E-01	0.40	2 58	
0 332	1194	2 640E-01	0 70	4 50	
0 620	2232	4 267E-01	1 13	7 28	
1 035	3726	5 860E-01	1 55	9 99	
2 27	8154	7 894E-01	2 09	13 46	
3 35	12060	8 385E-01	2 22	14 30	
5 38	19362	8 573E-01	2 27	14 62	
8 27	29784	8 595E-01	2 27	14 66	
9 68	34860	8 596E-01	2 27	14.66	
10 9	39300	8 596E-01	2 27	14 66	
13 2	47640	8 596E-01	2 27	14 66	
16 6	59580	8 596E-01	2 27	14 66	
41 7	150000	8 596E-01	2 27	14 66	
64 6	232605	8 596E-01	2 27	14 66	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Bj... Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 3

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 gpm

Ammonia and methane are considered

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\,000\,\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\,312$

Radiolytic Power of Waste $wastepower = 0\,656\,\frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\,000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = \text{"no"}$

CGM Measurement $conc_{LFL\_cgm0} = 0\,000\,\%LFL$

DCRT Waste Temperature $T = 320\,950\,K$

Nitrate Concentration $NO_3 = 1\,780\,\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1\,700\,\frac{mole}{liter}$

Aluminum Concentration $Al = 1\,480\,\frac{mole}{liter}$

TOC Concentration $TOC = 2\,630\,\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\,660\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\,550\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\,779 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author *D C Hedengren* Date *1/26/00* Checked by *J D Bigbee* Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\%$

Final Fill Factor $fff = 40\ 240\%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12480\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\%$

Final H2 Concentration (%LFL) $fh2c = 2\ 134\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 17\ 344\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7\ 168\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\ 828\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\%$

Final Fill Factor $fff2 = 80\ 479\%$

Initial Fill Volume $tvol_{init2} = 12480\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 2\ 134\%$

Final H2 Concentration (%LFL) $fh2c2 = 6\ 962\%$

Final Flammable Gas Concentration $ffgc2 = 22\ 172\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 12\ 202\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 26\ 862\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 223\ 178\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 23\ 796\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 87\ 367\ day$

Author D C Hedengren Date 1/26/00 Checked by J D Bj Date 1/26/00

DCRT **244-BX**
Case **3**

Table BX-2 BY-106 Ammonia Calculations for WSU Worst Case (3 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-BX		
Source Tank	BY-106				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 3 92		
Receiving Tank	244-BX		During Addition of Waste		
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1030	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	164800	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	39810	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	32	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	354	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	28	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	8925	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	35750	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	110260	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	78130	Temperature of Air in Vapor Space	°F	119 8
CO_3^{2}	µg/ml	6600	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	1988	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	2023	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	293	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	4652	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	3 92
$\%H_2O$	%	59 39			
Specific Gravity	unitless	1 312			
Total Organic Carbon	g/l	2 63			
Cs-137	µCi/ml	207			
Temperature	°F	118			

Author DC Hedengren Date 1/26/00 Checked by JD Bryan Date 1/26/00

DCRT 244 BX
Case 3

Table BX-2 (Cont'd) BY-106 Ammonia Calculations for WSU Worst Case (3 pages)

Source Tank	BY 106	INPUT DATA	Date	36546 35139		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1030
Na^{+1}	22 99	7 1683341	0 1143	0 819340583	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 48	0 2174	0 320781838				0 060479017
Fe^{+3}	55 85	0 00	0 1161	6 68329E-05				
Cr^{+3}	52	6 798E 03	0 0648	0 000440515	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	4 769E 04	0 1654	7 88826E-05				
K^{+1}	39 09	2 283E 01	0 0922	0 021051036	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 10	0 0839	0 176359996	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	1 78	0 0128	0 022761556	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	1 70	0 0795	0 135012879				
CO_3^{2}	60 0092	0 11	0 1423	0 0156506				
PO_4^{-3}	94 9676	0 02	0 2119	0 004435576				
SO_4^{2}	96 0576	2 106E 02	0 1117	0 002352433				
F^{-1}	19	1 541E 02	0 092	0 001418059				
Cl^{-1}	35 453	1 312E 01	0 0318	0 004172399				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		14 75718636		1 523923187				
Mass fraction water in liq		0 59						Temperature
Liquid density (kg/m3)		1312 000						deg F
T (C)		48						118
								Temperature
								deg C
								47 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 060479017	-0 0481	1 662709797	22 25758937	10 43058893	0 005798236	
Hydrogen			2 861E-02	1 264E+01	7 291E-04	4 495E-05	0 000E+00	
Methane			-9 736E-03	2 400E+01	1 055E-03	3 424E-05	0 000E+00	

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-BX
Case 3

Table BX 2 (Cont'd) BY 106 Ammonia Calculations for WSU Worst Case (3 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	0 58	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	6 291E-03	0 02	0 11	
0 0183	66	1 139E-02	0 03	0 19	
0 0333	120	2 028E-02	0 05	0 35	
0 0617	222	3 603E-02	0 10	0 61	
0 1033	372	5 696E-02	0 15	0 97	
0 1750	630	8 753E-02	0 23	1 49	
0 332	1194	1 358E-01	0 36	2 32	
0 620	2232	1 832E-01	0 48	3 12	
1 035	3726	2 085E-01	0 55	3 56	
2 27	8154	2 190E-01	0 58	3 74	
3 35	12060	2 193E-01	0 58	3 74	
5 38	19362	2 193E-01	0 58	3 74	
8 27	29784	2 193E-01	0 58	3 74	
9 68	34860	2 193E-01	0 58	3 74	
10 9	39300	2 193E-01	0 58	3 74	
13 2	47640	2 193E-01	0 58	3 74	
16 6	59580	2 193E-01	0 58	3 74	
41 7	150000	2 193E-01	0 58	3 74	
64 6	232605	2 193E-01	0 58	3 74	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Bgr Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 3
WSU

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 gpm

Ammonia and methane are considered WSU model

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\,780 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,312$	Nitrite Concentration	$NO_2 = 1\,700 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\,656 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,480 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 2\,630 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no"	Ammonia Concentration	$NH_3 = 3\,740\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,550\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 320\,950\,K$		

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\,779 \times 10^{-5} \frac{mole}{liter}$

or $gr_{sol} = 0\,049 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,049 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 40\ 240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 2\ 134\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 6\ 424\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7\ 168\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 10\ 908\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 2\ 134\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 6\ 962\,\%$

Final Flammable Gas Concentration $ffgc2 = 11\ 252\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 12\ 202\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 15\ 942\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 221\ 540\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 8\ 986\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 36\ 077\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 104\ 370\,day$

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244-BX-DCRT

CASE 4

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 4

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 8 gpm

Ammonia and methane are considered

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3.000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1.312$

Radiolytic Power of Waste $wastepower = 0.656 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0.000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = $ 'no'

CGM Measurement $conc_{LFL\_cgm0} = 0.000\,\%LFL$

DCRT Waste Temperature $T = 320.950\,K$

Nitrate Concentration $NO_3 = 1.780 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1.700 \frac{mole}{liter}$

Aluminum Concentration $Al = 1.480 \frac{mole}{liter}$

TOC Concentration $TOC = 2.630 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14.660\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0.550\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 8.000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 26.000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5.779 \times 10^{-5} \frac{mole}{liter}$

or $gr_{sol} = 0.098 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\,\%$

Period 2

Second Flow Rate $flow_2 = 8.000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 26.000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0.098 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40.240\,\%$

Author D. C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 8\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 26\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 40\ 240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 2\ 046\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 17\ 256\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7\ 168\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\ 828\,\%$

Period 2

Second Flow Rate $flow_2 = 8\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 26\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 2\ 046\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 6\ 596\,\%$

Final Flammable Gas Concentration $ffgc2 = 21\ 806\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 12\ 202\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 26\ 862\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 223\ 178\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 23\ 796\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 87\ 367\,day$

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244-BX-DCRT

CASE 5

Author D C Hedengren Date 1/26/00 Checked by J. D. Rigby Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 5

Calculations based on tank 241-BY-106
- the initial condition of the tank is 0% full
- this model calculates the flammable gas concentration in the DCRT headspace at 80% full from an initial pumping rate of 4 gpm (to 40% full) followed by an
- immediate change in pumping rate to 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\,780\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,312$	Nitrite Concentration	$NO_2 = 1\,700\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\,656\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,480\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 2\,630\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 320\,950\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 5\,779 \times 10^{-5}\,\frac{mole}{liter}$ or $gr_{sol} = 0\,049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,049\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author D.C. Hedengren Date 1/26/00 Checked by J.D. Berger Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4.000 \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 52.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\,\%$ Final Fill Factor $fff = 40.240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$ Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 2.134\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 2.134\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7.168\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 7.168\,\%$

Period 2

Second Flow Rate $flow_2 = 4.000 \frac{gal}{min}$ Time Pumped at Second Flow Rate $tim2 = 52.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40.240\,\%$ Final Fill Factor $fff2 = 80.479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$ Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 2.134\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 6.962\,\%$ Final Flammable Gas Concentration $ffgc2 = 6.962\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 12.202\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 12.202\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 220.979\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 12.815\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 40.461\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 110.538\,day$

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244-BX-DCRT

CASE 6

Author D. C. Hedengren Date 1/26/00 Checked by J. D. Ryan Date 1/26/00

CH2MHILL
Hanford Group, Inc

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d)

DCRT 244-BX
CASE 6

Modified for 244-BX DCRT Vault Case (Ventilation rate of 3 cfh) Use Vertical DCRT for model Wetted surface area set at 1302 sq ft

$d := 12\ ft$

Input length of DCRT (L)

$L := 100.47\ ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10^{-6})

$flow := 1 \cdot 10^{-6} \cdot \frac{gal}{min}$ $flow = 2.228 \times 10^{-9}\ ft^3\ sec^{-1}$ $\frac{flow}{\left(\frac{ft^3}{hr}\right)} = 8.021 \times 10^{-6}$

Higher Input flow rate

$flow_2 := 1 \cdot 10^{-6} \cdot \frac{gal}{min}$ $flow_2 = 2.228 \times 10^{-9}\ ft^3\ sec^{-1}$ $\frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 8.021 \times 10^{-6}$

Calculate total DCRT volume (tvol)

$$tvol := L\ \pi \left(\frac{d}{2}\right)^2$$ Assume DCRT has flat ends [Eqn 1]

$tvol = 11363\ ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.292 \cdot tvol + 0 \cdot hr \cdot 0 \cdot \frac{gal}{min}$ $tvol_{init} = 3.318 \times 10^3\ ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 1\ hr$

Time at pumping rate 2

$time_2 := 1\ hr$

Volume of fill at start of pumping rate 2

$tvol_2 := tvol_{init} + time \cdot flow$ $tvol_2 = 3318\ ft^3$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

$$vol_{H2_0} = if\left[flag_{cgm} = \text{"yes"}, conc_{H2\_cgm}\left(tvol - tvol_{init}\right), vol_{H2_0}\right]$$

$vol_{H2_0} = 0.000\,ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 14.66\ \%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 0.0\ \%LFL_{CH4}$ (Reference)

End of Input Section

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow\ t - tvol_{init}$ $hvol(lim) = 8.045 \times 10^3\,ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft^2) $2\,\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,L = 4014\,ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,\frac{flow\ t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] \rightarrow \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(flow\ t + tvol_{init}\right)}{d}$$ [Eqn 8]

$Awet(t) := 1302\,ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim) = 1.302 \times 10^3\,ft^2$

$Awet(0\ hr) = 1.302 \times 10^3\,ft^2$ Check the answers

$Awet(1\ hr) = 1.302 \times 10^3\,ft^2$ $Awet(lim) = 1.302 \times 10^3\,ft^2$

Author D C Hedengren Date 1/26/00 Checked by J.D. R[illegible] Date 1/26/00

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol2(time) := tvol - flow_2 \cdot time - tvol_{init2}$ $hvol2(lim2) = 8.045 \times 10^3 ft^3$ [Eqn 4]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi \left(\frac{d}{2}\right)^2 + \pi \cdot d \cdot \frac{flow_2 \cdot t + tvol_{init2}}{\pi \left(\frac{d}{2}\right)^2}\right] = \pi \left(\frac{d}{2}\right)^2 + \frac{4 \left(flow_2 \cdot t + tvol_{init2}\right)}{d}$$ [Eqn 8]

$Awet(tt2) := 1302 ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim2) = 1.302 \times 10^3 ft^2$

$Awet(0 \cdot hr) = 1.302 \times 10^3 ft^2$ Check the answers

$Awet(1 \cdot hr) = 1.302 \times 10^3 ft^2$

$Awet(lim2) = 1302.000 ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 1.780$ $\frac{NO_2}{\left(\frac{mole}{liter}\right)} = 1.700$ $\frac{Al}{\left(\frac{mole}{liter}\right)} = 1.480$ $\frac{TOC}{\left(\frac{gm}{liter}\right)} = 2.630$

Author D C Hedengren Date 1/26/00 Checked by [illegible signature] Date 1/26/00

SUMMARY:

DCRT 244-BX
CASE 6

Modified for 244-BX DCRT Vault Case (Ventilation rate of 3 cfh) Use Vertical DCRT for model Wetted surface area set at 1302 sq ft

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 780\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 312$	Nitrite Concentration	$NO_2 = 1\ 700\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 656\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 480\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 2\ 630\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 14\ 660\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 320\ 950\,K$		

Period 1

Initial Flow Rate $flow = 1\ 000 \times 10^{-6}\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 1\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 29\ 200\,\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6}\,\frac{gal}{min}$

Time pumped at Second flow rate $tim2 = 1\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 29\ 200\,\%$

Author D C Hedengren Date 1/26/00 Checked by J.D. Bohn Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 1.000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 29.200\,\%$

Final Fill Factor $fff = 29.200\,\%$

Initial Fill Volume $tvol_{init} = 24820\,gal$

Final Fill Volume $ffv = 24820\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 5.078 \times 10^{-3}\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 14.665\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 13.545\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 28.205\,\%$

Period 2

Second Flow Rate $flow_2 = 1.000 \times 10^{-6} \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 29.200\,\%$

Final Fill Factor $fff2 = 29.200\,\%$

Initial Fill Volume $tvol_{init2} = 24820\,gal$

Final Fill Volume $ffv2 = 24820\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5.078 \times 10^{-3}\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0.010\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 14.670\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 13.545\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 28.205\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 28.994\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0.000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 10.000 \times 10^{8}\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 10.000 \times 10^{8}\,day$

This document was too large to scan as a single document. It has been divided into smaller sections.

2 Section of 3

Document Information			
Document #	**RPP-4941**	**Revision**	**0**
Title	METHODOLOGY FOR PREDICTING FLAMMABLE GAS MIXTURES IN DCRT		
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Recipient		**Recipient Co**	
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Projects			
Other Information			

244-S-DCRT

CASE 1

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

SUMMARY:

DCRT 244-S CASE 1 — Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\,000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\,660 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,468$	Nitrite Concentration	$NO_2 = 3\,100 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,218 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,630 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 3\,228 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\,471 \times 10^{-4} \frac{mole}{liter}$ or $gr_{sol} = 0\,135 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time pumped at Second flow rate $tim2 = 35\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,135 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$

Author D C Hedengren Date 1/27/99 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\ \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 34\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\%$ Final Fill Factor $fff = 39\ 825\%$

Initial Fill Volume $tvol_{init} = 0\ gal$ Final Fill Volume $ffv = 8160\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\%$

Final H2 Concentration (%LFL) $fh2c = 5\ 855\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 5\ 855\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\ 812\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 16\ 812\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\ \frac{gal}{min}$ Time pumped at Second Flow Rate $tim2 = 35\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\%$ Final Fill Factor $fff2 = 80\ 821\%$

Initial Fill Volume $tvol_{init2} = 8160\ gal$ Final Fill Volume $ffv2 = 16560\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\ 855\%$

Final H2 Concentration (%LFL) $fh2c2 = 20\ 221\%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 20\ 221\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\ 072\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 33\ 072\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\ 012 \times 10^3\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 2\ 306\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 9\ 361\ day$

Author D C Hedengren Date 1/26/00 Checked by Michael A Kappel Date 1/26/00

SUMMARY:

DCRT 244-S CASE 1 Time to get to 95% of SS LFL following fill Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 5\,000\,\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\,468$

Radiolytic Power of Waste $wastepower = 1\,218\,\frac{lb}{ft\,sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\,000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = $ "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\,000\,\%LFL$

DCRT Waste Temperature $T = 348\,150\,K$

Nitrate Concentration $NO_3 = 2\,660\,\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\,100\,\frac{mole}{liter}$

Aluminum Concentration $Al = 1\,630\,\frac{mole}{liter}$

TOC Concentration $TOC = 3\,228\,\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\,000\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\,000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\,471 \times 10^{-4}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,135\,\frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 69\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 1\,000 \times 10^{-6}\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 3\,369 \times 10^{-8}\,\frac{ft^3}{hr}$

Time pumped at Second flow rate $lim2 = 212\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\,821\,\%$

Author D C Hedengren Date 1/26/00 Checked by [illegible] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\ \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 69\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$ Final Fill Factor $fff = 80\ 821\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$ Final Fill Volume $ffv = 16560\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 20\ 221\ \%$ Final Flammable Gas Concentration (%LFL) $ffgc = 20\ 221\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 33\ 072\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 33\ 072\ \%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6}\ \frac{gal}{min}$ Time pumped at Second Flow Rate $lim2 = 212\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 821\ \%$ Final Fill Factor $fff2 = 80\ 821\ \%$

Initial Fill Volume $tvol_{init2} = 16560\ gal$ Final Fill Volume $ffv2 = 16560\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 20\ 221\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 31\ 409\ \%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 31\ 409\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\ 072\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 33\ 072\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\ 012 \times 10^{3}\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 2\ 306\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 9\ 361\ day$

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244-S-DCRT

CASE 2

Author D C Hedengren Date 1/26/99 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S CASE 2

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 5.000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1.468$

Radiolytic Power of Waste $wastepower = 1.218 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0.000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = $ 'no"

CGM Measurement $conc_{LFL\_cgm0} = 0.000\,\%LFL$

DCRT Waste Temperature $T = 348.150\,K$

Nitrate Concentration $NO_3 = 2.660 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3.100 \frac{mole}{liter}$

Aluminum Concentration $Al = 1.630 \frac{mole}{liter}$

TOC Concentration $TOC = 3.228 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0.000\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0.000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4.000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1.471 \times 10^{-4} \frac{mole}{liter}$

or $gr_{sol} = 0.135 \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 34.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\,\%$

Period 2

Second Flow Rate $flow_2 = 4.000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0.135 \frac{ft^3}{hr}$

Time pumped at Second flow rate $lim2 = 35.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39.825\,\%$

Author D. C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$ Final Fill Factor $fff = 39\,825\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$ Final Fill Volume $ffv = 8160\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 5\,855\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 5\,855\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\,812\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 16\,812\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$ Time pumped at Second Flow Rate $tim2 = 35\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$ Final Fill Factor $fff2 = 80\,821\,\%$

Initial Fill Volume $tvol_{init2} = 8160\,gal$ Final Fill Volume $ffv2 = 16560\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\,855\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 20\,221\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 20\,221\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\,072\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 33\,072\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\,012 \times 10^3\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 2\,306\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 9\,361\,day$

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244-S-DCRT

CASE 3

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-S
Case 3

Table S3-1 Henry's Law Constant Calculation for Tank S-107 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S-107				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	126749	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	7731	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	20	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	1220	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	8	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	1285	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	0	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	93425	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	46735	Temperature of Air in Vapor Space	°F	107 8
CO_3^{2}	µg/ml	0	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3854	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3642	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	327	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	3542	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	68 21			
Specific Gravity	unitless	1 238			
Total Organic Carbon	g/l	0			
Cs-137	µCi/ml	0			
Temperature	°F	106			

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **3**

Table S3-1 (Cont'd) Henry's Law Constant Calculation for Tank S-107 (2 pages)

Source Tank	S 107	INPUT DATA	Date	36547 33921		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1
Na^{+1}	22 99	5 5132231	0 1143	0 630161405	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 29	0 2174	0 062295011				5 87175E-05
Fe^{+3}	55 85	0 00	0 1161	4 15756E-05				
Cr^{+3}	52	2 346E 02	0 0648	0 001520308	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	1 431E 04	0 1654	2 36648E-05				
K^{+1}	39 09	3 287E 02	0 0922	0 003030877	Ammonia	0	-0 0481	
OH^{1}	17 0074	0 00	0 0839	0	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	1 51	0 0128	0 019286218	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	1 02	0 0795	0 080760616				
CO_3^{2}	60 0092	0 00	0 1423	0				
PO_4^{-3}	94 9676	0 04	0 2119	0 008599381				
SO_4^{2}	96 0576	3 791E 02	0 1117	0 004235078				
F^{-1}	19	1 721E 02	0 092	0 001583368				
Cl^{-1}	35 453	9 991E 02	0 0318	0 00317704				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		8 57481132		0 814714542				
Mass fraction water in liq		0 68						Temperature
Liquid density (kg/m3)		1238 000						deg F
T (C)		41						106
								Temperature
								deg C
								41 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		5 87175E-05	-0 0481	2 525027532	29 44631257	9 847670167	5 96258E-06	
Hydrogen			2 662E-02	3 859E+00	7 371E-04	1 613E-04	0 000E+00	
Methane			-6 242E-03	5 770E+00	1 131E-03	1 655E-04	0 000E+00	

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DCRT **244-S**
Case **3**

Table S3-2 Henry's Law Constant Calculation for Tank SX-102 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-102				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1370	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	45600	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	36	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	2770	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	15	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3550	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	50050	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	158001	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	151000	Temperature of Air in Vapor Space	°F	143 8
CO_3^{2}	µg/ml	8800	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3490	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3330	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	78	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	10200	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	48 03			
Specific Gravity	unitless	1 45			
Total Organic Carbon	g/l	1 51			
Cs-137	µCi/ml	438			
Temperature	°F	142			

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Case 3

Table S3-2 (Cont d) Henry s Law Constant Calculation for Tank SX 102 (2 pages)

Source Tank	SX 102	INPUT DATA	Date	36547 34767		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1370
Na^{+1}	22 99	10 221838	0 1143	1 168356055	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 69	0 2174	0 367436902				0 080442965
Fe^{+3}	55 85	0 00	0 1161	7 58755E-05				
Cr^{+3}	52	5 327E 02	0 0648	0 003451837	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 470E 04	0 1654	4 08499E-05				
K^{+1}	39 09	9 082E 02	0 0922	0 008373255	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 94	0 0839	0 246903995	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 55	0 0128	0 032616922	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 28	0 0795	0 260936365				
CO_3^{2}	60 0092	0 15	0 1423	0 020867482				
PO_4^{-3}	94 9676	0 04	0 2119	0 007787204				
SO_4^{2}	96 0576	3 467E 02	0 1117	0 003872267				
F^{-1}	19	4 105E 03	0 092	0 000377684				
Cl^{-1}	35 453	2 877E 01	0 0318	0 009149011				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 34008819		2 130245706				
Mass fraction water in liq		0 48						Temperature
Liquid density (kg/m3)		1450 000						deg F
T (C)		61						142
								Temperature
								deg C
								61 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 080442965	-0 0481	12 69952459	13 11687776	0 71932242	0 111831583	
Hydrogen			3 260E-02	2 720E+01	7 293E-04	1 867E-05	0 000E+00	
Methane			1 672E-02	5 935E+01	9 547E-04	1 120E-05	0 000E+00	

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Total Generation Rate of NH_3	G_r	0 3927	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	11 18	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	3 330E-02	0 09	0 59	
0 0183	66	6 084E-02	0 17	1 08	
0 0333	120	1 099E-01	0 30	1 95	
0 0617	222	2 010E-01	0 55	3 57	
0 1033	372	3 312E-01	0 91	5 88	
0 1750	630	5 449E-01	1 50	9 68	
0 332	1194	9 703E-01	2 67	17 23	
0 620	2232	1 623E+00	4 47	28 82	
1 035	3726	2 328E+00	6 41	41 33	
2 27	8154	3 428E+00	9 44	60 87	
3 35	12060	3 798E+00	10 45	67 45	
5 38	19362	4 006E+00	11 03	71 14	
8 27	29784	4 049E+00	11 15	71 91	
9 68	34860	4 052E+00	11 15	71 96	
10 9	39300	4 053E+00	11 16	71 98	
13 2	47640	4 054E+00	11 16	71 99	
16 6	59580	4 054E+00	11 16	71 99	
41 7	150000	4 054E+00	11 16	71 99	
67 6	243444	4 054E+00	11 16	71 99	Time to fill from 0% to 80% at 4gpm

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DCRT 244-S
Case 3

Table S3-3 Henry's Law Constant Calculation for Tank SX-103 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-103				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1800	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	237393	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44121	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	32	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	84	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	13	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4242	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	41517	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	158629	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	158479	Temperature of Air in Vapor Space	°F	162 8
CO_3^{2}	µg/ml	12750	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3329	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	2014	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	101	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	10996	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non-Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	46 95			
Specific Gravity	unitless	1 47			
Total Organic Carbon	g/l	3 051			
Cs-137	µCi/ml	440			
Temperature	°F	161			

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DCRT 244-S
Case 3

Table S3-3 (Cont'd) Henry s Law Constant Calculation for Tank SX-103 (2 pages)

Source Tank	SX 103	INPUT DATA	Date	36547 34508		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1800
Na^{+1}	22 99	10 325935	0 1143	1 180254342	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 64	0 2174	0 355519272				0 105691487
Fe^{+3}	55 85	0 00	0 1161	6 67289E-05				
Cr^{+3}	52	1 608E 03	0 0648	0 000104178	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 180E 04	0 1654	3 60606E-05				
K^{+1}	39 09	1 085E 01	0 0922	0 010005419	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 44	0 0839	0 204809454	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 56	0 0128	0 03274666	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 44	0 0795	0 273860708				
CO_3^{2}	60 0092	0 21	0 1423	0 030234116				
PO_4^{-3}	94 9676	0 04	0 2119	0 007427969				
SO_4^{2}	96 0576	2 097E 02	0 1117	0 002341971				
F^{-1}	19	5 316E 03	0 092	0 000489053				
Cl^{-1}	35 453	3 102E 01	0 0318	0 009862993				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 10037354		2 107758925				
Mass fraction water in liq		0 47						Temperature
Liquid density (kg/m3)		1470 000						deg F
T (C)		72						161
								Temperature
								deg C
								71 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 105691487	-0 0481	12 38314497	8 863887473	0 494021907	0 21394089	
Hydrogen			-3 575E-02	2 256E+01	7 432E-04	2 273E-05	0 000E+00	
Methane			2 225E-02	4 347E+01	9 109E-04	1 446E-05	0 000E+00	

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Total Generation Rate of NH_3	G_r	0 5865	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	21 39	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	4 827E-02	0 14	0 88	
0 0183	66	8 825E-02	0 25	1 62	
0 0333	120	1 597E-01	0 45	2 92	
0 0617	222	2 927E-01	0 83	5 36	
0 1033	372	4 841E-01	1 37	8 87	
0 1750	630	8 013E-01	2 28	14 68	
0 332	1194	1 446E+00	4 11	26 49	
0 620	2232	2 475E+00	7 03	45 33	
1 035	3726	3 657E+00	10 38	66 99	
2 27	8154	5 768E+00	16 38	105 66	
3 35	12060	6 646E+00	18 87	121 74	
5 38	19362	7 279E+00	20 67	133 33	
8 27	29784	7 477E+00	21 23	136 97	
9 68	34860	7 499E+00	21 29	137 36	
10 9	39300	7 507E+00	21 31	137 51	
13 2	47640	7 512E+00	21 33	137 60	
16 6	59580	7 514E+00	21 33	137 63	
41 7	150000	7 514E+00	21 33	137 63	
67 6	243444	7 514E+00	21 33	137 63	Time to fill from 0% to 80% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by Michael A Knoll Date 1/26/00

DCRT 244-S
Case 3

Table S3-4 Henry's Law Constant Calculation for Tank SX-105 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1210	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	168 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs-137	µCi/ml	384			
Temperature	°F	167			

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DCRT **244-S**
Case **3**

Table S3-4 (Cont'd) Henry s Law Constant Calculation for Tank SX-105 (2 pages)

Source Tank	SX 105	INPUT DATA	Date	36547 34508		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1210
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 071048166
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E-05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{-1}	19	5 466E 03	0 092	0 000502894				
Cl^{-1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		75						167
								Temperature
								deg C
								75
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 071048166	-0 0481	11 89866249	7 867518994	0 416120578	0 170739371	
Hydrogen			3 675E-02	2 045E+01	7 499E-04	2 308E-05	0 000E+00	
Methane			2 400E-02	3 757E+01	9 021E-04	1 511E-05	0 000E+00	

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Total Generation Rate of NH_3	G_r	0 4187	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	17 07	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	3 414E-02	0 10	0 63	
0 0183	66	6 244E-02	0 18	1 15	
0 0333	120	1 130E 01	0 32	2 09	
0 0617	222	2 074E-01	0 59	3 84	
0 1033	372	3 434E 01	0 98	6 35	
0 1750	630	5 699E-01	1 63	10 54	
0 332	1194	1 034E+00	2 96	19 11	
0 620	2232	1 785E+00	5 12	33 01	
1 035	3726	2 668E+00	7 65	49 35	
2 27	8154	4 329E+00	12 41	80 06	
3 35	12060	5 077E+00	14 55	93 89	
5 38	19362	5 670E+00	16 25	104 86	
8 27	29784	5 887E+00	16 88	108 87	
9 68	34860	5 915E+00	16 96	109 39	
10 9	39300	5 926E+00	16 99	109 60	
13 2	47640	5 934E+00	17 01	109 75	
16 6	59580	5 937E+00	17 02	109 79	
41 7	150000	5 937E+00	17 02	109 80	
67 6	243444	5 937E+00	17 02	109 80	Time to fill from 0% to 80% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by Michael Kappell Date 1/26/00

DCRT **244-S**
Case **3**

Table S3-5 Henry's Law Constant Calculation for Tank SX-102 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet						
				244-S		
Source Tank	SX-102					
Dilution Ratio	0 1			Correction Factor for Schumpe Model 6		
Receiving Tank	244-S					
Liquid Waste Characteristics (Source Tank)				Tank Characteristics (Receiving Tank)		
Parameter	Units	Value		Parameter	Units	Value
NH_3	µg/ml	1370		Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235000		Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	45600		Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	36		Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	2770		Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	15		Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3550		Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	50050		Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	158001		Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	151000		Temperature of Air in Vapor Space	°F	143 8
CO_3^{2}	µg/ml	8800		Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3490		Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3330		Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	78		Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	10200		Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0		Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0		Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	48 03				
Specific Gravity	unitless	1 45				
Total Organic Carbon	g/l	1 51				
Cs-137	µCi/ml	438				
Temperature	°F	142				

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DCRT 244-S
Case 3

Table S3-5 (Cont d) Henry s Law Constant Calculation for Tank SX-102 (2 pages)

Source Tank	SX-102	INPUT DATA	Date	36547 37592		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1370
Na^{+1}	22 99	10 221838	0 1143	1 168356055	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 69	0 2174	0 367436902				0 080442965
Fe^{+3}	55 85	0 00	0 1161	7 58755E-05				
Cr^{+3}	52	5 327E 02	0 0648	0 003451837	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 470E 04	0 1654	4 08499E-05				
K^{+1}	39 09	9 082E 02	0 0922	0 008373255	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 94	0 0839	0 246903995	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 56	0 0128	0 032616922	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 28	0 0795	0 260936365				
CO_3^{2}	60 0092	0 15	0 1423	0 020867482				
PO_4^{-3}	94 9676	0 04	0 2119	0 007787204				
SO_4^{2}	96 0576	3 467E 02	0 1117	0 003872267				
F^{-1}	19	4 105E 03	0 092	0 000377684				
Cl^{-1}	35 453	2 877E 01	0 0318	0 009149011				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 34008819		2 130245706				
Mass fraction water in liq		0 48						Temperature
Liquid density (kg/m3)		1450 000						deg F
T (C)		61						142
								Temperature
								deg C
								61 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part. P atm	
Ammonia		0 080442965	-0 0481	2 116587432	13 11687776	4 315934518	0 018638597	
Hydrogen			-3 260E-02	2 720E+01	7 293E-04	1 867E-05	0 000E+00	
Methane			1 672E-02	5 935E+01	9 547E-04	1 120E-05	0 000E+00	

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Total Generation Rate of NH_3	G_r	0 2571	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	1 86	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	2 154E-02	0 06	0 38	
0 0183	66	3 897E-02	0 11	0 69	
0 0333	120	6 918E-02	0 19	1 23	
0 0617	222	1 224E-01	0 34	2 17	
0 1033	372	1 923E 01	0 53	3 42	
0 1750	630	2 926E 01	0 81	5 20	
0 332	1194	4 453E 01	1 23	7 91	
0 620	2232	5 857E 01	1 61	10 40	
1 035	3726	6 530E-01	1 80	11 60	
2 27	8154	6 763E-01	1 86	12 01	
3 35	12060	6 768E-01	1 86	12 02	
5 38	19362	6 768E-01	1 86	12 02	
8 27	29784	6 768E-01	1 86	12 02	
9 68	34860	6 768E-01	1 86	12 02	
10 9	39300	6 768E 01	1 86	12 02	
13 2	47640	6 768E-01	1 86	12 02	
16 6	59580	6 768E-01	1 86	12 02	
41 7	150000	6 768E-01	1 86	12 02	
67 6	243444	6 768E-01	1 86	12 02	Time to fill from 0% to 80% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-S CASE 3

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh) Includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\,660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,468$	Nitrite Concentration	$NO_2 = 3\,100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,218\,\frac{lb}{ft\,sec^3}$	Aluminum Concentration	$Al = 1\,630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 3\,228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = no"	Ammonia Concentration	$NH_3 = 72\,150\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 1\,890\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\,471 \times 10^{-4}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,135\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 35\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,135\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 39\ 825\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 8160\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 5\ 855\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 79\ 895\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\ 812\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 88\ 962\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\ \frac{gal}{min}$

Time pumped at Second Flow Rate $lim2 = 35\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\ \%$

Final Fill Factor $fff2 = 80\ 821\ \%$

Initial Fill Volume $tvol_{init2} = 8160\ gal$

Final Fill Volume $ffv2 = 16560\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\ 855\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 20\ 221\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 94\ 261\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\ 072\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 105\ 222\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\ 023 \times 10^3\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\ 000\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0\ 000\ day$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-S CASE 3

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh)--Includes ammonia from SX-102 (WSU model) and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\,660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,468$	Nitrite Concentration	$NO_2 = 3\,100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,218\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 3\,228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = 'no	Ammonia Concentration	$NH_3 = 12\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 1\,890\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\,471 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\,135\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time pumped at Second flow rate $tim2 = 35\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,135\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 39\ 825\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 8160\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 5\ 855\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 19\ 745\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\ 812\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 28\ 812\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 35\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\ \%$

Final Fill Factor $fff2 = 80\ 821\ \%$

Initial Fill Volume $tvol_{init2} = 8160\ gal$

Final Fill Volume $ffv2 = 16560\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\ 855\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 20\ 221\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 34\ 111\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\ 072\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 45\ 072\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\ 014 \times 10^3\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\ 667\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 7\ 633\ day$

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244-S-DCRT

CASE 4

Author D C Hedengren Date 1/26/00 Checked by [illegible] Date 1/26/00

SUMMARY: DCRT 244-S CASE 4

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 5 cfh) Includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\ 000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\ 660 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 468$	Nitrite Concentration	$NO_2 = 3\ 100 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 218 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 630 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\ ft^3$	TOC Concentration	$TOC = 3\ 228 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 72\ 150\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 1\ 890\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\ 150\ K$		

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\ 471 \times 10^{-4} \frac{mole}{liter}$

or $gr_{sol} = 0\ 135 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 35\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 135 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\ \%$

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 39\,825\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8160\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 5\,855\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 79\,895\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\,812\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 88\,962\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time pumped at Second Flow Rate $lim2 = 35\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$

Final Fill Factor $fff2 = 80\,821\,\%$

Initial Fill Volume $tvol_{init2} = 8160\,gal$

Final Fill Volume $ffv2 = 16560\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\,855\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 20\,221\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 94\,261\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\,072\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 105\,222\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\,023 \times 10^{3}\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\,000\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0\,000\,day$

Author D C Halvorsen Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-S CASE 4

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 8 gpm (Ventilation rate of 5 cfh) Includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\ 660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 468$	Nitrite Concentration	$NO_2 = 3\ 100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 218\,\frac{lb}{ft\,sec^3}$	Aluminum Concentration	$Al = 1\ 630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 3\ 228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 72\ 150\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 1\ 890\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\ 150\,K$		

Period 1

Initial Flow Rate	$flow = 8\ 000\,\frac{gal}{min}$	Time Pumped at Inital Flow Rate	$time = 17\ 000\,hr$
Hydrogen Carryover Rate	$gr_{sol\_molar} = 1\ 471 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 269\,\frac{ft^3}{hr}$	Initial Fill Factor	$\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate	$flow_2 = 8\ 000\,\frac{gal}{min}$	Time pumped at Second flow rate	$lim2 = 18\ 000\,hr$
Hydrogen Carryover Rate	$gr_{sol2} = 0\ 269\,\frac{ft^3}{hr}$	Initial Fill Factor	$\frac{tvol_{init2}}{tvol} = 39\ 825\,\%$

Author D.C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 8.000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 17.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\,\%$

Final Fill Factor $fff = 39.825\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8160\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 5.595\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 79.635\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16.812\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 88.962\,\%$

Period 2

Second Flow Rate $flow_2 = 8.000 \frac{gal}{min}$

Time pumped at Second Flow Rate $lim2 = 18.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39.825\,\%$

Final Fill Factor $fff2 = 81.992\,\%$

Initial Fill Volume $tvol_{init2} = 8160\,gal$

Final Fill Volume $ffv2 = 16800\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5.595\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 19.555\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 93.595\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33.533\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 105.683\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1.070 \times 10^3\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0.000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0.000\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0.000\,day$

Author D C. Hedengren Date 1/26/00 Checked by [illegible] Date 1/26/00

SUMMARY: DCRT 244-S CASE 4

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 12 gpm (Ventilation rate of 5 cfh) Includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\ 660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 468$	Nitrite Concentration	$NO_2 = 3\ 100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 218\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 3\ 228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no'	Ammonia Concentration	$NH_3 = 72\ 150\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 1\ 890\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\ 150\,K$		

Period 1

Initial Flow Rate $flow = 12\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 11\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\ 471 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 404\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 12\ 000\,\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 12\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 404\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 38\ 654\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 12\ 000\ \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 11\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$ Final Fill Factor $fff = 38\ 654\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$ Final Fill Volume $ffv = 7920\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 5\ 293\ \%$ Final Flammable Gas Concentration (%LFL) $ffgc = 79\ 333\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16\ 344\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 88\ 494\ \%$

Period 2

Second Flow Rate $flow_2 = 12\ 000\ \frac{gal}{min}$ Time pumped at Second Flow Rate $lim2 = 12\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 38\ 654\ \%$ Final Fill Factor $fff2 = 80\ 821\ \%$

Initial Fill Volume $tvol_{init2} = 7920\ gal$ Final Fill Volume $ffv2 = 16560\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\ 293\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 18\ 329\ \%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 92\ 369\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\ 072\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 105\ 222\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\ 023 \times 10^3\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\ 000\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0\ 000\ day$

Author D. C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-S CASE 4

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 16 gpm (Ventilation rate of 5 cfh) Includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\,660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,468$	Nitrite Concentration	$NO_2 = 3\,100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,218\,\frac{lb}{ft\,sec^3}$	Aluminum Concentration	$Al = 1\,630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 3\,228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 72\,150\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 1\,890\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\,150\,K$		

Period 1

Initial Flow Rate $flow = 16\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 8\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\,471 \times 10^{-4}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,539\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 16\,000\,\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 9\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,539\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 37\,482\,\%$

Author D C Hadangan Date 1/26/00 Checked by [signature] Date 1/26/0

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 16\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 8\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 37\ 482\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 7680\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 5\ 045\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 79\ 085\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 15\ 877\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 88\ 027\ \%$

Period 2

Second Flow Rate $flow_2 = 16\ 000\ \frac{gal}{min}$

Time pumped at Second Flow Rate $lim2 = 9\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 37\ 482\ \%$

Final Fill Factor $fff2 = 79\ 650\ \%$

Initial Fill Volume $tvol_{init2} = 7680\ gal$

Final Fill Volume $ffv2 = 16320\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\ 045\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 17\ 420\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 91\ 460\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 32\ 610\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 104\ 760\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 979\ 195\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\ 000\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0\ 000\ day$

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/0*

SUMMARY: DCRT 244-S CASE 4

Calculations based on worst case hydrogen tank 241-SX-105 and S-107 dissolved hydrogen

- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 20 gpm (Ventilation rate of 5 cfh) Includes ammonia from SX-102 and methane from S-107

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 5\ 000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 468$

Radiolytic Power of Waste $wastepower = 1\ 218 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\, ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ no

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\,\%LFL$

DCRT Waste Temperature $T = 348\ 150\, K$

Nitrate Concentration $NO_3 = 2\ 660 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 100 \frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 630 \frac{mole}{liter}$

TOC Concentration $TOC = 3\ 228 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 72\ 150\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 1\ 890\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 20\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 7\ 000\, hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\ 471 \times 10^{-4} \frac{mole}{liter}$

or $gr_{sol} = 0\ 674 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 20\ 000 \frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 7\ 000\, hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 674 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 996\,\%$

Author *D. C. Hedengren* Date *1/26/00* Checked by *Michael A. Kephle* Date *1/26/0*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 7\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,996\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8400\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 5\,648\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 79\,688\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 17\,280\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 89\,430\,\%$

Period 2

Second Flow Rate $flow_2 = 20\,000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 7\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,996\,\%$

Final Fill Factor $fff2 = 81\,992\,\%$

Initial Fill Volume $tvol_{init2} = 8400\,gal$

Final Fill Volume $ffv2 = 16800\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 5\,648\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 18\,603\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 92\,643\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 33\,533\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 105\,683\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 1\,070 \times 10^3\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\,000\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0\,000\,day$

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244-S-DCRT

CASE 5

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-S CASE 5 Calculations based on pumping 222-S Lab waste to 244-S
- the initial condition of the tank is 13% full
- this model calulates the remainder until filled to 80% full with pumping rate of 115 gpm (Ventilation rate of 3 cfh)--No dissolved hydrogen or methane

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 100$

Radiolytic Power of Waste $wastepower = 0\ 030\frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = $ "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 293\ 150\ K$

Nitrate Concentration $NO_3 = 1\ 000\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 0\ 000\frac{mole}{liter}$

Aluminum Concentration $Al = 0\ 000\frac{mole}{liter}$

TOC Concentration $TOC = 1\ 000\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\ 480\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 115\ 000\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\frac{mole}{liter}$

or $gr_{sol} = 0\ 000\frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 1\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 13\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 115\ 000\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\frac{ft^3}{hr}$

Time pumped at Second flow rate $tim2 = 1\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 46\ 675\ \%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY·

Period 1

Initial Flow Rate $flow = 115\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 1\ 000 hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 13\ 000\%$

Final Fill Factor $fff = 46\ 675\%$

Initial Fill Volume $tvol_{init} = 2664\ gal$

Final Fill Volume $ffv = 9564\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\%$

Final H2 Concentration (%LFL) $fh2c = 4\ 144 \times 10^{-3}\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 0\ 484\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 3\ 331\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 3\ 811\%$

Period 2

Second Flow Rate $flow_2 = 115\ 000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 1\ 000 hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 46\ 675\%$

Final Fill Factor $fff2 = 80\ 351\%$

Initial Fill Volume $tvol_{init2} = 9564\ gal$

Final Fill Volume $ffv2 = 16464\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 4\ 144 \times 10^{-3}\%$

Final H2 Concentration (%LFL) $fh2c2 = 0\ 017\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 0\ 497\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 4\ 912\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 5\ 392\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 138\ 296\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 33\ 399\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 85\ 525\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 259\ 638\ day$

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244-S-DCRT

CASE 6

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S Calculations based on pumping Active Catch Tanks to 244-S
CASE 6 - the initial condition of the tank is 10% full
- this model calulates the remainder until filled to 80% full with pumping rate of 120 gpm (Ventilation rate of 3 cfh) No dissolved hydrogen or methane

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\ 000\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 015$	Nitrite Concentration	$NO_2 = 0\ 000\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 8\ 339\times 10^{-3}\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 000\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 40\ 000\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 2\ 500\times 10^{-3}\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\ 150\,K$		

Period 1

Initial Flow Rate $flow = 120\ 000\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 1\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\frac{mole}{liter}$

or $gr_{sol} = 0\ 000\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 10\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 120\ 000\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 1\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 45\ 140\,\%$

Author D C Hedengren Date 1/26/00 Checked by [illegible] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 120\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 1\,000 hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 10\,000\,\%$

Final Fill Factor $fff = 45\,140\,\%$

Initial Fill Volume $tvol_{init} = 2049\,gal$

Final Fill Volume $ffv = 9249\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 3\,912 \times 10^{-3}\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 6\,412 \times 10^{-3}\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 3\,314\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 3\,316\,\%$

Period 2

Second Flow Rate $flow_2 = 120\,000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 1\,000 hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 45\,140\,\%$

Final Fill Factor $fff2 = 80\,279\,\%$

Initial Fill Volume $tvol_{init2} = 9249\,gal$

Final Fill Volume $ffv2 = 16449\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 3\,912 \times 10^{-3}\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0\,017\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 0\,020\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 5\,006\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 5\,008\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 140\,237\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 33\,556\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 84\,851\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 254\,255\,day$

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244-S-DCRT

CASE 7

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S Calculations based on heel in 244-S
CASE 7
- the initial condition of the tank is 0% full
- this model calulates the remainder until filled to 80% full with pumping rate of 4 gpm (Ventilation rate of 3 cfh)--No dissolved hydrogen or methane

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 260\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 150$	Nitrite Concentration	$NO_2 = 1\ 030\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 422\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 000\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 1\ 380\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"		
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Ammonia Concentration	$NH_3 = 0\ 290\,\%LFL_{NH3}$
DCRT Waste Temperature	$T = 313\ 150\,K$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 35\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$

Time pumped at Second flow rate $tim2 = 34\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 996\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 35\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,996\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8400\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0\,114\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 0\,404\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 3\,326\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 3\,616\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 34\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,996\,\%$

Final Fill Factor $fff2 = 80\,821\,\%$

Initial Fill Volume $tvol_{init2} = 8400\,gal$

Final Fill Volume $ffv2 = 16560\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0\,114\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0\,558\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 0\,848\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 5\,374\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 5\,664\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 153\,972\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 29\,080\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 73\,919\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 210\,193\,day$

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244-S-DCRT

CASE 8

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Worst Case Tank Waste SX-105 1/13/00 14 27
Ammonia in liquid waste in SX-105--25%, 50%, and 100% LFL
at various temperatures between 70 and 170 deg F

Table S8-1 Shumpe Model for SX-105 Ammonia Values

Model	Temperature (° F)	Ammonia in Vapor Space (% LFL)	Ammonia in liquid waste (µg/mL)
Schumpe	70	25	2555
Schumpe	70	50	5111
Schumpe	70	100	10221
Schumpe	80	25	1962
Schumpe	80	50	3925
Schumpe	80	100	7850
Schumpe	90	25	1521
Schumpe	90	50	3041
Schumpe	90	100	6083
Schumpe	100	25	1188
Schumpe	100	50	2377
Schumpe	100	100	4754
Schumpe	110	25	936
Schumpe	110	50	1873
Schumpe	110	100	3745
Schumpe	120	25	743
Schumpe	120	50	1487
Schumpe	120	100	2974
Schumpe	130	25	594
Schumpe	130	50	1189
Schumpe	130	100	2378
Schumpe	140	25	478
Schumpe	140	50	957
Schumpe	140	100	1915
Schumpe	150	25	388
Schumpe	150	50	776
Schumpe	150	100	1552
Schumpe	160	25	316
Schumpe	160	50	633
Schumpe	160	100	1266
Schumpe	170	25	259
Schumpe	170	50	519
Schumpe	170	100	1039

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DCRT **244-S**
Case **8 (Story 1)**

Worst Case Tank Waste SX-105 1/22/00 11 16
Ammonia in liquid waste in SX-105–25%, 50%, and 100% LFL
at various temperatures between 70 and 170 deg F

Table S8-2 WSU Model for SX-105 Ammonia Values

Model	Temperature (° F)	Ammonia in Vapor Space (% LFL)	Ammonia in liquid waste (µg/mL)
WSU	70	25	15325
WSU	70	50	30650
WSU	70	100	61300
WSU	80	25	11770
WSU	80	50	23535
WSU	80	100	47070
WSU	90	25	9118
WSU	90	50	18235
WSU	90	100	36474
WSU	100	25	7125
WSU	100	50	14250
WSU	100	100	28500
WSU	110	25	5612
WSU	110	50	11225
WSU	110	100	22451
WSU	120	25	4455
WSU	120	50	8911
WSU	120	100	17822
WSU	130	25	3563
WSU	130	50	7125
WSU	130	100	14250
WSU	140	25	2868
WSU	140	50	5736
WSU	140	100	11473
WSU	150	25	2324
WSU	150	50	4649
WSU	150	100	9297
WSU	160	25	1895
WSU	160	50	3791
WSU	160	100	7582
WSU	170	25	1555
WSU	170	50	3110
WSU	170	100	6219

Author D C Hedengren Date 1/26/00 Checked by J D Ryker Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-3 S and SX Farms Ammonia Data

Tank	Ammonia in liquid waste (µg/mL)	Temperature (° F)	Ionic Strength (molarity)	Henry s Law Constant, K[NH_3] (mole/L $_{liquid}$ atm)	Ammonia in Vapor Space (% LFL)
S 101	1	116	15 7	3 511	0 01
S 102	1700	105	20 04	1 801	35 7
S 103	1410	86	18 12	4 547	11 7
S 106	430	80	22 42	3 863	4 2
S 107	1	106	7 56	10 6	0
S-109	1550	85	19 73	4 985	11 8
S-111	1500	90	18 49	4 24	13 4
SX-101	132	133	20 56	0 6021	8 3
SX-102	1370	142	21 34	0 7193	72
SX 103	1800	161	21 1	0 494	137 6
SX 104	793	144	22 36	0 954	31 4
SX 105	1210	167	20 72	0 4161	109 8
SX-106	2500	105	20 8	2 154	43 9

Note 15 5% NH3 = 100% LFL

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-4 Henry's Law Constant Calculation for Tank S-101 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S 101				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	215000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	24500	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	20	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	813	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	8	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	2360	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	0	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	94000	Temperature of Air in Vapor Space	°F	117 8
CO_3^{2}	µg/ml	5300	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3861	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	5650	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	106	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	7450	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	62 66			
Specific Gravity	unitless	1 36			
Total Organic Carbon	g/l	0 267			
Cs-137	µCi/ml	0			
Temperature	°F	116			

Author D C Hedengren Date 1/26/00 Checked by J D Baker Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-4 (Cont d) Henry s Law Constant Calculation for Tank S 101 (2 pages)

Source Tank	S 101	INPUT DATA	Date	36538 62121		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1
Na^{1}	22 99	9 3518782	0 1143	1 068919679	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 91	0 2174	0 19741654				5 87175E 05
Fe^{+3}	55 85	0 00	0 1161	4 17835E 05				
Cr^{3}	52	1 563E 02	0 0648	0 001013123	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	1 366E 04	0 1654	2 25942E-05				
K^{+1}	39 09	6 037E 02	0 0922	0 005566423	Ammonia	0	0 0481	
OH^{1}	17 0074	0 00	0 0839	0	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364723	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 04	0 0795	0 162436989				
CO_3^{2}	60 0092	0 09	0 1423	0 012567906				
PO_4^{-3}	94 9676	0 04	0 2119	0 008615636				
SO_4^{2}	96 0576	5 882E 02	0 1117	0 006570066				
F^{1}	19	5 579E 03	0 092	0 000513263				
Cl^{1}	35 453	2 101E 01	0 0318	0 006682367				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		15 70232786		1 507731093				
Mass fraction water in liq		0 63						Temperature
Liquid density (kg/m3)		1360 000						deg F
T (C)		47						116
								Temperature
								deg C
								46 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		5 87175E 05	0 0481	5 655215037	23 3029728	3 511490548	1 67215E 05	
Hydrogen			2 828E 02	1 158E+01	7 300E 04	5 372E 05	0 000E+00	
Methane			-9 153E 03	2 312E+01	1 066E 03	3 929E 05	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-5 Henry's Law Constant Calculation for Tank S-102 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S 102				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1700	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	231999	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	43500	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	38	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	97	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	16	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3190	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40950	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	158999	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	112000	Temperature of Air in Vapor Space	°F	106 8
CO_3^{2}	µg/ml	26410	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	4880	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4610	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	314	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	10200	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50			
Specific Gravity	unitless	1 39			
Total Organic Carbon	g/l	3 906			
Cs 137	µCi/ml	324			
Temperature	°F	105			

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DCRT 244-S
Case 8 (Story 1)

Table S8-5 (Cont d) Henry s Law Constant Calculation for Tank S 102 (2 pages)

Source Tank	S 102	INPUT DATA	Date	36538 64032		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1700
Na^{+1}	22 99	10 091315	0 1143	1 153437345	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 61	0 2174	0 350515599				0 099819737
Fe^{+3}	55 85	0 00	0 1161	7 98252E 05				
Cr^{+3}	52	1 860E 03	0 0648	0 000120503	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 674E 04	0 1654	4 42308E-05				
K^{+1}	39 09	8 161E 02	0 0922	0 007524111	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 202012359	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 56	0 0128	0 032823072	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 43	0 0795	0 193541981				
CO_3^{2}	60 0092	0 44	0 1423	0 062626114				
PO_4^{3}	94 9676	0 05	0 2119	0 010888678				
SO_4^{2}	96 0576	4 799E 02	0 1117	0 005360716				
F^{1}	19	1 653E 02	0 092	0 001520419				
Cl^{1}	35 453	2 877E 01	0 0318	0 009149015				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 03832024		2 029643968				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1390 000						deg F
T (C)		41						105
								Temperature
								deg C
								40 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 099819737	0 0481	11 63592102	30 15616267	1 801192447	0 055418696	
Hydrogen			2 645E 02	3 159E+01	7 380E 04	1 623E 05	0 000E+00	
Methane			5 951E 03	8 136E+01	1 138E 03	9 723E 06	0 000E+00	

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DCRT 244-S

Case 8 (Story 1)

Table S8-6 Henry's Law Constant Calculation for Tank S-103 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S 103				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1410	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	215000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	24500	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	20	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	269	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	8	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	2360	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	36467	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	94000	Temperature of Air in Vapor Space	°F	87 8
CO_3^{2}	µg/ml	22279	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3861	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	5650	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	106	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	7450	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	49 8			
Specific Gravity	unitless	1 36			
Total Organic Carbon	g/l	4 679			
Cs-137	µCi/ml	365			
Temperature	°F	86			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-6 (Cont d) Henry s Law Constant Calculation for Tank S 103 (2 pages)

Source Tank	S 103	INPUT DATA	Date	36538 6412		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W [1]	ci (moles/L)	hi	hi ci				1410
Na^{+1}	22 99	9 3518782	0 1143	1 068919679	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 91	0 2174	0 19741654				0 082791664
Fe^{+3}	55 85	0 00	0 1161	4 17835E 05				
Cr^{+3}	52	5 173E 03	0 0648	0 000335215	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	1 366E 04	0 1654	2 25942E 05				
K^{+1}	39 09	6 037E 02	0 0922	0 005566423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 14	0 0839	0 179897062	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364723	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 04	0 0795	0 162436989				
CO_3^{2}	60 0092	0 37	0 1423	0 052830261				
PO_4^{3}	94 9676	0 04	0 2119	0 008615575				
SO_4^{2}	96 0576	5 882E 02	0 1117	0 006570066				
F^{1}	19	5 579E 03	0 092	0 000513263				
Cl^{1}	35 453	2 101E 01	0 0318	0 006682367				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		18 11899028		1 727212542				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1360 000						deg F
T (C)		30						86
								Temperature
								deg C
								30
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 082791664	0 0481	7 172806414	48 15160904	4 546633478	0 018209443	
Hydrogen			2 330E 02	2 019E+01	7 647E 04	2 565E 05	0 000E+00	
Methane			4 200E 04	5 243E+01	1 315E 03	1 698E 05	0 000E+00	

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Case 8 (Story 1)

Table S8-7 Henry's Law Constant Calculation for Tank S-106 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S 106				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	430	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	244000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	37967	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	9410	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	1840	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	54865	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	240000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	109000	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	15750	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	6380	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	5730	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	140	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	11100	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	51 28			
Specific Gravity	unitless	1 45			
Total Organic Carbon	g/l	1 525			
Cs 137	µCi/ml	267			
Temperature	°F	80			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-7 (Cont d) Henry s Law Constant Calculation for Tank S 106 (2 pages)

Source Tank	S 106	INPUT DATA	Date	36538 6416		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				430
Na^{+1}	22 99	10 613319	0 1143	1 213102343	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 41	0 2174	0 305931275				0 025248522
Fe^{+3}	55 85	0 00	0 1161	6 25713E 05				
Cr^{+3}	52	1 810E 01	0 0648	0 011726316	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 044E 04	0 1654	3 38068E 05				
K^{1}	39 09	4 707E 02	0 0922	0 004339949	Ammonia	0	0 0481	
OH^{1}	17 0074	3 23	0 0839	0 270657096	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	3 87	0 0128	0 049544399	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 37	0 0795	0 188357879				
CO_3^{2}	60 0092	0 26	0 1423	0 03734813				
PO_4^{-3}	94 9676	0 07	0 2119	0 014235613				
SO_4^{2}	96 0576	5 965E 02	0 1117	0 006663089				
F^{1}	19	7 368E 03	0 092	0 000677895				
Cl^{1}	35 453	3 131E 01	0 0318	0 009956277				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		22 42496069		2 112636639				
Mass fraction water in liq		0 51						Temperature
Liquid density (kg/m3)		1450 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 025248522	0 0481	10 81424066	56 17624453	3 862537344	0 006536771	
Hydrogen			2 230E 02	4 098E+01	7 771E 04	1 410E 05	0 000E+00	
Methane			1 327E 03	1 388E+02	1 389E 03	7 439E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-8 Henry's Law Constant Calculation for Tank S-107 (2 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S 107				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	126749	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	7731	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	20	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	1220	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	8	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	1285	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	0	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	93425	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	46735	Temperature of Air in Vapor Space	°F	107 8
CO_3^{2}	μg/ml	0	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3854	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	3642	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	327	Surface Area of Still Waste	m²	16 417
Cl^{1}	μg/ml	3542	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	68 21			
Specific Gravity	unitless	1 238			
Total Organic Carbon	g/l	0			
Cs 137	μCi/ml	0			
Temperature	°F	106			

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DCRT 244-S
Case 8 (Story 1)

Table S8-8 (Cont d) Henry s Law Constant Calculation for Tank S 107 (2 pages)

Source Tank	S 107	INPUT DATA	Date	36538 64239		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1
Na^{+1}	22 99	5 5132231	0 1143	0 630161405	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 29	0 2174	0 062295011				5 87175E 05
Fe^{+3}	55 85	0 00	0 1161	4 15756E 05				
Cr^{+3}	52	2 346E 02	0 0648	0 001520308	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	1 431E 04	0 1654	2 36648E 05				
K^{1}	39 09	3 287E 02	0 0922	0 003030877	Ammonia	0	0 0481	
OH^{1}	17 0074	0 00	0 0839	0	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	1 51	0 0128	0 019286218	Methane	0 524	0 0022	
NO_2^{1}	46 0055	1 02	0 0795	0 080760616				
CO_3^{2}	60 0092	0 00	0 1423	0				
PO_4^{3}	94 9676	0 04	0 2119	0 008599381				
SO_4^{2}	96 0576	3 791E 02	0 1117	0 004235078				
F^{1}	19	1 721E 02	0 092	0 001583368				
Cl^{1}	35 453	9 991E 02	0 0318	0 00317704				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		8 57481132		0 814714542				
Mass fraction water in liq		0 68						Temperature
Liquid density (kg/m3)		1238 000						deg F
T (C)		41						106
								Temperature
								deg C
								41 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		5 87175E 05	0 0481	2 525027532	29 44631257	9 847670167	5 96258E 06	
Hydrogen			2 662E 02	3 859E+00	7 371E 04	1 613E-04	0 000E+00	
Methane			6 242E 03	5 770E+00	1 131E 03	1 655E 04	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-9 Henry's Law Constant Calculation for Tank S-109 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S-109				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1550	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	211750	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	34499	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	7241	Flow Rate of Waste	gpm	4
$Ni^{\ 2}$	µg/ml	11	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	1780	Ventilation Flow Rate for Receiving Tank	cfm	0 05
$OH^{\ 1}$	µg/ml	81883	Total Ventilation Flow Rate for Stack	cfm	0 05
$NO_3^{\ 1}$	µg/ml	237288	Total Bubbler Flow Rate	cfh	3
$NO_2^{\ 1}$	µg/ml	64455	Temperature of Air in Vapor Space	°F	86 8
$CO_3^{\ 2}$	µg/ml	9800	Stream Diameter	inches	1
$PO_4^{\ 3}$	µg/ml	1836	Tortuosity Factor	unitless	1
$SO_4^{\ 2}$	µg/ml	2502	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
$F^{\ 1}$	µg/ml	89	Surface Area of Still Waste	m^2	16 417
$Cl^{\ 1}$	µg/ml	7147	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
$Br^{\ 1}$	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	52 94			
Specific Gravity	unitless	1 463			
Total Organic Carbon	g/l	1 115			
Cs 137	µCi/ml	315			
Temperature	°F	85			

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DCRT 244-S
Case 8 (Story 1)

Table S8-9 (Cont d) Henry s Law Constant Calculation for Tank S-109 (2 pages)

Source Tank	S 109	INPUT DATA	Date	36538 64205		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1550
Na^{+1}	22 99	9 2105263	0 1143	1 052763158	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 28	0 2174	0 277986753				0 091012113
Fe^{+3}	55 85	0 00	0 1161	6 1532E 05				
Cr^{+3}	52	1 393E 01	0 0648	0 009023712	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	1 874E 04	0 1654	3 09896E-05				
K^{+1}	39 09	4 554E 02	0 0922	0 004198414	Ammonia	0	0 0481	
OH^{1}	17 0074	4 81	0 0839	0 403940855	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	3 83	0 0128	0 048984516	Methane	0 524	0 0022	
NO_2^{1}	46 0055	1 40	0 0795	0 111381737				
CO_3^{2}	60 0092	0 16	0 1423	0 02323877				
PO_4^{3}	94 9676	0 02	0 2119	0 004096643				
SO_4^{2}	96 0576	2 605E 02	0 1117	0 002909436				
F^{1}	19	4 684E 03	0 092	0 000430947				
Cl^{1}	35 453	2 016E 01	0 0318	0 006410589				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 1321802		1 945458051				
Mass fraction water in liq		0 53						Temperature
Liquid density (kg/m3)		1463 000						deg F
T (C)		29						85
								Temperature
								deg C
								29 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 091012113	0 0481	8 491808336	49 39378673	4 505058159	0 020202206	
Hydrogen			2 313E 02	2 862E+01	7 666E 04	2 075E 05	0 000E+00	
Methane			1 289E 04	8 765E+01	1 326E 03	1 172E 05	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-10 Henry s Law Constant Calculation for Tank S-111 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	S 111				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1500	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	217000	Volume of Vapor Space	L	15359
Al^{3}	µg/ml	25500	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	20	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	4380	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	8	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	1560	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	47250	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	190000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	64600	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	29200	Stream Diameter	inches	1
PO_4^{3}	µg/ml	2540	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4650	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	112	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	6020	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	52 46			
Specific Gravity	unitless	1 39			
Total Organic Carbon	g/l	1 423			
Cs 137	µCi/ml	275			
Temperature	°F	90			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8 10 (Cont d) Henry s Law Constant Calculation for Tank S 111 (2 pages)

Source Tank	S 111	INPUT DATA	Date	36538 64257		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1500
Na^{+1}	22 99	9 4388799	0 1143	1 078863978	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 95	0 2174	0 20547416				0 088076239
Fe^{+3}	55 85	0 00	0 1161	4 17834E 05				
Cr^{+3}	52	8 423E 02	0 0648	0 005458155	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	1 366E 04	0 1654	2 25942E 05				
K^{+1}	39 09	3 991E 02	0 0922	0 003679502	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 78	0 0839	0 233091184	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	3 06	0 0128	0 039222808	Methane	0 524	0 0022	
NO_2^{1}	46 0055	1 40	0 0795	0 111632256				
CO_3^{2}	60 0092	0 49	0 1423	0 069242069				
PO_4^{3}	94 9676	0 03	0 2119	0 005667476				
SO_4^{2}	96 0576	4 841E 02	0 1117	0 005407218				
F^{1}	19	5 895E 03	0 092	0 000542316				
Cl^{1}	35 453	1 698E 01	0 0318	0 005399718				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		18 49276578		1 763745217				
Mass fraction water in liq		0 52						Temperature
Liquid density (kg/m3)		1390 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 088076239	0 0481	7 485885544	43 52508667	4 239743162	0 020773956	
Hydrogen			2 396E 02	2 093E+01	7 576E-04	2 640E 05	0 000E+00	
Methane			1 584E 03	5 426E+01	1 271E 03	1 708E 05	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-11 Henry's Law Constant Calculation for Tank SX-101 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-101				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	132	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	242000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	75600	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	36	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	12100	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	2520	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	48660	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	105000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	78000	Temperature of Air in Vapor Space	°F	134 8
CO_3^{2}	µg/ml	8050	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	5180	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	1830	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	71	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	16700	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	49 1			
Specific Gravity	unitless	1 499			
Total Organic Carbon	g/l	0 335			
Cs 137	µCi/ml	403			
Temperature	°F	133			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8 11 (Cont d) Henry s Law Constant Calculation for Tank SX 101 (2 pages)

Source Tank	SX 101	INPUT DATA	Date	36538 67349		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				132
Na^{+1}	22 99	10 526318	0 1143	1 203158188	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	2 80	0 2174	0 609170967				0 007750709
Fe^{+3}	55 85	0 00	0 1161	7 40047E-05				
Cr^{+3}	52	2 327E 01	0 0648	0 015078465	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 044E 04	0 1654	3 38068E 05				
K^{+1}	39 09	6 447E 02	0 0922	0 005943819	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 86	0 0839	0 240046921	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	1 69	0 0128	0 021675707	Methane	0 524	0 0022	
NO_2^{1}	46 0055	1 70	0 0795	0 134788258				
CO_3^{2}	60 0092	0 13	0 1423	0 019089001				
PO_4^{-3}	94 9676	0 05	0 2119	0 011558078				
SO_4^{2}	96 0576	1 905E 02	0 1117	0 002127998				
F^{1}	19	3 737E 03	0 092	0 000343789				
Cl^{1}	35 453	4 710E 01	0 0318	0 014979321				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 55889224		2 278068325				
Mass fraction water in liq		0 49						Temperature
Liquid density (kg/m3)		1499 000						deg F
T (C)		56						133
								Temperature
								deg C
								56 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 007750709	0 0481	19 46191664	15 9199367	0 602058723	0 012873676	
Hydrogen			3 110E 02	4 352E+01	7 269E-04	1 229E 05	0 000E+00	
Methane			1 410E-02	9 731E+01	9 854E-04	7 453E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-12 Henry's Law Constant Calculation for Tank SX-102 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 102				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1370	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	45600	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	36	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	2770	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	15	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3550	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	50050	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	158001	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	151000	Temperature of Air in Vapor Space	°F	143 8
CO_3^{2}	µg/ml	8800	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3490	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3330	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	78	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	10200	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	48 03			
Specific Gravity	unitless	1 45			
Total Organic Carbon	g/l	1 51			
Cs 137	µCi/ml	438			
Temperature	°F	142			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8 12 (Cont d) Henry s Law Constant Calculation for Tank SX 102 (2 pages)

Source Tank	SX 102	INPUT DATA	Date	36538 67349		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1370
Na^{+1}	22 99	10 221838	0 1143	1 168356055	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 69	0 2174	0 367436902				0 080442965
Fe^{+3}	55 85	0 00	0 1161	7 58755E 05				
Cr^{+3}	52	5 327E 02	0 0648	0 003451837	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 470E 04	0 1654	4 08499E 05				
K^{+1}	39 09	9 082E 02	0 0922	0 008373255	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 94	0 0839	0 246903995	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 55	0 0128	0 032616922	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 28	0 0795	0 260936365				
CO_3^{2}	60 0092	0 15	0 1423	0 020867482				
PO_4^{3}	94 9676	0 04	0 2119	0 007787204				
SO_4^{2}	96 0576	3 467E 02	0 1117	0 003872267				
F^{1}	19	4 105E 03	0 092	0 000377684				
Cl^{1}	35 453	2 877E 01	0 0318	0 009149011				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 34008819		2 130245706				
Mass fraction water in liq		0 48						Temperature
Liquid density (kg/m3)		1450 000						deg F
T (C)		61						142
								Temperature
								deg C
								61 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 080442965	0 0481	12 69952459	13 11687776	0 71932242	0 111831583	
Hydrogen			3 260E 02	2 720E+01	7 293E 04	1 867E 05	0 000E+00	
Methane			1 672E 02	5 935E+01	9 547E 04	1 120E 05	0 000E+00	

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Case 8 (Story 1)

Table S8-13 Henry's Law Constant Calculation for Tank SX-103 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-103				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1800	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	237393	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44121	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	32	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	84	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	13	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4242	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	41517	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	158629	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	158479	Temperature of Air in Vapor Space	°F	162 8
CO_3^{2}	µg/ml	12750	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3329	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	2014	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	101	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	10996	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	46 95			
Specific Gravity	unitless	1 47			
Total Organic Carbon	g/l	3 051			
Cs-137	µCi/ml	440			
Temperature	°F	161			

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DCRT **244-S**
Case *8 (Story 1)*

Table S8 13 (Cont d) Henry s Law Constant Calculation for Tank SX-103 (2 pages)

Source Tank	SX 103	INPUT DATA	Date	36538 67349		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1800
Na^{+1}	22 99	10 325935	0 1143	1 180254342	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 64	0 2174	0 355519272				0 105691487
Fe^{+3}	55 85	0 00	0 1161	6 67289E 05				
Cr^{+3}	52	1 608E 03	0 0648	0 000104178	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 180E 04	0 1654	3 60606E 05				
K^{+1}	39 09	1 085E 01	0 0922	0 010005419	Ammonia	0	0 0481	
OH^{1}	17 0074	2 44	0 0839	0 204809454	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 56	0 0128	0 03274666	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 44	0 0795	0 273860708				
CO_3^{2}	60 0092	0 21	0 1423	0 030234116				
PO_4^{3}	94 9676	0 04	0 2119	0 007427969				
SO_4^{2}	96 0576	2 097E 02	0 1117	0 002341971				
F^{1}	19	5 316E 03	0 092	0 000489053				
Cl^{1}	35 453	3 102E 01	0 0318	0 009862993				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 10037354		2 107758925				
Mass fraction water in liq		0 47						Temperature
Liquid density (kg/m3)		1470 000						deg F
T (C)		72						161
								Temperature
								deg C
								71 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 105691487	0 0481	12 38314497	8 863887473	0 494021907	0 21394089	
Hydrogen			3 575E 02	2 256E+01	7 432E 04	2 273E 05	0 000E+00	
Methane			2 225E 02	4 347E+01	9 109E 04	1 446E 05	0 000E+00	

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Case 8 (Story 1)

Table S8-14 Henry's Law Constant Calculation for Tank SX-104 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 104				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	793	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	249900	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	35574	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	34	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	939	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	14	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	2881	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	34150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	291060	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	117306	Temperature of Air in Vapor Space	°F	145 8
CO_3^{2}	µg/ml	24770	Stream Diameter	inches	1
PO_4^{3}	µg/ml	12730	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3896	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	187	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8232	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 76			
Specific Gravity	unitless	1 47			
Total Organic Carbon	g/l	2 195			
Cs 137	µCi/ml	283			
Temperature	°F	144			

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DCRT 244-S
Case 8 (Story 1)

Table S8-14 (Cont d) Henry s Law Constant Calculation for Tank SX 104 (2 pages)

Source Tank	SX 104	INPUT DATA	Date	36538 67349		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				793
Na^{1}	22 99	10 869943	0 1143	1 242434537	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 32	0 2174	0 28664891				0 046562972
Fe^{+3}	55 85	0 00	0 1161	7 02836E 05				
Cr^{+3}	52	1 806E 02	0 0648	0 00117055	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 301E 04	0 1654	3 80589E 05				
K^{+1}	39 09	7 371E 02	0 0922	0 00679577	Ammonia	0	0 0481	
OH^{1}	17 0074	2 01	0 0839	0 168466961	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	4 69	0 0128	0 060085058	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	2 55	0 0795	0 202711132				
CO_3^{2}	60 0092	0 41	0 1423	0 058735991				
PO_4^{3}	94 9676	0 13	0 2119	0 028404734				
SO_4^{2}	96 0576	4 055E 02	0 1117	0 004529859				
F^{1}	19	9 826E 03	0 092	0 000903973				
Cl^{1}	35 453	2 322E 01	0 0318	0 007383793				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		22 36238608		2 068379609				
Mass fraction water in liq		0 51						Temperature
Liquid density (kg/m3)		1470 000						deg F
T (C)		62						144
								Temperature
								deg C
								62 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 046562972	0 0481	9 834421976	12 5733831	0 953986563	0 048808834	
Hydrogen			3 293E 02	2 148E+01	7 302E 04	2 537E 05	0 000E+00	
Methane			1 730E 02	4 802E+01	9 488E 04	1 474E 05	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-15 Henry's Law Constant Calculation for Tank SX-105 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1210	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	168 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	167			

Author A26 [signature] Date 1/26/99 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8 15 (Cont d) Henry s Law Constant Calculation for Tank SX 105 (2 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 67349		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1210
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 071048166
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{-1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		75						167
								Temperature
								deg C
								75
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 071048166	0 0481	11 89866249	7 867518994	0 416120578	0 170739371	
Hydrogen			3 675E-02	2 045E+01	7 499E 04	2 308E 05	0 000E+00	
Methane			2 400E-02	3 757E+01	9 021E 04	1 511E 05	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-16 Henry's Law Constant Calculation for Tank SX-106 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 106				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2500	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	245000	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	25887	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	130	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3891	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	33117	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	209656	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	132044	Temperature of Air in Vapor Space	°F	106 8
CO_3^{2}	µg/ml	25594	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3514	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	7202	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	311	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	11732	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	45 79			
Specific Gravity	unitless	1 42			
Total Organic Carbon	g/l	3 951			
Cs 137	µCi/ml	377			
Temperature	°F	105			

Author D C Hedengren Date 1/26/00 Checked by J D Rayburn Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8 16 (Cont d) Henry s Law Constant Calculation for Tank SX 106 (2 pages)

Source Tank	SX 106	INPUT DATA	Date	36538 67349		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				2500
Na^{+1}	22 99	10 656794	0 1143	1 218071584	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 96	0 2174	0 208596444				0 146793731
Fe^{+3}	55 85	0 00	0 1161	6 25714E 05				
Cr^{3}	52	2 492E 03	0 0648	0 000161455	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 044E 04	0 1654	3 38068E 05				
K^{+1}	39 09	9 955E 02	0 0922	0 009178144	Ammonia	0	-0 0481	
OH^{1}	17 0074	1 95	0 0839	0 163371021	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	3 38	0 0128	0 043280378	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 87	0 0795	0 228178871				
CO_3^{2}	60 0092	0 43	0 1423	0 060690647				
PO_4^{3}	94 9676	0 04	0 2119	0 007841637				
SO_4^{2}	96 0576	7 497E 02	0 1117	0 008374652				
F^{1}	19	1 638E 02	0 092	0 00150663				
Cl^{1}	35 453	3 309E 01	0 0318	0 010523043				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 80351412		1 959870885				
Mass fraction water in liq		0 46						Temperature
Liquid density (kg/m3)		1420 000						deg F
T (C)		41						105
								Temperature
								deg C
								40 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 146793731	0 0481	9 103782124	30 15616267	2 153838868	0 068154463	
Hydrogen			2 645E 02	2 568E+01	7 380E 04	1 869E 05	0 000E+00	
Methane			5 951E 03	6 856E+01	1 138E 03	1 079E 05	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-17 SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	2555	Percent Fill of Receiving Tank	%	80
Na^{1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	70			

Author D C Hedengren Date 1/26/00 Checked by S D R[illegible] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70269		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				2555
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 150023193
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 150023193	0 0481	11 89866249	73 15835385	3 869415064	0 038771543	
Hydrogen			2 064E 02	4 411E+01	8 025E 04	1 145E 05	0 000E+00	
Methane			4 238E 03	1 445E+02	1 537E-03	6 696E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Based on Henry's Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	*T sec*	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	4 308E 02	**0 10**	**0 67**	
0 0183	66	7 809E 02	**0 19**	**1 22**	
0 0333	120	1 391E 01	**0 34**	**2 18**	
0 0617	222	2 478E 01	**0 60**	**3 88**	
0 1033	372	3 932E 01	**0 95**	**6 15**	
0 1750	630	6 075E 01	**1 47**	**9 50**	
0 332	1194	9 525E 01	**2 31**	**14 90**	
0 620	2232	1 305E+00	**3 16**	**20 40**	
1 035	3726	1 504E+00	**3 65**	**23 52**	
2 27	8154	1 595E+00	**3 87**	**24 95**	
3 35	12060	1 598E+00	**3 87**	**24 99**	
5 38	19362	1 598E+00	**3 87**	**25 00**	
8 27	29784	1 598E+00	**3 87**	**25 00**	
9 68	34860	1 598E+00	**3 87**	**25 00**	
10 9	39300	1 598E+00	**3 87**	**25 00**	
13 2	47640	1 598E+00	**3 87**	**25 00**	
16 6	59580	1 598E+00	**3 87**	**25 00**	
67 6	243444	1 598E+00	**3 87**	**25 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 598E+00	**3 87**	**25 00**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by S.D.Rfn Date 1/21/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	5111	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	70			

Author DC Hedengren Date 1/26/00 Checked by J. D. Rifle Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 7064		Revision	0	NH_3	
Dilution Ratio	0 1							ug/ml	
Ion	M W	ci (moles/L)	hi	hi ci				5111	
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L	
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 300105104	
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05					
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)		
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05					
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481		
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218		
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022		
NO_2^{1}	46 0055	3 10	0 0795	0 246775523					
CO_3^{2}	60 0092	0 24	0 1423	0 033508286					
PO_4^{3}	94 9676	0 03	0 2119	0 007286383					
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295					
F^{1}	19	5 466E 03	0 092	0 000502894					
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632					
Li^{+1}	6 94	0 00	0 0754	0					
Br^{1}	79 916	0 000E+00	0 0269	0					
								Average	
		20 71872705		2 072068917					
Mass fraction water in liq		0 43						Temperature	
Liquid density (kg/m3)		1468 000						deg F	
T (C)		21						70	
								Temperature	
								deg C	
								21 11111111	
					PNL 10785				
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3		
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm		
Ammonia		0 300105104	0 0481	11 89866249	73 15835385	3 869415064	0 077558261		
Hydrogen			2 064E 02	4 411E+01	8 025E 04	1 145E 05	0 000E+00		
Methane			4 238E 03	1 445E+02	1 537E 03	6 696E-06	0 000E+00		

Author DC Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	8 618E 02	**0 21**	**1 35**	
0 0183	66	1 562E 01	**0 38**	**2 44**	
0 0333	120	2 783E 01	**0 67**	**4 35**	
0 0617	222	4 958E 01	**1 20**	**7 75**	
0 1033	372	7 865E 01	**1 91**	**12 30**	
0 1750	630	1 215E+00	**2 95**	**19 00**	
0 332	1194	1 905E+00	**4 62**	**29 80**	
0 620	2232	2 610E+00	**6 33**	**40 81**	
1 035	3726	3 008E+00	**7 29**	**47 05**	
2 27	8154	3 191E+00	**7 73**	**49 90**	
3 35	12060	3 197E+00	**7 75**	**50 00**	
5 38	19362	3 197E+00	**7 75**	**50 00**	
8 27	29784	3 197E+00	**7 75**	**50 00**	
9 68	34860	3 197E+00	**7 75**	**50 00**	
10 9	39300	3 197E+00	**7 75**	**50 00**	
13 2	47640	3 197E+00	**7 75**	**50 00**	
16 6	59580	3 197E+00	**7 75**	**50 00**	
67 6	243444	3 197E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 197E+00	**7 75**	**50 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	10221	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	70			

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX 105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70711		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				10221
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 600151491
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
$NO_3{}^{1}$	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
$NO_2{}^{1}$	46 0055	3 10	0 0795	0 246775523				
$CO_3{}^{2}$	60 0092	0 24	0 1423	0 033508286				
$PO_4{}^{3}$	94 9676	0 03	0 2119	0 007286383				
$SO_4{}^{2}$	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 600151491	0 0481	11 89866249	73 15835385	3 869415064	0 155101348	
Hydrogen			2 064E 02	4 411E+01	8 025E 04	1 145E 05	0 000E+00	
Methane			4 238E 03	1 445E+02	1 537E 03	6 696E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**%$NH_{3(Max)}$**	**15 51**	%		Based on Henry s Law Constant
		Variable Delta C	**Variable Delta C**	**Variable Delta C**	
Time hours	*T sec*	***NH_3 mole/m^3***	**%NH_3**	**% LFL NH_3**	
0 0100	36	1 723E 01	**0 42**	**2 70**	
0 0183	66	3 124E 01	**0 76**	**4 89**	
0 0333	120	5 566E 01	**1 35**	**8 70**	
0 0617	222	9 914E 01	**2 40**	**15 51**	
0 1033	372	1 573E+00	**3 81**	**24 60**	
0 1750	630	2 430E+00	**5 89**	**38 01**	
0 332	1194	3 810E+00	**9 24**	**59 59**	
0 620	2232	5 219E+00	**12 65**	**81 62**	
1 035	3726	6 016E+00	**14 58**	**94 08**	
2 27	8154	6 381E+00	**15 47**	**99 79**	
3 35	12060	6 393E+00	**15 50**	**99 99**	
5 38	19362	6 394E+00	**15 50**	**100 00**	
8 27	29784	6 394E+00	**15 50**	**100 00**	
9 68	34860	6 394E+00	**15 50**	**100 00**	
10 9	39300	6 394E+00	**15 50**	**100 00**	
13 2	47640	6 394E+00	**15 50**	**100 00**	
16 6	59580	6 394E+00	**15 50**	**100 00**	
67 6	243444	6 394E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 394E+00	**15 50**	**100 00**	Steady state with continuous addition

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			*Tank Characteristics (Receiving Tank)*		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1962	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	80			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70744		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1962
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 11520372
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{-1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 11520372	0 0481	11 89866249	56 17624453	2 971215116	0 038773268	
Hydrogen			2 230E 02	4 075E+01	7 771E 04	1 200E 05	0 000E+00	
Methane			1 327E 03	1 258E+02	1 389E 03	6 949E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	3 526E 02	0 09	0 56	
0 0183	66	6 403E 02	0 16	1 02	
0 0333	120	1 145E 01	0 28	1 82	
0 0617	222	2 052E 01	0 51	3 27	
0 1033	372	3 284E 01	0 81	5 23	
0 1750	630	5 149E 01	1 27	8 20	
0 332	1194	8 306E 01	2 05	13 23	
0 620	2232	1 185E+00	2 93	18 89	
1 035	3726	1 419E+00	3 51	22 62	
2 27	8154	1 560E+00	3 85	24 85	
3 35	12060	1 568E+00	3 87	24 98	
5 38	19362	1 569E+00	3 87	24 99	
8 27	29784	1 569E+00	3 87	24 99	
9 68	34860	1 569E+00	3 87	24 99	
10 9	39300	1 569E+00	3 87	24 99	
13 2	47640	1 569E+00	3 87	24 99	
16 6	59580	1 569E+00	3 87	24 99	
67 6	243444	1 569E+00	3 87	24 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 569E+00	3 87	24 99	Steady state with continuous addition

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3925	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	80			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8 17 (Cont d) SX 105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70766		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3925
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 230466158
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 230466158	-0 0481	11 89866249	56 17624453	2 971215116	0 077566298	
Hydrogen			2 230E 02	4 075E+01	7 771E 04	1 200E 05	0 000E+00	
Methane			1 327E 03	1 258E+02	1 389E-03	6 949E 06	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	7 053E 02	0 17	1 12	
0 0183	66	1 281E 01	0 32	2 04	
0 0333	120	2 290E 01	0 57	3 65	
0 0617	222	4 105E 01	1 01	6 54	
0 1033	372	6 570E 01	1 62	10 47	
0 1750	630	1 030E+00	2 54	16 41	
0 332	1194	1 662E+00	4 10	26 48	
0 620	2232	2 372E+00	5 86	37 79	
1 035	3726	2 840E+00	7 01	45 25	
2 27	8154	3 120E+00	7 71	49 71	
3 35	12060	3 137E+00	7 75	49 98	
5 38	19362	3 138E+00	7 75	50 00	
8 27	29784	3 138E+00	7 75	50 00	
9 68	34860	3 138E+00	7 75	50 00	
10 9	39300	3 138E+00	7 75	50 00	
13 2	47640	3 138E+00	7 75	50 00	
16 6	59580	3 138E+00	7 75	50 00	
67 6	243444	3 138E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 138E+00	7 75	50 00	Steady state with continuous addition

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	7850	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	80			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX 105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70784		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				7850
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 460932316
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 460932316	0 0481	11 89866249	56 17624453	2 971215116	0 155132597	
Hydrogen			2 230E 02	4 075E+01	7 771E 04	1 200E 05	0 000E+00	
Methane			1 327E 03	1 258E+02	1 389E 03	6 949E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 51**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 411E 01	**0 35**	**2 25**	
0 0183	66	2 562E 01	**0 63**	**4 08**	
0 0333	120	4 580E 01	**1 13**	**7 30**	
0 0617	222	8 209E 01	**2 03**	**13 08**	
0 1033	372	1 314E+00	**3 25**	**20 94**	
0 1750	630	2 060E+00	**5 09**	**32 82**	
0 332	1194	3 323E+00	**8 21**	**52 95**	
0 620	2232	4 743E+00	**11 71**	**75 57**	
1 035	3726	5 679E+00	**14 03**	**90 49**	
2 27	8154	6 240E+00	**15 41**	**99 42**	
3 35	12060	6 273E+00	**15 49**	**99 96**	
5 38	19362	6 276E+00	**15 50**	**100 00**	
8 27	29784	6 276E+00	**15 50**	**100 00**	
9 68	34860	6 276E+00	**15 50**	**100 00**	
10 9	39300	6 276E+00	**15 50**	**100 00**	
13 2	47640	6 276E+00	**15 50**	**100 00**	
16 6	59580	6 276E+00	**15 50**	**100 00**	
67 6	243444	6 276E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 276E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1521	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	90			

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Case 8 (Story 1)

Table S8 17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70817		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1521
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 089309306
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 089309306	0 0481	11 89866249	43 52508667	2 302083319	0 038794993	
Hydrogen			2 396E 02	3 764E+01	7 576E 04	1 267E 05	0 000E+00	
Methane			1 584E 03	1 095E+02	1 271E 03	7 308E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 892E 02	**0 07**	**0 47**	
0 0183	66	5 261E 02	**0 13**	**0 85**	
0 0333	120	9 431E 02	**0 24**	**1 53**	
0 0617	222	1 699E 01	**0 43**	**2 76**	
0 1033	372	2 740E 01	**0 69**	**4 45**	
0 1750	630	4 349E 01	**1 09**	**7 06**	
0 332	1194	7 189E 01	**1 81**	**11 67**	
0 620	2232	1 065E+00	**2 68**	**17 28**	
1 035	3726	1 324E+00	**3 33**	**21 49**	
2 27	8154	1 520E+00	**3 82**	**24 66**	
3 35	12060	1 538E+00	**3 87**	**24 96**	
5 38	19362	1 541E+00	**3 88**	**25 00**	
8 27	29784	1 541E+00	**3 88**	**25 00**	
9 68	34860	1 541E+00	**3 88**	**25 00**	
10 9	39300	1 541E+00	**3 88**	**25 00**	
13 2	47640	1 541E+00	**3 88**	**25 00**	
16 6	59580	1 541E+00	**3 88**	**25 00**	
67 6	243444	1 541E+00	**3 88**	**25 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 541E+00	**3 88**	**25 00**	Steady state with continuous addition

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Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3041	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	90			

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Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70834		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3041
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 178559895
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 178559895	0 0481	11 89866249	43 52508667	2 302083319	0 07756448	
Hydrogen			2 396E 02	3 764E+01	7 576E 04	1 267E 05	0 000E+00	
Methane			1 584E 03	1 095E+02	1 271E 03	7 308E 06	0 000E+00	

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Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	5 783E 02	**0 15**	**0 94**	
0 0183	66	1 052E 01	**0 26**	**1 71**	
0 0333	120	1 886E 01	**0 47**	**3 06**	
0 0617	222	3 397E 01	**0 85**	**5 51**	
0 1033	372	5 478E 01	**1 38**	**8 89**	
0 1750	630	8 695E 01	**2 19**	**14 11**	
0 332	1194	1 437E+00	**3 62**	**23 33**	
0 620	2232	2 129E+00	**5 36**	**34 55**	
1 035	3726	2 647E+00	**6 66**	**42 96**	
2 27	8154	3 039E+00	**7 64**	**49 31**	
3 35	12060	3 075E+00	**7 74**	**49 91**	
5 38	19362	3 081E+00	**7 75**	**49 99**	
8 27	29784	3 081E+00	**7 75**	**49 99**	
9 68	34860	3 081E+00	**7 75**	**49 99**	
10 9	39300	3 081E+00	**7 75**	**49 99**	
13 2	47640	3 081E+00	**7 75**	**49 99**	
16 6	59580	3 081E+00	**7 75**	**49 99**	
67 6	243444	3 081E+00	**7 75**	**49 99**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 081E+00	**7 75**	**49 99**	Steady state with continuous addition

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	6083	Percent Fill of Receiving Tank	%	80
Na [1]	μg/ml	235679	Volume of Vapor Space	L	15359
Al [3]	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe [3]	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr [3]	μg/ml	338	Flow Rate of Waste	gpm	4
Ni [2]	μg/ml	12	Total Pressure in Vapor Space	atm	1
K [1]	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH [1]	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 [1]	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2 [1]	μg/ml	142805	Temperature of Air in Vapor Space	°F	91 8
CO_3 [2]	μg/ml	14131	Stream Diameter	inches	1
PO_4 [3]	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4 [2]	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F [1]	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl [1]	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li [+1]	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br [1]	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	90			

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DCRT 244-S
Case 8 (Story 1)

Table S8 17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70853		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				6083
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 357178507
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 357178507	0 0481	11 89866249	43 52508667	2 302083319	0 155154466	
Hydrogen			2 396E 02	3 764E+01	7 576E 04	1 267E 05	0 000E+00	
Methane			1 584E 03	1 095E+02	1 271E 03	7 308E 06	0 000E+00	

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Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**15 52**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	1 157E 01	**0 29**	**1 88**	
0 0183	66	2 104E 01	**0 53**	**3 41**	
0 0333	120	3 772E 01	**0 95**	**6 12**	
0 0617	222	6 796E 01	**1 71**	**11 03**	
0 1033	372	1 096E+00	**2 76**	**17 78**	
0 1750	630	1 739E+00	**4 37**	**28 22**	
0 332	1194	2 875E+00	**7 23**	**46 66**	
0 620	2232	4 259E+00	**10 71**	**69 11**	
1 035	3726	5 295E+00	**13 32**	**85 93**	
2 27	8154	6 078E+00	**15 29**	**98 63**	
3 35	12060	6 152E+00	**15 47**	**99 83**	
5 38	19362	6 162E+00	**15 50**	**100 00**	
8 27	29784	6 162E+00	**15 50**	**100 00**	
9 68	34860	6 162E+00	**15 50**	**100 00**	
10 9	39300	6 162E+00	**15 50**	**100 00**	
13 2	47640	6 162E+00	**15 50**	**100 00**	
16 6	59580	6 162E+00	**15 50**	**100 00**	
67 6	243444	6 162E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 162E+00	**15 50**	**100 00**	Steady state with continuous addition

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1188	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	100			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 70878		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1188
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 069756381
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 069756381	0 0481	11 89866249	34 01071777	1 798859279	0 03877812	
Hydrogen			2 562E 02	3 477E+01	7 434E 04	1 345E 05	0 000E+00	
Methane			4 496E 03	9 526E+01	1 178E 03	7 779E 06	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	%$NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	%NH_3	% LFL NH_3	
0 0100	36	2 379E 02	0 06	0 39	
0 0183	66	4 333E 02	0 11	0 72	
0 0333	120	7 785E 02	0 20	1 29	
0 0617	222	1 409E 01	0 36	2 33	
0 1033	372	2 286E 01	0 59	3 78	
0 1750	630	3 664E 01	0 94	6 05	
0 332	1194	6 185E 01	1 58	10 22	
0 620	2232	9 465E 01	2 42	15 64	
1 035	3726	1 219E+00	3 12	20 15	
2 27	8154	1 471E+00	3 77	24 30	
3 35	12060	1 505E+00	3 85	24 87	
5 38	19362	1 512E+00	3 87	24 98	
8 27	29784	1 512E+00	3 87	24 99	
9 68	34860	1 512E+00	3 87	24 99	
10 9	39300	1 512E+00	3 87	24 99	
13 2	47640	1 512E+00	3 87	24 99	
16 6	59580	1 512E+00	3 87	24 99	
67 6	243444	1 512E+00	3 87	24 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 512E+00	3 87	24 99	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. [signature] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2377	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	100			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71042		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2377
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 13957148
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
		20 71872705		2 072068917				Average
Mass fraction water in liq		0 43						
Liquid density (kg/m3)		1468 000						Temperature
T (C)		38						deg F
								100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 13957148	0 0481	11 89866249	34 01071777	1 798859279	0 077588882	
Hydrogen			2 562E 02	3 477E+01	7 434E 04	1 345E-05	0 000E+00	
Methane			4 496E 03	9 526E+01	1 178E 03	7 779E 06	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	4 760E 02	**0 12**	**0 79**	
0 0183	66	8 669E 02	**0 22**	**1 43**	
0 0333	120	1 558E 01	**0 40**	**2 57**	
0 0617	222	2 819E 01	**0 72**	**4 66**	
0 1033	372	4 573E 01	**1 17**	**7 56**	
0 1750	630	7 332E 01	**1 88**	**12 11**	
0 332	1194	1 238E+00	**3 17**	**20 45**	
0 620	2232	1 894E+00	**4 85**	**31 29**	
1 035	3726	2 440E+00	**6 25**	**40 31**	
2 27	8154	2 943E+00	**7 54**	**48 62**	
3 35	12060	3 011E+00	**7 71**	**49 75**	
5 38	19362	3 026E+00	**7 75**	**49 99**	
8 27	29784	3 026E+00	**7 75**	**50 00**	
9 68	34860	3 026E+00	**7 75**	**50 00**	
10 9	39300	3 026E+00	**7 75**	**50 00**	
13 2	47640	3 026E+00	**7 75**	**50 00**	
16 6	59580	3 026E+00	**7 75**	**50 00**	
67 6	243444	3 026E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 026E+00	**7 75**	**50 00**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. R[illegible] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	4754	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	100			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8 17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71059		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				4754
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 279142959
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
$NO_3{}^{1}$	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
$NO_2{}^{1}$	46 0055	3 10	0 0795	0 246775523				
$CO_3{}^{2}$	60 0092	0 24	0 1423	0 033508286				
$PO_4{}^{3}$	94 9676	0 03	0 2119	0 007286383				
$SO_4{}^{2}$	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 279142959	0 0481	11 89866249	34 01071777	1 798859279	0 155177763	
Hydrogen			2 562E-02	3 477E+01	7 434E 04	1 345E 05	0 000E+00	
Methane			4 496E 03	9 526E+01	1 178E 03	7 779E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 52**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	9 520E 02	**0 24**	**1 57**	
0 0183	66	1 734E 01	**0 44**	**2 86**	
0 0333	120	3 115E 01	**0 80**	**5 15**	
0 0617	222	5 637E 01	**1 44**	**9 31**	
0 1033	372	9 146E 01	**2 34**	**15 11**	
0 1750	630	1 466E+00	**3 76**	**24 23**	
0 332	1194	2 475E+00	**6 34**	**40 89**	
0 620	2232	3 788E+00	**9 70**	**62 58**	
1 035	3726	4 879E+00	**12 50**	**80 62**	
2 27	8154	5 886E+00	**15 07**	**97 24**	
3 35	12060	6 023E+00	**15 42**	**99 50**	
5 38	19362	6 051E+00	**15 50**	**99 98**	
8 27	29784	6 052E+00	**15 50**	**100 00**	
9 68	34860	6 052E+00	**15 50**	**100 00**	
10 9	39300	6 052E+00	**15 50**	**100 00**	
13 2	47640	6 052E+00	**15 50**	**100 00**	
16 6	59580	6 052E+00	**15 50**	**100 00**	
67 6	243444	6 052E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 052E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	936	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{-3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	110			

Author D C Hedengren Date 1/26/00 Checked by J D Bly Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71084		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				936
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 054959573
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 054959573	0 0481	11 89866249	26 79087387	1 416994854	0 038786007	
Hydrogen			2 728E-02	3 212E+01	7 337E 04	1 437E 05	0 000E+00	
Methane			7 407E 03	8 291E+01	1 103E 03	8 373E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 968E 02	**0 05**	**0 33**	
0 0183	66	3 589E 02	**0 09**	**0 60**	
0 0333	120	6 461E 02	**0 17**	**1 09**	
0 0617	222	1 173E 01	**0 31**	**1 97**	
0 1033	372	1 913E 01	**0 50**	**3 22**	
0 1750	630	3 093E 01	**0 81**	**5 20**	
0 332	1194	5 311E 01	**1 38**	**8 93**	
0 620	2232	8 359E 01	**2 18**	**14 06**	
1 035	3726	1 112E+00	**2 90**	**18 70**	
2 27	8154	1 413E+00	**3 68**	**23 77**	
3 35	12060	1 469E+00	**3 83**	**24 70**	
5 38	19362	1 485E+00	**3 87**	**24 97**	
8 27	29784	1 486E+00	**3 87**	**24 99**	
9 68	34860	1 486E+00	**3 87**	**24 99**	
10 9	39300	1 486E+00	**3 87**	**24 99**	
13 2	47640	1 486E+00	**3 87**	**24 99**	
16 6	59580	1 486E+00	**3 87**	**24 99**	
67 6	243444	1 486E+00	**3 87**	**24 99**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 486E+00	**3 87**	**24 99**	Steady state with continuous addition

Author *[signature]* Date 1/26/00 Checked by *[signature]* Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1873	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	110			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX 105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71274		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1873
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 109977864
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0'0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 109977864	0 0481	11 89866249	26 79087387	1 416994854	0 077613453	
Hydrogen			2 728E 02	3 212E+01	7 337E 04	1 437E 05	0 000E+00	
Methane			7 407E 03	8 291E+01	1 103E-03	8 373E 06	0 000E+00	

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Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	3 939E 02	0 10	0 66	
0 0183	66	7 182E 02	0 19	1 21	
0 0333	120	1 293E 01	0 34	2 17	
0 0617	222	2 347E 01	0 61	3 95	
0 1033	372	3 828E 01	1 00	6 44	
0 1750	630	6 189E 01	1 61	10 41	
0 332	1194	1 063E+00	2 77	17 87	
0 620	2232	1 673E+00	4 36	28 13	
1 035	3726	2 226E+00	5 80	37 43	
2 27	8154	2 828E+00	7 37	47 56	
3 35	12060	2 939E+00	7 66	49 43	
5 38	19362	2 971E+00	7 74	49 97	
8 27	29784	2 973E+00	7 75	50 00	
9 68	34860	2 974E+00	7 75	50 00	
10 9	39300	2 974E+00	7 75	50 00	
13 2	47640	2 974E+00	7 75	50 00	
16 6	59580	2 974E+00	7 75	50 00	
67 6	243444	2 974E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 974E+00	7 75	50 00	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. Rfu Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3745	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	110			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 7129		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3745
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 21989701
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 21989701	0 0481	11 89866249	26 79087387	1 416994854	0 155185468	
Hydrogen			2 728E 02	3 212E+01	7 337E 04	1 437E 05	0 000E+00	
Methane			7 407E 03	8 291E+01	1 103E 03	8 373E 06	0 000E+00	

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Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**15 52**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	7 876E 02	**0 21**	**1 32**	
0 0183	66	1 436E 01	**0 37**	**2 41**	
0 0333	120	2 585E 01	**0 67**	**4 35**	
0 0617	222	4 694E 01	**1 22**	**7 89**	
0 1033	372	7 653E 01	**1 99**	**12 87**	
0 1750	630	1 237E+00	**3 23**	**20 81**	
0 332	1194	2 125E+00	**5 54**	**35 74**	
0 620	2232	3 345E+00	**8 72**	**56 24**	
1 035	3726	4 450E+00	**11 60**	**74 83**	
2 27	8154	5 655E+00	**14 74**	**95 10**	
3 35	12060	5 877E+00	**15 32**	**98 83**	
5 38	19362	5 941E+00	**15 49**	**99 90**	
8 27	29784	5 945E+00	**15 50**	**99 98**	
9 68	34860	5 945E+00	**15 50**	**99 98**	
10 9	39300	5 945E+00	**15 50**	**99 98**	
13 2	47640	5 945E+00	**15 50**	**99 98**	
16 6	59580	5 945E+00	**15 50**	**99 98**	
67 6	243444	5 945E+00	**15 50**	**99 98**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 945E+00	**15 50**	**99 98**	Steady state with continuous addition

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Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	743	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	120			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71323		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				743
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 043627097
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 043627097	0 0481	11 89866249	21 2653246	1 124743287	0 038788493	
Hydrogen			2 894E 02	2 968E+01	7 283E 04	1 544E 05	0 000E+00	
Methane			1 032E 02	7 216E+01	1 044E 03	9 105E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 639E 02	**0 04**	**0 28**	
0 0183	66	2 991E 02	**0 08**	**0 51**	
0 0333	120	5 393E 02	**0 14**	**0 92**	
0 0617	222	9 820E 02	**0 26**	**1 68**	
0 1033	372	1 608E 01	**0 43**	**2 75**	
0 1750	630	2 618E 01	**0 69**	**4 48**	
0 332	1194	4 561E 01	**1 21**	**7 80**	
0 620	2232	7 350E 01	**1 95**	**12 58**	
1 035	3726	1 006E+00	**2 67**	**17 22**	
2 27	8154	1 347E+00	**3 57**	**23 05**	
3 35	12060	1 427E+00	**3 78**	**24 41**	
5 38	19362	1 457E+00	**3 86**	**24 93**	
8 27	29784	1 460E+00	**3 87**	**24 98**	
9 68	34860	1 460E+00	**3 87**	**24 98**	
10 9	39300	1 460E+00	**3 87**	**24 98**	
13 2	47640	1 460E+00	**3 87**	**24 98**	
16 6	59580	1 460E+00	**3 87**	**24 98**	
67 6	243444	1 460E+00	**3 87**	**24 98**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 460E+00	**3 87**	**24 98**	Steady state with continuous addition

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1487	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	120			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX 105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71355		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1487
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 087312911
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 087312911	0 0481	11 89866249	21 2653246	1 124743287	0 077629191	
Hydrogen			2 894E 02	2 968E+01	7 283E 04	1 544E 05	0 000E+00	
Methane			1 032E 02	7 216E+01	1 044E 03	9 105E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	3 281E 02	**0 09**	**0 56**	
0 0183	66	5 986E 02	**0 16**	**1 02**	
0 0333	120	1 079E 01	**0 29**	**1 85**	
0 0617	222	1 965E 01	**0 52**	**3 36**	
0 1033	372	3 218E 01	**0 85**	**5 51**	
0 1750	630	5 239E 01	**1 39**	**8 96**	
0 332	1194	9 127E 01	**2 42**	**15 62**	
0 620	2232	1 471E+00	**3 90**	**25 17**	
1 035	3726	2 014E+00	**5 34**	**34 46**	
2 27	8154	2 696E+00	**7 15**	**46 13**	
3 35	12060	2 856E+00	**7 57**	**48 86**	
5 38	19362	2 916E+00	**7 73**	**49 89**	
8 27	29784	2 922E+00	**7 75**	**50 00**	
9 68	34860	2 922E+00	**7 75**	**50 00**	
10 9	39300	2 922E+00	**7 75**	**50 00**	
13 2	47640	2 922E+00	**7 75**	**50 00**	
16 6	59580	2 922E+00	**7 75**	**50 00**	
67 6	243444	2 922E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 922E+00	**7 75**	**50 00**	Steady state with continuous addition

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Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2974	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	120			

Author DC Hedengren Date 1/26/00 Checked by J.D Berglin Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71378		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2974
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 174625823
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 174625823	0 0481	11 89866249	21 2653246	1 124743287	0 155258382	
Hydrogen			2 894E 02	2 968E+01	7 283E 04	1 544E 05	0 000E+00	
Methane			1 032E 02	7 216E+01	1 044E 03	9 105E 06	0 000E+00	

Author DC Hedengren Date 1/26/00 Checked by SD Baker Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 53**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	6 561E 02	**0 17**	**1 12**	
0 0183	66	1 197E 01	**0 32**	**2 05**	
0 0333	120	2 159E 01	**0 57**	**3 69**	
0 0617	222	3 931E 01	**1 04**	**6 73**	
0 1033	372	6 436E 01	**1 71**	**11 01**	
0 1750	630	1 048E+00	**2 78**	**17 93**	
0 332	1194	1 825E+00	**4 84**	**31 23**	
0 620	2232	2 942E+00	**7 80**	**50 34**	
1 035	3726	4 028E+00	**10 68**	**68 92**	
2 27	8154	5 391E+00	**14 30**	**92 25**	
3 35	12060	5 711E+00	**15 15**	**97 73**	
5 38	19362	5 831E+00	**15 46**	**99 77**	
8 27	29784	5 844E+00	**15 50**	**99 99**	
9 68	34860	5 844E+00	**15 50**	**100 00**	
10 9	39300	5 844E+00	**15 50**	**100 00**	
13 2	47640	5 844E+00	**15 50**	**100 00**	
16 6	59580	5 845E+00	**15 50**	**100 00**	
67 6	243444	5 845E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 845E+00	**15 50**	**100 00**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. Bafus Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	594	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	130			

Author D C Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71417		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				594
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 034878191
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 034878191	0 0481	11 89866249	17 00210138	0 899257347	0 03878555	
Hydrogen			3 060E 02	2 742E+01	7 267E 04	1 668E 05	0 000E+00	
Methane			1 323E 02	6 280E+01	9 973E 04	9 994E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable Delta C	**Variable Delta C**	**Variable Delta C**	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 375E 02	**0 04**	**0 24**	
0 0183	66	2 511E 02	**0 07**	**0 44**	
0 0333	120	4 533E 02	**0 12**	**0 79**	
0 0617	222	8 274E 02	**0 22**	**1 44**	
0 1033	372	1 359E 01	**0 37**	**2 37**	
0 1750	630	2 226E 01	**0 60**	**3 87**	
0 332	1194	3 923E 01	**1 06**	**6 83**	
0 620	2232	6 451E 01	**1 74**	**11 23**	
1 035	3726	9 053E 01	**2 44**	**15 76**	
2 27	8154	1 273E+00	**3 43**	**22 16**	
3 35	12060	1 378E+00	**3 72**	**23 98**	
5 38	19362	1 427E+00	**3 85**	**24 83**	
8 27	29784	1 434E+00	**3 87**	**24 97**	
9 68	34860	1 435E+00	**3 87**	**24 97**	
10 9	39300	1 435E+00	**3 87**	**24 97**	
13 2	47640	1 435E+00	**3 87**	**24 97**	
16 6	59580	1 435E+00	**3 87**	**24 98**	
67 6	243444	1 435E+00	**3 87**	**24 98**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 435E+00	**3 87**	**24 98**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Bigler Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1189	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	130			

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Case 8 (Story 1)

Table S8 17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71446		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1189
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 069815099
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 069815099	0 0481	11 89866249	17 00210138	0 899257347	0 077636395	
Hydrogen			3 060E 02	2 742E+01	7 267E-04	1 668E 05	0 000E+00	
Methane			1 323E 02	6 280E+01	9 973E-04	9 994E 06	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	2 753E 02	0 07	0 48	
0 0183	66	5 027E 02	0 14	0 87	
0 0333	120	9 074E 02	0 24	1 58	
0 0617	222	1 656E 01	0 45	2 88	
0 1033	372	2 721E 01	0 73	4 74	
0 1750	630	4 455E 01	1 20	7 75	
0 332	1194	7 853E 01	2 12	13 67	
0 620	2232	1 291E+00	3 48	22 48	
1 035	3726	1 812E+00	4 89	31 54	
2 27	8154	2 548E+00	6 87	44 35	
3 35	12060	2 758E+00	7 44	48 01	
5 38	19362	2 856E+00	7 71	49 71	
8 27	29784	2 871E+00	7 75	49 97	
9 68	34860	2 872E+00	7 75	49 99	
10 9	39300	2 872E+00	7 75	49 99	
13 2	47640	2 872E+00	7 75	49 99	
16 6	59580	2 872E+00	7 75	49 99	
67 6	243444	2 872E+00	7 75	49 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 872E+00	7 75	49 99	Steady state with continuous addition

Author D E Hedengren Date 1/26/00 Checked by J D Bolin Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2378	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	130			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71459		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				2378
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 139630197
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 139630197	0 0481	11 89866249	17 00210138	0 899257347	0 15527279	
Hydrogen			3 060E 02	2 742E+01	7 267E 04	1 668E-05	0 000E+00	
Methane			1 323E 02	6 280E+01	9 973E 04	9 994E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**15 53**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	5 506E 02	**0 15**	**0 96**	
0 0183	66	1 005E 01	**0 27**	**1 75**	
0 0333	120	1 815E 01	**0 49**	**3 16**	
0 0617	222	3 312E 01	**0 89**	**5 76**	
0 1033	372	5 441E 01	**1 47**	**9 47**	
0 1750	630	8 910E 01	**2 40**	**15 51**	
0 332	1194	1 571E+00	**4 24**	**27 34**	
0 620	2232	2 583E+00	**6 97**	**44 95**	
1 035	3726	3 624E+00	**9 78**	**63 08**	
2 27	8154	5 096E+00	**13 75**	**88 70**	
3 35	12060	5 516E+00	**14 88**	**96 01**	
5 38	19362	5 712E+00	**15 41**	**99 42**	
8 27	29784	5 743E+00	**15 49**	**99 95**	
9 68	34860	5 744E+00	**15 50**	**99 98**	
10 9	39300	5 744E+00	**15 50**	**99 98**	
13 2	47640	5 745E+00	**15 50**	**99 98**	
16 6	59580	5 745E+00	**15 50**	**99 98**	
67 6	243444	5 745E+00	**15 50**	**99 98**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 745E+00	**15 50**	**99 98**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	478	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
$NO_3{}^{1}$	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
$NO_2{}^{1}$	µg/ml	142805	Temperature of Air in Vapor Space	°F	141 8
$CO_3{}^{2}$	µg/ml	14131	Stream Diameter	inches	1
$PO_4{}^{3}$	µg/ml	3266	Tortuosity Factor	unitless	1
$SO_4{}^{2}$	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	140			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71491		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				478
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 028066961
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		60						140
								Temperature
								deg C
								60
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 028066961	0 0481	11 89866249	13 68741	0 723940161	0 038769726	
Hydrogen			3 227E 02	2 533E+01	7 285E 04	1 810E 05	0 000E+00	
Methane			1 614E 02	5 466E+01	9 609E 04	1 106E 05	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 163E 02	**0 03**	**0 21**	
0 0183	66	2 125E 02	**0 06**	**0 38**	
0 0333	120	3 840E 02	**0 11**	**0 68**	
0 0617	222	7 021E 02	**0 19**	**1 24**	
0 1033	372	1 157E 01	**0 32**	**2 05**	
0 1750	630	1 903E 01	**0 52**	**3 37**	
0 332	1194	3 387E 01	**0 93**	**5 99**	
0 620	2232	5 663E 01	**1 55**	**10 02**	
1 035	3726	8 117E 01	**2 23**	**14 37**	
2 27	8154	1 194E+00	**3 28**	**21 13**	
3 35	12060	1 322E+00	**3 63**	**23 40**	
5 38	19362	1 394E+00	**3 82**	**24 67**	
8 27	29784	1 409E+00	**3 86**	**24 93**	
9 68	34860	1 410E+00	**3 87**	**24 95**	
10 9	39300	1 410E+00	**3 87**	**24 95**	
13 2	47640	1 410E+00	**3 87**	**24 96**	
16 6	59580	1 410E+00	**3 87**	**24 96**	
67 6	243444	1 410E+00	**3 87**	**24 96**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 410E+00	**3 87**	**24 96**	Steady state with continuous addition

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DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	957	Percent Fill of Receiving Tank	%	80
Na [1]	µg/ml	235679	Volume of Vapor Space	L	15359
Al [3]	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K [1]	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH [1]	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 [1]	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2 [1]	µg/ml	142805	Temperature of Air in Vapor Space	°F	141 8
CO_3 [2]	µg/ml	14131	Stream Diameter	inches	1
PO_4 [3]	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4 [2]	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F [1]	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl [1]	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br [1]	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	140			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 7152		Revision	0	NH_3	
Dilution Ratio	0 1							ug/ml	
Ion	M W	ci (moles/L)	hi	hi ci				957	
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L	
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 05619264	
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05					
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)		
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05					
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481		
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218		
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022		
NO_2^{1}	46 0055	3 10	0 0795	0 246775523					
CO_3^{2}	60 0092	0 24	0 1423	0 033508286					
PO_4^{3}	94 9676	0 03	0 2119	0 007286383					
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295					
F^{1}	19	5 466E 03	0 092	0 000502894					
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632					
Li^{+1}	6 94	0 00	0 0754	0					
Br^{1}	79 916	0 000E+00	0 0269	0					
								Average	
		20 71872705		2 072068917					
Mass fraction water in liq		0 43						Temperature	
Liquid density (kg/m3)		1468 000						deg F	
T (C)		60						140	
								Temperature	
								deg C	
								60	
					PNL 10785				
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3		
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm		
Ammonia		0 05619264	0 0481	11 89866249	13 68741	0 723940161	0 07762056		
Hydrogen			3 227E 02	2 533E+01	7 285E 04	1 810E-05	0 000E+00		
Methane			1 614E 02	5 466E+01	9 609E 04	1 106E 05	0 000E+00		

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**7 76**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 329E 02	**0 06**	**0 41**	
0 0183	66	4 254E 02	**0 12**	**0 75**	
0 0333	120	7 688E 02	**0 21**	**1 36**	
0 0617	222	1 406E 01	**0 39**	**2 49**	
0 1033	372	2 316E 01	**0 64**	**4 10**	
0 1750	630	3 809E 01	**1 05**	**6 74**	
0 332	1194	6 781E 01	**1 86**	**12 00**	
0 620	2232	1 134E+00	**3 11**	**20 07**	
1 035	3726	1 625E+00	**4 46**	**28 76**	
2 27	8154	2 391E+00	**6 56**	**42 31**	
3 35	12060	2 647E+00	**7 26**	**46 85**	
5 38	19362	2 790E+00	**7 65**	**49 39**	
8 27	29784	2 820E+00	**7 74**	**49 91**	
9 68	34860	2 822E+00	**7 74**	**49 95**	
10 9	39300	2 823E+00	**7 74**	**49 96**	
13 2	47640	2 823E+00	**7 74**	**49 97**	
16 6	59580	2 823E+00	**7 74**	**49 97**	
67 6	243444	2 823E+00	**7 74**	**49 97**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 823E+00	**7 74**	**49 97**	Steady state with continuous addition

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1915	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	140			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71817		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1915
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 112443998
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		60						140
								Temperature
								deg C
								60
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 112443998	0 0481	11 89866249	13 68741	0 723940161	0 155322227	
Hydrogen			3 227E 02	2 533E+01	7 285E 04	1 810E 05	0 000E+00	
Methane			1 614E 02	5 466E+01	9 609E 04	1 106E 05	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 53	%		Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	4 660E 02	0 13	0 82	
0 0183	66	8 513E 02	0 23	1 51	
0 0333	120	1 538E 01	0 42	2 72	
0 0617	222	2 813E 01	0 77	4 98	
0 1033	372	4 634E 01	1 27	8 20	
0 1750	630	7 623E 01	2 09	13 49	
0 332	1194	1 357E+00	3 72	24 02	
0 620	2232	2 269E+00	6 22	40 16	
1 035	3726	3 252E+00	8 92	57 56	
2 27	8154	4 784E+00	13 12	84 67	
3 35	12060	5 297E+00	14 53	93 75	
5 38	19362	5 583E+00	15 32	98 82	
8 27	29784	5 643E+00	15 48	99 88	
9 68	34860	5 647E+00	15 49	99 95	
10 9	39300	5 648E+00	15 50	99 97	
13 2	47640	5 649E+00	15 50	99 98	
16 6	59580	5 649E+00	15 50	99 98	
67 6	243444	5 649E+00	15 50	99 98	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 649E+00	15 50	99 98	Steady state with continuous addition

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	388	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
$NO_3{}^{1}$	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
$NO_2{}^{1}$	µg/ml	142805	Temperature of Air in Vapor Space	°F	151 8
$CO_3{}^{2}$	µg/ml	14131	Stream Diameter	inches	1
$PO_4{}^{3}$	µg/ml	3266	Tortuosity Factor	unitless	1
$SO_4{}^{2}$	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	150			

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX 105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71845		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				388
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 022782387
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 022782387	0 0481	11 89866249	11 09126307	0 586627475	0 038836209	
Hydrogen			3 393E-02	2 340E+01	7 338E 04	1 974E 05	0 000E+00	
Methane			1 905E 02	4 757E+01	9 331E 04	1 234E 05	0 000E+00	

Author DCHedengren Date 1/26/00 Checked by J.D. R[illegible] Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	9 946E 03	**0 03**	**0 18**	
0 0183	66	1 818E 02	**0 05**	**0 33**	
0 0333	120	3 288E 02	**0 09**	**0 59**	
0 0617	222	6 021E 02	**0 17**	**1 08**	
0 1033	372	9 941E 02	**0 28**	**1 79**	
0 1750	630	1 641E 01	**0 46**	**2 95**	
0 332	1194	2 946E 01	**0 82**	**5 30**	
0 620	2232	4 994E 01	**1 39**	**8 99**	
1 035	3726	7 288E 01	**2 03**	**13 11**	
2 27	8154	1 116E+00	**3 11**	**20 08**	
3 35	12060	1 264E+00	**3 52**	**22 74**	
5 38	19362	1 360E+00	**3 79**	**24 47**	
8 27	29784	1 385E+00	**3 86**	**24 93**	
9 68	34860	1 388E+00	**3 87**	**24 97**	
10 9	39300	1 388E+00	**3 87**	**24 98**	
13 2	47640	1 389E+00	**3 87**	**24 99**	
16 6	59580	1 389E+00	**3 87**	**24 99**	
67 6	243444	1 389E+00	**3 87**	**24 99**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 389E+00	**3 87**	**24 99**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D R[illegible] Date 1/26/01

DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	776	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	150			

Author DC Hedengren Date 1/26/00 Checked by J.D. B... Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71862		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				776
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 045564774
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 045564774	0 0481	11 89866249	11 09126307	0 586627475	0 077672418	
Hydrogen			3 393E 02	2 340E+01	7 338E 04	1 974E-05	0 000E+00	
Methane			1 905E 02	4 757E+01	9 331E 04	1 234E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Bryan Date 1/28/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 77	%		Based on Henry s Law Constant
		Variable Delta C	Variable Delta C	Variable Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 989E 02	0 06	0 36	
0 0183	66	3 636E 02	0 10	0 65	
0 0333	120	6 575E 02	0 18	1 18	
0 0617	222	1 204E 01	0 34	2 17	
0 1033	372	1 988E 01	0 55	3 58	
0 1750	630	3 283E 01	0 92	5 91	
0 332	1194	5 891E 01	1 64	10 60	
0 620	2232	9 988E 01	2 79	17 97	
1 035	3726	1 458E+00	4 07	26 23	
2 27	8154	2 232E+00	6 23	40 17	
3 35	12060	2 528E+00	7 05	45 48	
5 38	19362	2 720E+00	7 58	48 94	
8 27	29784	2 771E+00	7 73	49 85	
9 68	34860	2 775E+00	7 74	49 94	
10 9	39300	2 777E+00	7 74	49 96	
13 2	47640	2 778E+00	7 75	49 98	
16 6	59580	2 778E+00	7 75	49 98	
67 6	243444	2 778E+00	7 75	49 98	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 778E+00	7 75	49 98	Steady state with continuous addition

Author DC Hedengren Date 1/26/06 Checked by JD Rogers Date 1/26/06

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1552	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	150			

Author DC Hedengren Date 1/26/00 Checked by JD R[illegible] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71878		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1552
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 091129548
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 091129548	0 0481	11 89866249	11 09126307	0 586627475	0 155344835	
Hydrogen			3 393E 02	2 340E+01	7 338E 04	1 974E 05	0 000E+00	
Methane			1 905E 02	4 757E+01	9 331E 04	1 234E 05	0 000E+00	

Author DC Hedengren Date 1/26/00 Checked by J.D. Bryan Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 53	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	3 978E 02	**0 11**	**0 72**	
0 0183	66	7 272E 02	**0 20**	**1 31**	
0 0333	120	1 315E 01	**0 37**	**2 37**	
0 0617	222	2 408E 01	**0 67**	**4 33**	
0 1033	372	3 976E 01	**1 11**	**7 15**	
0 1750	630	6 566E 01	**1 83**	**11 81**	
0 332	1194	1 178E+00	**3 29**	**21 20**	
0 620	2232	1 998E+00	**5 57**	**35 94**	
1 035	3726	2 915E+00	**8 13**	**52 45**	
2 27	8154	4 465E+00	**12 45**	**80 34**	
3 35	12060	5 055E+00	**14 10**	**90 96**	
5 38	19362	5 439E+00	**15 17**	**97 87**	
8 27	29784	5 541E+00	**15 45**	**99 70**	
9 68	34860	5 550E+00	**15 48**	**99 87**	
10 9	39300	5 553E+00	**15 49**	**99 93**	
13 2	47640	5 555E+00	**15 49**	**99 96**	
16 6	59580	5 556E+00	**15 49**	**99 96**	
67 6	243444	5 556E+00	**15 49**	**99 97**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 556E+00	**15 49**	**99 97**	Steady state with continuous addition

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	316	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	160			

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

DCRT **244-S**
Case ***8 (Story 1)***

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 7197		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				316
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 018554728
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 018554728	0 0481	11 89866249	9 043660443	0 478327821	0 038790818	
Hydrogen			3 559E 02	2 161E+01	7 422E 04	2 161E 05	0 000E+00	
Methane			2 196E 02	4 140E+01	9 126E 04	1 387E 05	0 000E+00	

Author DC Halenger Date 1/26/00 Checked by SD B Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	8 560E 03	**0 02**	**0 16**	
0 0183	66	1 565E 02	**0 04**	**0 29**	
0 0333	120	2 832E 02	**0 08**	**0 52**	
0 0617	222	5 194E 02	**0 15**	**0 95**	
0 1033	372	8 591E 02	**0 24**	**1 57**	
0 1750	630	1 423E 01	**0 40**	**2 60**	
0 332	1194	2 570E 01	**0 73**	**4 70**	
0 620	2232	4 408E 01	**1 25**	**8 06**	
1 035	3726	6 531E 01	**1 85**	**11 94**	
2 27	8154	1 036E+00	**2 94**	**18 95**	
3 35	12060	1 199E+00	**3 40**	**21 92**	
5 38	19362	1 318E+00	**3 74**	**24 11**	
8 27	29784	1 357E+00	**3 85**	**24 82**	
9 68	34860	1 361E+00	**3 86**	**24 90**	
10 9	39300	1 363E+00	**3 86**	**24 93**	
13 2	47640	1 364E+00	**3 87**	**24 95**	
16 6	59580	1 364E+00	**3 87**	**24 95**	
67 6	243444	1 364E+00	**3 87**	**24 95**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 364E+00	**3 87**	**24 95**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Fyler Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	633	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	*Non Fumigation Divisor at 100 meters*	*unitless*	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	160			

Author D C Hedengren Date 1/26/00 Checked by J D Bj Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 71987		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				633
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 037168173
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 037168173	0 0481	11 89866249	9 043660443	0 478327821	0 077704393	
Hydrogen			3 559E 02	2 161E+01	7 422E 04	2 161E-05	0 000E+00	
Methane			2 196E 02	4 140E+01	9 126E 04	1 387E 05	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 77	%		Based on Henry s Law Constant
		Variable Delta C	Variable Delta C	Variable Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 715E 02	0 05	0 31	
0 0183	66	3 135E 02	0 09	0 57	
0 0333	120	5 674E 02	0 16	1 04	
0 0617	222	1 040E 01	0 29	1 90	
0 1033	372	1 721E 01	0 49	3 15	
0 1750	630	2 850E 01	0 81	5 21	
0 332	1194	5 149E 01	1 46	9 42	
0 620	2232	8 830E 01	2 50	16 15	
1 035	3726	1 308E+00	3 71	23 93	
2 27	8154	2 076E+00	5 89	37 97	
3 35	12060	2 401E+00	6 81	43 91	
5 38	19362	2 641E+00	7 49	48 29	
8 27	29784	2 718E+00	7 71	49 71	
9 68	34860	2 727E+00	7 73	49 87	
10 9	39300	2 730E+00	7 74	49 93	
13 2	47640	2 733E+00	7 75	49 97	
16 6	59580	2 733E+00	7 75	49 98	
67 6	243444	2 733E+00	7 75	49 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 733E+00	7 75	49 99	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1266	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	160			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 72002		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1266
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 074336346
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 074336346	0 0481	11 89866249	9 043660443	0 478327821	0 155408785	
Hydrogen			3 559E 02	2 161E+01	7 422E 04	2 161E 05	0 000E+00	
Methane			2 196E 02	4 140E+01	9 126E 04	1 387E 05	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 54	%		Based on Henry s Law Constant
		Variable Delta C	**Variable Delta C**	**Variable Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	3 429E 02	**0 10**	**0 63**	
0 0183	66	6 271E 02	**0 18**	**1 15**	
0 0333	120	1 135E 01	**0 32**	**2 08**	
0 0617	222	2 081E 01	**0 59**	**3 81**	
0 1033	372	3 442E 01	**0 98**	**6 29**	
0 1750	630	5 701E 01	**1 62**	**10 42**	
0 332	1194	1 030E+00	**2 92**	**18 83**	
0 620	2232	1 766E+00	**5 01**	**32 30**	
1 035	3726	2 617E+00	**7 42**	**47 85**	
2 27	8154	4 152E+00	**11 77**	**75 94**	
3 35	12060	4 803E+00	**13 61**	**87 83**	
5 38	19362	5 281E+00	**14 97**	**96 58**	
8 27	29784	5 437E+00	**15 41**	**99 42**	
9 68	34860	5 454E+00	**15 46**	**99 74**	
10 9	39300	5 461E+00	**15 48**	**99 87**	
13 2	47640	5 465E+00	**15 49**	**99 95**	
16 6	59580	5 466E+00	**15 49**	**99 97**	
67 6	243444	5 467E+00	**15 50**	**99 97**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 467E+00	**15 50**	**99 97**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	259	*Percent Fill of Receiving Tank*	%	80
Na [1]	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni [2]	μg/ml	12	Total Pressure in Vapor Space	atm	1
K [1]	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH [1]	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 [1]	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2 [1]	μg/ml	142805	Temperature of Air in Vapor Space	°F	171 8
CO_3 [2]	μg/ml	14131	Stream Diameter	inches	1
PO_4 [3]	μg/ml	3266	*Tortuosity Factor*	unitless	1
SO_4 [2]	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F [1]	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl [1]	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br [1]	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	170			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 7202		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				259
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 015207831
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 015207831	0 0481	11 89866249	7 417920838	0 392340903	0 038761777	
Hydrogen			3 725E 02	1 997E+01	7 536E 04	2 375E 05	0 000E+00	
Methane			2 487E 02	3 604E+01	8 985E 04	1 569E-05	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	7 440E 03	**0 02**	**0 14**	
0 0183	66	1 361E 02	**0 04**	**0 25**	
0 0333	120	2 464E 02	**0 07**	**0 46**	
0 0617	222	4 523E 02	**0 13**	**0 84**	
0 1033	372	7 492E 02	**0 22**	**1 39**	
0 1750	630	1 244E 01	**0 36**	**2 31**	
0 332	1194	2 260E 01	**0 65**	**4 20**	
0 620	2232	3 912E 01	**1 13**	**7 27**	
1 035	3726	5 871E 01	**1 69**	**10 91**	
2 27	8154	9 608E 01	**2 77**	**17 85**	
3 35	12060	1 133E+00	**3 26**	**21 06**	
5 38	19362	1 274E+00	**3 67**	**23 67**	
8 27	29784	1 328E+00	**3 82**	**24 67**	
9 68	34860	1 335E+00	**3 85**	**24 81**	
10 9	39300	1 338E+00	**3 85**	**24 87**	
13 2	47640	1 340E+00	**3 86**	**24 91**	
16 6	59580	1 341E+00	**3 86**	**24 92**	
67 6	243444	1 341E+00	**3 86**	**24 92**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 341E+00	**3 86**	**24 92**	Steady state with continuous addition

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/01*

DCRT **244 S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	519	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs-137	μCi/ml	384			
Temperature	°F	170			

Author DC Hedengren Date 1/26/00 Checked by J. D. R[illegible] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 72038		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				519
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 030474379
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 030474379	0 0481	11 89866249	7 417920838	0 392340903	0 077673213	
Hydrogen			3 725E 02	1 997E+01	7 536E 04	2 375E 05	0 000E+00	
Methane			2 487E 02	3 604E+01	8 985E-04	1 569E 05	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 77	%		Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 491E 02	**0 04**	**0 28**	
0 0183	66	2 727E 02	**0 08**	**0 51**	
0 0333	120	4 938E 02	**0 14**	**0 92**	
0 0617	222	9 063E 02	**0 26**	**1 68**	
0 1033	372	1 501E 01	**0 43**	**2 79**	
0 1750	630	2 493E 01	**0 72**	**4 63**	
0 332	1194	4 528E 01	**1 30**	**8 41**	
0 620	2232	7 840E 01	**2 26**	**14 57**	
1 035	3726	1 176E+00	**3 39**	**21 86**	
2 27	8154	1 925E+00	**5 55**	**35 78**	
3 35	12060	2 271E+00	**6 54**	**42 20**	
5 38	19362	2 553E+00	**7 35**	**47 44**	
8 27	29784	2 661E+00	**7 66**	**49 44**	
9 68	34860	2 676E+00	**7 71**	**49 72**	
10 9	39300	2 682E+00	**7 72**	**49 83**	
13 2	47640	2 686E+00	**7 74**	**49 91**	
16 6	59580	2 688E+00	**7 74**	**49 94**	
67 6	243444	2 688E+00	**7 74**	**49 95**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 688E+00	**7 74**	**49 95**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J. D. R Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1039	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	170			

Author DC Hedengren Date 1/26/00 Checked by JD Bryan Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-17 (Cont d) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36538 72057		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1039
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 061007475
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 061007475	0 0481	11 89866249	7 417920838	0 392340903	0 155496086	
Hydrogen			3 725E 02	1 997E+01	7 536E 04	2 375E 05	0 000E+00	
Methane			2 487E 02	3 604E+01	8 985E 04	1 569E 05	0 000E+00	

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Case 8 (Story 1)

Table S8-17 (Cont'd) SX-105 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 55	%		Based on Henry s Law Constant
		Var able	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	2 985E 02	0 09	0 55	
0 0183	66	5 459E 02	0 16	1 01	
0 0333	120	9 885E 02	0 28	1 84	
0 0617	222	1 814E 01	0 52	3 37	
0 1033	372	3 006E 01	0 87	5 58	
0 1750	630	4 991E 01	1 44	9 27	
0 332	1194	9 065E 01	2 61	16 84	
0 620	2232	1 569E+00	4 52	29 16	
1 035	3726	2 355E+00	6 78	43 76	
2 27	8154	3 854E+00	11 10	71 62	
3 35	12060	4 546E+00	13 09	84 47	
5 38	19362	5 111E+00	14 72	94 97	
8 27	29784	5 327E+00	15 34	98 98	
9 68	34860	5 356E+00	15 43	99 53	
10 9	39300	5 368E+00	15 46	99 76	
13 2	47640	5 377E+00	15 49	99 92	
16 6	59580	5 380E+00	15 50	99 98	
67 6	243444	5 381E+00	15 50	99 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 381E+00	15 50	99 99	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J. D Rh Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	15325	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	70			

Author DC Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 35541		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				15325
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 899845573
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 899845573	0 0481	1 983110415	73 15835385	23 21649039	0 038758898	
Hydrogen			2 064E 02	4 411E+01	8 025E 04	1 145E 05	0 000E+00	
Methane			4 238E 03	1 445E+02	1 537E 03	6 696E 06	0 000E+00	

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Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 199E 01	0 29	1 87	
0 0183	66	2 129E 01	0 52	3 33	
0 0333	120	3 658E 01	0 89	5 72	
0 0617	222	6 101E 01	1 48	9 54	
0 1033	372	8 842E 01	2 14	13 83	
0 1750	630	1 190E+00	2 88	18 61	
0 332	1194	1 478E+00	3 58	23 12	
0 620	2232	1 586E+00	3 84	24 80	
1 035	3726	1 598E+00	3 87	24 99	
2 27	8154	1 599E+00	3 87	25 00	
3 35	12060	1 599E+00	3 87	25 00	
5 38	19362	1 599E+00	3 87	25 00	
8 27	29784	1 599E+00	3 87	25 00	
9 68	34860	1 599E+00	3 87	25 00	
10 9	39300	1 599E+00	3 87	25 00	
13 2	47640	1 599E+00	3 87	25 00	
16 6	59580	1 599E+00	3 87	25 00	
67 6	243444	1 599E+00	3 87	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 599E+00	3 87	25 00	Steady state with continuous addition

Author DC Helengson Date 1/26/00 Checked by J D. R Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	30650	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	70			

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 35642		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				30650
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				1 799691146
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		1 799691146	0 0481	1 983110415	73 15835385	23 21649039	0 077517795	
Hydrogen			2 064E 02	4 411E+01	8 025E 04	1 145E 05	0 000E+00	
Methane			4 238E 03	1 445E+02	1 537E 03	6 696E 06	0 000E+00	

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Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**7 75**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	2 397E 01	**0 58**	**3 75**	
0 0183	66	4 257E 01	**1 03**	**6 66**	
0 0333	120	7 315E 01	**1 77**	**11 44**	
0 0617	222	1 220E+00	**2 96**	**19 08**	
0 1033	372	1 768E+00	**4 29**	**27 66**	
0 1750	630	2 380E+00	**5 77**	**37 22**	
0 332	1194	2 956E+00	**7 17**	**46 23**	
0 620	2232	3 172E+00	**7 69**	**49 60**	
1 035	3726	3 196E+00	**7 75**	**49 98**	
2 27	8154	3 197E+00	**7 75**	**50 00**	
3 35	12060	3 197E+00	**7 75**	**50 00**	
5 38	19362	3 197E+00	**7 75**	**50 00**	
8 27	29784	3 197E+00	**7 75**	**50 00**	
9 68	34860	3 197E+00	**7 75**	**50 00**	
10 9	39300	3 197E+00	**7 75**	**50 00**	
13 2	47640	3 197E+00	**7 75**	**50 00**	
16 6	59580	3 197E+00	**7 75**	**50 00**	
67 6	243444	3 197E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 197E+00	**7 75**	**50 00**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. [illegible] Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	61300	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	70			

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Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 35657		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				61300
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				3 599382292
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		3 599382292	0 0481	1 983110415	73 15835385	23 21649039	0 15503559	
Hydrogen			2 064E 02	4 411E+01	8 025E 04	1 145E 05	0 000E+00	
Methane			4 238E 03	1 445E+02	1 537E 03	6 696E 06	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	15 50	%		Max NH3 Conc Based on Henrys Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	4 795E 01	1 16	7 50	
0 0183	66	8 515E 01	2 06	13 32	
0 0333	120	1 463E+00	3 55	22 88	
0 0617	222	2 440E+00	5 92	38 16	
0 1033	372	3 537E+00	8 57	55 31	
0 1750	630	4 760E+00	11 54	74 44	
0 332	1194	5 912E+00	14 33	92 46	
0 620	2232	6 343E+00	15 38	99 20	
1 035	3726	6 392E+00	15 50	99 97	
2 27	8154	6 394E+00	15 50	100 00	
3 35	12060	6 394E+00	15 50	100 00	
5 38	19362	6 394E+00	15 50	100 00	
8 27	29784	6 394E+00	15 50	100 00	
9 68	34860	6 394E+00	15 50	100 00	
10 9	39300	6 394E+00	15 50	100 00	
13 2	47640	6 394E+00	15 50	100 00	
16 6	59580	6 394E+00	15 50	100 00	
67 6	243444	6 394E+00	15 50	100 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 394E+00	15 50	100 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J. D. R[illegible] Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	11770	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	80			

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 35948		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				11770
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 691104887
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 691104887	0 0481	1 983110415	56 17624453	17 8272907	0 038766681	
Hydrogen			2 230E 02	4 075E+01	7 771E 04	1 200E 05	0 000E+00	
Methane			1 327E 03	1 258E+02	1 389E 03	6 949E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 063E 01	**0 26**	**1 69**	
0 0183	66	1 894E 01	**0 47**	**3 02**	
0 0333	120	3 273E 01	**0 81**	**5 21**	
0 0617	222	5 512E 01	**1 36**	**8 78**	
0 1033	372	8 093E 01	**2 00**	**12 89**	
0 1750	630	1 110E+00	**2 74**	**17 68**	
0 332	1194	1 416E+00	**3 50**	**22 56**	
0 620	2232	1 549E+00	**3 83**	**24 68**	
1 035	3726	1 568E+00	**3 87**	**24 99**	
2 27	8154	1 569E+00	**3 88**	**25 00**	
3 35	12060	1 569E+00	**3 88**	**25 00**	
5 38	19362	1 569E+00	**3 88**	**25 00**	
8 27	29784	1 569E+00	**3 88**	**25 00**	
9 68	34860	1 569E+00	**3 88**	**25 00**	
10 9	39300	1 569E+00	**3 88**	**25 00**	
13 2	47640	1 569E+00	**3 88**	**25 00**	
16 6	59580	1 569E+00	**3 88**	**25 00**	
67 6	243444	1 569E+00	**3 88**	**25 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 569E+00	**3 88**	**25 00**	Steady state with continuous addition

Author [signature] Date 1/26/06 Checked by [signature] Date 1/26/06

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	23535	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs-137	µCi/ml	384			
Temperature	°F	80			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 35971		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				23535
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				1 381916187
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		1 381916187	0 0481	1 983110415	56 17624453	17 8272907	0 077516893	
Hydrogen			2 230E 02	4 075E+01	7 771E 04	1 200E 05	0 000E+00	
Methane			1 327E 03	1 258E+02	1 389E 03	6 949E 06	0 000E+00	

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Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 126E 01	**0 53**	**3 39**	
0 0183	66	3 788E 01	**0 94**	**6 03**	
0 0333	120	6 544E 01	**1 62**	**10 43**	
0 0617	222	1 102E+00	**2 72**	**17 56**	
0 1033	372	1 618E+00	**4 00**	**25 78**	
0 1750	630	2 219E+00	**5 48**	**35 35**	
0 332	1194	2 832E+00	**6 99**	**45 12**	
0 620	2232	3 097E+00	**7 65**	**49 35**	
1 035	3726	3 136E+00	**7 74**	**49 96**	
2 27	8154	3 138E+00	**7 75**	**50 00**	
3 35	12060	3 138E+00	**7 75**	**50 00**	
5 38	19362	3 138E+00	**7 75**	**50 00**	
8 27	29784	3 138E+00	**7 75**	**50 00**	
9 68	34860	3 138E+00	**7 75**	**50 00**	
10 9	39300	3 138E+00	**7 75**	**50 00**	
13 2	47640	3 138E+00	**7 75**	**50 00**	
16 6	59580	3 138E+00	**7 75**	**50 00**	
67 6	243444	3 138E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 138E+00	**7 75**	**50 00**	Steady state with continuous addition

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	47070	Percent Fill of Receiving Tank	%	80
Na^{1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	80			

Author D C Hedengren Date 1/26/00 Checked by J D Ruf Date 1/26/01

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 35987		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				47070
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				2 763832373
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		2 763832373	0 0481	1 983110415	56 17624453	17 8272907	0 155033786	
Hydrogen			2 230E 02	4 075E+01	7 771E 04	1 200E 05	0 000E+00	
Methane			1 327E 03	1 258E+02	1 389E 03	6 949E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**15 50**	**%**		Max NH3 Conc Based on Henrys Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	4 252E 01	**1 05**	**6 78**	
0 0183	66	7 575E 01	**1 87**	**12 07**	
0 0333	120	1 309E+00	**3 23**	**20 85**	
0 0617	222	2 204E+00	**5 44**	**35 12**	
0 1033	372	3 236E+00	**7 99**	**51 57**	
0 1750	630	4 438E+00	**10 96**	**70 71**	
0 332	1194	5 663E+00	**13 99**	**90 24**	
0 620	2232	6 195E+00	**15 30**	**98 71**	
1 035	3726	6 271E+00	**15 49**	**99 93**	
2 27	8154	6 276E+00	**15 50**	**100 00**	
3 35	12060	6 276E+00	**15 50**	**100 00**	
5 38	19362	6 276E+00	**15 50**	**100 00**	
8 27	29784	6 276E+00	**15 50**	**100 00**	
9 68	34860	6 276E+00	**15 50**	**100 00**	
10 9	39300	6 276E+00	**15 50**	**100 00**	
13 2	47640	6 276E+00	**15 50**	**100 00**	
16 6	59580	6 276E+00	**15 50**	**100 00**	
67 6	243444	6 276E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 276E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	9118	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	90			

Author DC Hedengren Date 1/26/00 Checked by JD R[illegible] Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36033		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				9118
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 535386097
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{-3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 535386097	0 0481	1 983110415	43 52508667	13 81249991	0 038760985	
Hydrogen			2 396E 02	3 764E+01	7 576E 04	1 267E 05	0 000E+00	
Methane			1 584E 03	1 095E+02	1 271E 03	7 308E 06	0 000E+00	

Author DC Hedengren Date 1/26/06 Checked by J.D. Berger Date 1/26/06

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	9 349E 02	**0 24**	**1 52**	
0 0183	66	1 671E 01	**0 42**	**2 71**	
0 0333	120	2 902E 01	**0 73**	**4 71**	
0 0617	222	4 934E 01	**1 24**	**8 01**	
0 1033	372	7 339E 01	**1 85**	**11 91**	
0 1750	630	1 026E+00	**2 58**	**16 64**	
0 332	1194	1 347E+00	**3 39**	**21 87**	
0 620	2232	1 509E+00	**3 80**	**24 48**	
1 035	3726	1 538E+00	**3 87**	**24 96**	
2 27	8154	1 541E+00	**3 87**	**25 00**	
3 35	12060	1 541E+00	**3 87**	**25 00**	
5 38	19362	1 541E+00	**3 87**	**25 00**	
8 27	29784	1 541E+00	**3 87**	**25 00**	
9 68	34860	1 541E+00	**3 87**	**25 00**	
10 9	39300	1 541E+00	**3 87**	**25 00**	
13 2	47640	1 541E+00	**3 87**	**25 00**	
16 6	59580	1 541E+00	**3 87**	**25 00**	
67 6	243444	1 541E+00	**3 87**	**25 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 541E+00	**3 87**	**25 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	18235	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	90			

Author DC Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36079		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				18235
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				1 070713476
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		1 070713476	0 0481	1 983110415	43 52508667	13 81249991	0 077517718	
Hydrogen			2 396E 02	3 764E+01	7 576E 04	1 267E 05	0 000E+00	
Methane			1 584E 03	1 095E+02	1 271E 03	7 308E 06	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/01

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**7 75**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	1 870E 01	**0 47**	**3 03**	
0 0183	66	3 341E 01	**0 84**	**5 42**	
0 0333	120	5 803E 01	**1 46**	**9 42**	
0 0617	222	9 868E 01	**2 48**	**16 01**	
0 1033	372	1 468E+00	**3 69**	**23 82**	
0 1750	630	2 051E+00	**5 16**	**33 28**	
0 332	1194	2 695E+00	**6 78**	**43 73**	
0 620	2232	3 017E+00	**7 59**	**48 97**	
1 035	3726	3 076E+00	**7 74**	**49 92**	
2 27	8154	3 081E+00	**7 75**	**50 00**	
3 35	12060	3 081E+00	**7 75**	**50 00**	
5 38	19362	3 081E+00	**7 75**	**50 00**	
8 27	29784	3 081E+00	**7 75**	**50 00**	
9 68	34860	3 081E+00	**7 75**	**50 00**	
10 9	39300	3 081E+00	**7 75**	**50 00**	
13 2	47640	3 081E+00	**7 75**	**50 00**	
16 6	59580	3 081E+00	**7 75**	**50 00**	
67 6	243444	3 081E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 081E+00	**7 75**	**50 00**	Steady state with continuous addition

Author D C Ebelongron Date 1/26/00 Checked by J D Rifn Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	36474	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	90			

Author DC Hedengren Date 1/26/00 Checked by JD Bl... Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36109		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				36474
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				2 141661822
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		2 141661822	0 0481	1 983110415	43 52508667	13 81249991	0 155052441	
Hydrogen			2 396E 02	3 764E+01	7 576E 04	1 267E 05	0 000E+00	
Methane			1 584E 03	1 095E+02	1 271E 03	7 308E 06	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Rafner Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	**15 51**	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	3 740E 01	**0 94**	**6 07**	
0 0183	66	6 683E 01	**1 68**	**10 84**	
0 0333	120	1 161E+00	**2 92**	**18 84**	
0 0617	222	1 974E+00	**4 96**	**32 03**	
0 1033	372	2 936E+00	**7 38**	**47 64**	
0 1750	630	4 102E+00	**10 32**	**66 57**	
0 332	1194	5 390E+00	**13 56**	**87 47**	
0 620	2232	6 035E+00	**15 18**	**97 94**	
1 035	3726	6 153E+00	**15 48**	**99 85**	
2 27	8154	6 163E+00	**15 50**	**100 00**	
3 35	12060	6 163E+00	**15 50**	**100 00**	
5 38	19362	6 163E+00	**15 50**	**100 00**	
8 27	29784	6 163E+00	**15 50**	**100 00**	
9 68	34860	6 163E+00	**15 50**	**100 00**	
10 9	39300	6 163E+00	**15 50**	**100 00**	
13 2	47640	6 163E+00	**15 50**	**100 00**	
16 6	59580	6 163E+00	**15 50**	**100 00**	
67 6	243444	6 163E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 163E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Fl... Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet						
				244-S		
Source Tank	SX 105					
Dilution Ratio	0 1			Correction Factor for Schumpe Model 6		
Receiving Tank	244 S					
Liquid Waste Characteristics (Source Tank)				Tank Characteristics (Receiving Tank)		
Parameter	Units	Value		Parameter	Units	Value
NH_3	µg/ml	7125		Percent Fill of Receiving Tank	%	80
Na [1]	µg/ml	235679		Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040		Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30		Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338		Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12		Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375		Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH [1]	µg/ml	40939		Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 [1]	µg/ml	164776		Total Bubbler Flow Rate	cfh	3
NO_2 [1]	µg/ml	142805		Temperature of Air in Vapor Space	°F	101 8
CO_3 [2]	µg/ml	14131		Stream Diameter	inches	1
PO_4 [3]	µg/ml	3266		Tortuosity Factor	unitless	1
SO_4 [2]	µg/ml	4194		Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F [1]	µg/ml	104		Surface Area of Still Waste	m^2	16 417
Cl [1]	µg/ml	8998		Fumigation Divisor at 100 meters	unitless	1
Li [1]	µg/ml	0		Non Fumigation Divisor at 100 meters	unitless	1
Br [1]	µg/ml	0		Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87				
Specific Gravity	unitless	1 468				
Total Organic Carbon	g/l	3 228				
Cs 137	µCi/ml	384				
Temperature	°F	100				

Author 1/26/00 Date 1/26/00 Checked by J.D. B. Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36134		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				7125
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 418362134
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 418362134	0 0481	1 983110415	34 01071777	10 79315568	0 038761799	
Hydrogen			2 562E 02	3 477E+01	7 434E 04	1 345E 05	0 000E+00	
Methane			4 496E 03	9 526E+01	1 178E 03	7 779E 06	0 000E+00	

Author *[signature]* Date 1/26/00 Checked by *[signature]* Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	8 161E 02	0 21	1 35	
0 0183	66	1 462E 01	0 37	2 42	
0 0333	120	2 553E 01	0 65	4 22	
0 0617	222	4 382E 01	1 12	7 24	
0 1033	372	6 599E 01	1 69	10 90	
0 1750	630	9 397E 01	2 41	15 53	
0 332	1194	1 273E+00	3 26	21 02	
0 620	2232	1 464E+00	3 75	24 20	
1 035	3726	1 508E+00	3 86	24 92	
2 27	8154	1 513E+00	3 87	25 00	
3 35	12060	1 513E+00	3 87	25 00	
5 38	19362	1 513E+00	3 87	25 00	
8 27	29784	1 513E+00	3 87	25 00	
9 68	34860	1 513E+00	3 87	25 00	
10 9	39300	1 513E+00	3 87	25 00	
13 2	47640	1 513E+00	3 87	25 00	
16 6	59580	1 513E+00	3 87	25 00	
67 6	243444	1 513E+00	3 87	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 513E+00	3 87	25 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D B Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	14250	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	100			

Author D C Hedengren Date 1/26/00 Checked by J D Jo Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36155		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				14250
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				0 836724269
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 836724269	0 0481	1 983110415	34 01071777	10 79315568	0 077523599	
Hydrogen			2 562E 02	3 477E+01	7 434E 04	1 345E 05	0 000E+00	
Methane			4 496E 03	9 526E+01	1 178E 03	7 779E 06	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 632E 01	0 42	2 70	
0 0183	66	2 925E 01	0 75	4 83	
0 0333	120	5 107E 01	1 31	8 44	
0 0617	222	8 764E 01	2 24	14 48	
0 1033	372	1 320E+00	3 38	21 81	
0 1750	630	1 879E+00	4 81	31 05	
0 332	1194	2 545E+00	6 52	42 05	
0 620	2232	2 929E+00	7 50	48 39	
1 035	3726	3 016E+00	7 72	49 84	
2 27	8154	3 026E+00	7 75	50 00	
3 35	12060	3 026E+00	7 75	50 00	
5 38	19362	3 026E+00	7 75	50 00	
8 27	29784	3 026E+00	7 75	50 00	
9 68	34860	3 026E+00	7 75	50 00	
10 9	39300	3 026E+00	7 75	50 00	
13 2	47640	3 026E+00	7 75	50 00	
16 6	59580	3 026E+00	7 75	50 00	
67 6	243444	3 026E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	3 026E+00	7 75	50 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	28500	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	100			

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/01

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36175		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				28500
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				1 673448537
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		1 673448537	0 0481	1 983110415	34 01071777	10 79315568	0 155047197	
Hydrogen			2 562E 02	3 477E+01	7 434E 04	1 345E 05	0 000E+00	
Methane			4 496E 03	9 526E+01	1 178E 03	7 779E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**15 50**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	3 264E 01	**0 84**	**5 39**	
0 0183	66	5 850E 01	**1 50**	**9 67**	
0 0333	120	1 021E+00	**2 62**	**16 87**	
0 0617	222	1 753E+00	**4 49**	**28 96**	
0 1033	372	2 640E+00	**6 76**	**43 61**	
0 1750	630	3 759E+00	**9 63**	**62 10**	
0 332	1194	5 090E+00	**13 04**	**84 10**	
0 620	2232	5 858E+00	**15 00**	**96 78**	
1 035	3726	6 033E+00	**15 45**	**99 68**	
2 27	8154	6 052E+00	**15 50**	**100 00**	
3 35	12060	6 052E+00	**15 50**	**100 00**	
5 38	19362	6 052E+00	**15 50**	**100 00**	
8 27	29784	6 052E+00	**15 50**	**100 00**	
9 68	34860	6 052E+00	**15 50**	**100 00**	
10 9	39300	6 052E+00	**15 50**	**100 00**	
13 2	47640	6 052E+00	**15 50**	**100 00**	
16 6	59580	6 052E+00	**15 50**	**100 00**	
67 6	243444	6 052E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	6 052E+00	**15 50**	**100 00**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	5612	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	110			

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36206		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				5612
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 329522568
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 329522568	0 0481	1 983110415	26 79087387	8 501969125	0 038758382	
Hydrogen			2 728E 02	3 212E+01	7 337E 04	1 437E 05	0 000E+00	
Methane			7 407E 03	8 291E+01	1 103E 03	8 373E 06	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	7 079E 02	0 18	1 19	
0 0183	66	1 272E 01	0 33	2 14	
0 0333	120	2 231E 01	0 58	3 75	
0 0617	222	3 863E 01	1 01	6 50	
0 1033	372	5 887E 01	1 53	9 90	
0 1750	630	8 536E 01	2 22	14 35	
0 332	1194	1 192E+00	3 11	20 04	
0 620	2232	1 414E+00	3 69	23 78	
1 035	3726	1 477E+00	3 85	24 84	
2 27	8154	1 486E+00	3 87	25 00	
3 35	12060	1 486E+00	3 87	25 00	
5 38	19362	1 486E+00	3 87	25 00	
8 27	29784	1 486E+00	3 87	25 00	
9 68	34860	1 486E+00	3 87	25 00	
10 9	39300	1 486E+00	3 87	25 00	
13 2	47640	1 486E+00	3 87	25 00	
16 6	59580	1 486E+00	3 87	25 00	
67 6	243444	1 486E+00	3 87	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 486E+00	3 87	25 00	Steady state with continuous addition

Author D C Halgren Date 1/26/00 Checked by J D Rf Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	11225	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	110			

Author *D C Halgren* Date *1/26/00* Checked by *J D Berger* Date *1/26/00*

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 3623		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				11225
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 659103854
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 659103854	0 0481	1 983110415	26 79087387	8 501969125	0 077523671	
Hydrogen			2 728E 02	3 212E+01	7 337E 04	1 437E 05	0 000E+00	
Methane			7 407E 03	8 291E+01	1 103E 03	8 373E 06	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D R[illegible] Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable Delta C	Variable Delta C	Variable Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 416E 01	0 37	2 38	
0 0183	66	2 544E 01	0 66	4 28	
0 0333	120	4 463E 01	1 16	7 51	
0 0617	222	7 726E 01	2 01	12 99	
0 1033	372	1 177E+00	3 07	19 80	
0 1750	630	1 707E+00	4 45	28 71	
0 332	1194	2 384E+00	6 21	40 09	
0 620	2232	2 829E+00	7 37	47 57	
1 035	3726	2 954E+00	7 70	49 68	
2 27	8154	2 973E+00	7 75	50 00	
3 35	12060	2 973E+00	7 75	50 00	
5 38	19362	2 973E+00	7 75	50 00	
8 27	29784	2 973E+00	7 75	50 00	
9 68	34860	2 973E+00	7 75	50 00	
10 9	39300	2 973E+00	7 75	50 00	
13 2	47640	2 973E+00	7 75	50 00	
16 6	59580	2 973E+00	7 75	50 00	
67 6	243444	2 973E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 973E+00	7 75	50 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	22451	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	110			

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36251		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				22451
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				1 318266425
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		1 318266425	0 0481	1 983110415	26 79087387	8 501969125	0 155054247	
Hydrogen			2 728E 02	3 212E+01	7 337E 04	1 437E 05	0 000E+00	
Methane			7 407E 03	8 291E+01	1 103E 03	8 373E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	15 51	%		Max NH3 Conc Based on Henry s Law Constant
		Variable Delta C	Variable Delta C	Variable Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	2 832E 01	0 74	4 76	
0 0183	66	5 089E 01	1 33	8 56	
0 0333	120	8 927E 01	2 33	15 01	
0 0617	222	1 545E+00	4 03	25 98	
0 1033	372	2 355E+00	6 14	39 60	
0 1750	630	3 415E+00	8 90	57 42	
0 332	1194	4 768E+00	12 43	80 18	
0 620	2232	5 658E+00	14 75	95 14	
1 035	3726	5 908E+00	15 40	99 36	
2 27	8154	5 946E+00	15 50	100 00	
3 35	12060	5 946E+00	15 50	100 00	
5 38	19362	5 946E+00	15 50	100 00	
8 27	29784	5 946E+00	15 50	100 00	
9 68	34860	5 946E+00	15 50	100 00	
10 9	39300	5 946E+00	15 50	100 00	
13 2	47640	5 946E+00	15 50	100 00	
16 6	59580	5 946E+00	15 50	100 00	
67 6	243444	5 946E+00	15 50	100 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 946E+00	15 50	100 00	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	4455	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	120			

Author D C Hedengren Date 1/26/00 Checked by J D Bl Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36277		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				4455
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 261586429
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 261586429	0 0481	1 983110415	21 2653246	6 748459719	0 03876239	
Hydrogen			2 894E 02	2 968E+01	7 283E 04	1 544E-05	0 000E+00	
Methane			1 032E 02	7 216E+01	1 044E 03	9 105E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	6 112E 02	**0 16**	**1 05**	
0 0183	66	1 101E 01	**0 29**	**1 88**	
0 0333	120	1 940E 01	**0 51**	**3 32**	
0 0617	222	3 384E 01	**0 90**	**5 79**	
0 1033	372	5 215E 01	**1 38**	**8 92**	
0 1750	630	7 694E 01	**2 04**	**13 16**	
0 332	1194	1 107E+00	**2 94**	**18 94**	
0 620	2232	1 358E+00	**3 60**	**23 23**	
1 035	3726	1 443E+00	**3 83**	**24 70**	
2 27	8154	1 461E+00	**3 87**	**25 00**	
3 35	12060	1 461E+00	**3 87**	**25 00**	
5 38	19362	1 461E+00	**3 87**	**25 00**	
8 27	29784	1 461E+00	**3 87**	**25 00**	
9 68	34860	1 461E+00	**3 87**	**25 00**	
10 9	39300	1 461E+00	**3 87**	**25 00**	
13 2	47640	1 461E+00	**3 87**	**25 00**	
16 6	59580	1 461E+00	**3 87**	**25 00**	
67 6	243444	1 461E+00	**3 87**	**25 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 461E+00	**3 87**	**25 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by S D [illegible] Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet						
				244-S		
Source Tank	SX 105					
Dilution Ratio	0 1			Correction Factor for Schumpe Model 6		
Receiving Tank	244 S					
Liquid Waste Characteristics (Source Tank)				Tank Characteristics (Receiving Tank)		
Parameter	Units	Value		Parameter	Units	Value
NH_3	µg/ml	8911		Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679		Volume of Vapor Space	L	15359
Al^{3}	µg/ml	44040		Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30		Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338		Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12		Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375		Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939		Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776		Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805		Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	14131		Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266		Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194		Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104		Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998		Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0		Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0		Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87				
Specific Gravity	unitless	1 468				
Total Organic Carbon	g/l	3 228				
Cs 137	µCi/ml	384				
Temperature	°F	120				

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36309		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				8911
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				0 523231576
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 523231576	0 0481	1 983110415	21 2653246	6 748459719	0 077533481	
Hydrogen			2 894E 02	2 968E+01	7 283E 04	1 544E 05	0 000E+00	
Methane			1 032E 02	7 216E+01	1 044E 03	9 105E 06	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 222E 01	0 32	2 09	
0 0183	66	2 202E 01	0 58	3 77	
0 0333	120	3 880E 01	1 03	6 64	
0 0617	222	6 770E 01	1 80	11 58	
0 1033	372	1 043E+00	2 77	17 85	
0 1750	630	1 539E+00	4 08	26 33	
0 332	1194	2 214E+00	5 87	37 88	
0 620	2232	2 716E+00	7 20	46 47	
1 035	3726	2 887E+00	7 66	49 40	
2 27	8154	2 922E+00	7 75	50 00	
3 35	12060	2 922E+00	7 75	50 00	
5 38	19362	2 922E+00	7 75	50 00	
8 27	29784	2 922E+00	7 75	50 00	
9 68	34860	2 922E+00	7 75	50 00	
10 9	39300	2 922E+00	7 75	50 00	
13 2	47640	2 922E+00	7 75	50 00	
16 6	59580	2 922E+00	7 75	50 00	
67 6	243444	2 922E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 922E+00	7 75	50 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Bj[illegible] Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	17822	Percent Fill of Receiving Tank	%	80
Na^{1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	120			

Author DC Hadenga Date 1/26/00 Checked by J D R Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8 18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36327		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				17822
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				1 046463152
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		1 046463152	0 0481	1 983110415	21 2653246	6 748459719	0 155066963	
Hydrogen			2 894E 02	2 968E+01	7 283E 04	1 544E 05	0 000E+00	
Methane			1 032E 02	7 216E+01	1 044E 03	9 105E 06	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 445E 01	**0 65**	**4 18**	
0 0183	66	4 404E 01	**1 17**	**7 54**	
0 0333	120	7 759E 01	**2 06**	**13 28**	
0 0617	222	1 354E+00	**3 59**	**23 17**	
0 1033	372	2 086E+00	**5 53**	**35 70**	
0 1750	630	3 078E+00	**8 16**	**52 66**	
0 332	1194	4 428E+00	**11 74**	**75 77**	
0 620	2232	5 431E+00	**14 40**	**92 93**	
1 035	3726	5 774E+00	**15 31**	**98 80**	
2 27	8154	5 844E+00	**15 50**	**99 99**	
3 35	12060	5 844E+00	**15 50**	**100 00**	
5 38	19362	5 844E+00	**15 50**	**100 00**	
8 27	29784	5 844E+00	**15 50**	**100 00**	
9 68	34860	5 844E+00	**15 50**	**100 00**	
10 9	39300	5 844E+00	**15 50**	**100 00**	
13 2	47640	5 844E+00	**15 50**	**100 00**	
16 6	59580	5 844E+00	**15 50**	**100 00**	
67 6	243444	5 844E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 844E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Rogers Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3563	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	130			

Author D C Hedengren Date 1/26/00 Checked by J.D. Ryan Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36355		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3563
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 209210426
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 209210426	0 0481	1 983110415	17 00210138	5 395544084	0 038774667	
Hydrogen			3 060E 02	2 742E+01	7 267E 04	1 668E 05	0 000E+00	
Methane			1 323E 02	6 280E+01	9 973E 04	9 994E 06	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable Delta C	Variable Delta C	Variable Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	5 259E 02	0 14	0 92	
0 0183	66	9 494E 02	0 26	1 65	
0 0333	120	1 679E 01	0 45	2 92	
0 0617	222	2 952E 01	0 80	5 14	
0 1033	372	4 594E 01	1 24	8 00	
0 1750	630	6 886E 01	1 86	11 99	
0 332	1194	1 020E+00	2 75	17 75	
0 620	2232	1 294E+00	3 49	22 53	
1 035	3726	1 406E+00	3 79	24 48	
2 27	8154	1 436E+00	3 87	25 00	
3 35	12060	1 437E+00	3 88	25 00	
5 38	19362	1 437E+00	3 88	25 00	
8 27	29784	1 437E+00	3 88	25 00	
9 68	34860	1 437E+00	3 88	25 00	
10 9	39300	1 437E+00	3 88	25 00	
13 2	47640	1 437E+00	3 88	25 00	
16 6	59580	1 437E+00	3 88	25 00	
67 6	243444	1 437E+00	3 88	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 437E+00	3 88	25 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	7125	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	130			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36381		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				7125
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 418362134
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 418362134	0 0481	1 983110415	17 00210138	5 395544084	0 077538452	
Hydrogen			3 060E 02	2 742E+01	7 267E 04	1 668E 05	0 000E+00	
Methane			1 323E 02	6 280E+01	9 973E 04	9 994E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 052E 01	0 28	1 83	
0 0183	66	1 899E 01	0 51	3 30	
0 0333	120	3 358E 01	0 91	5 84	
0 0617	222	5 902E 01	1 59	10 27	
0 1033	372	9 187E 01	2 48	15 99	
0 1750	630	1 377E+00	3 71	23 97	
0 332	1194	2 039E+00	5 50	35 49	
0 620	2232	2 588E+00	6 98	45 05	
1 035	3726	2 812E+00	7 59	48 95	
2 27	8154	2 872E+00	7 75	49 99	
3 35	12060	2 873E+00	7 75	50 00	
5 38	19362	2 873E+00	7 75	50 00	
8 27	29784	2 873E+00	7 75	50 00	
9 68	34860	2 873E+00	7 75	50 00	
10 9	39300	2 873E+00	7 75	50 00	
13 2	47640	2 873E+00	7 75	50 00	
16 6	59580	2 873E+00	7 75	50 00	
67 6	243444	2 873E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 873E+00	7 75	50 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Bj... Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	14250	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	130			

Author D C Hedengren Date 1/26/00 Checked by JD Bjn Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36395		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				14250
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 836724269
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 836724269	0 0481	1 983110415	17 00210138	5 395544084	0 155076903	
Hydrogen			3 060E 02	2 742E+01	7 267E 04	1 668E 05	0 000E+00	
Methane			1 323E 02	6 280E+01	9 973E 04	9 994E 06	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 103E 01	**0 57**	**3 66**	
0 0183	66	3 797E 01	**1 02**	**6 61**	
0 0333	120	6 716E 01	**1 81**	**11 69**	
0 0617	222	1 180E+00	**3 18**	**20 55**	
0 1033	372	1 837E+00	**4 96**	**31 98**	
0 1750	630	2 754E+00	**7 43**	**47 93**	
0 332	1194	4 078E+00	**11 00**	**70 97**	
0 620	2232	5 177E+00	**13 96**	**90 10**	
1 035	3726	5 624E+00	**15 17**	**97 89**	
2 27	8154	5 744E+00	**15 50**	**99 98**	
3 35	12060	5 745E+00	**15 50**	**100 00**	
5 38	19362	5 746E+00	**15 50**	**100 00**	
8 27	29784	5 746E+00	**15 50**	**100 00**	
9 68	34860	5 746E+00	**15 50**	**100 00**	
10 9	39300	5 746E+00	**15 50**	**100 00**	
13 2	47640	5 746E+00	**15 50**	**100 00**	
16 6	59580	5 746E+00	**15 50**	**100 00**	
67 6	243444	5 746E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 746F+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Rifken Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	2868	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	140			

Author D C Hedengren Date 1/26/00 Checked by J D Baker Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36425		Revision	0	NH_3	
Dilution Ratio	0 1							ug/ml	
Ion	M W	ci (moles/L)	hi	hi ci				2868	
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L	
Al^{3}	26 98	1 63	0 2174	0 35486642				0 168401769	
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05					
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)		
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05					
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481		
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218		
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022		
NO_2^{1}	46 0055	3 10	0 0795	0 246775523					
CO_3^{2}	60 0092	0 24	0 1423	0 033508286					
PO_4^{3}	94 9676	0 03	0 2119	0 007286383					
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295					
F^{1}	19	5 466E 03	0 092	0 000502894					
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632					
Li^{+1}	6 94	0 00	0 0754	0					
Br^{1}	79 916	0 000E+00	0 0269	0					
								Average	
		20 71872705		2 072068917					
Mass fraction water in liq		0 43						Temperature	
Liquid density (kg/m3)		1468 000						deg F	
T (C)		60						140	
								Temperature	
								deg C	
								60	
					PNL 10785				
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3		
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm		
Ammonia		0 168401769	0 0481	1 983110415	13 68741	4 343640964	0 038769726		
Hydrogen			3 227E 02	2 533E+01	7 285E 04	1 810E 05	0 000E+00		
Methane			1 614E 02	5 466E+01	9 609E 04	1 106E 05	0 000E+00		

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Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	4 513E 02	0 12	0 80	
0 0183	66	8 163E 02	0 22	1 44	
0 0333	120	1 449E 01	0 40	2 56	
0 0617	222	2 563E 01	0 70	4 54	
0 1033	372	4 026E 01	1 10	7 13	
0 1750	630	6 123E 01	1 68	10 84	
0 332	1194	9 313E 01	2 56	16 48	
0 620	2232	1 224E+00	3 36	21 66	
1 035	3726	1 363E+00	3 74	24 13	
2 27	8154	1 412E+00	3 87	24 98	
3 35	12060	1 412E+00	3 87	25 00	
5 38	19362	1 412E+00	3 87	25 00	
8 27	29784	1 412E+00	3 87	25 00	
9 68	34860	1 412E+00	3 87	25 00	
10 9	39300	1 412E+00	3 87	25 00	
13 2	47640	1 412E+00	3 87	25 00	
16 6	59580	1 412E+00	3 87	25 00	
67 6	243444	1 412E+00	3 87	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 412E+00	3 87	25 00	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by JD Berger Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	5736	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	140			

Author DC Hedengren Date 1/26/00 Checked by J D Rfr Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36456		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				5736
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 336803537
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		60						140
								Temperature
								deg C
								60
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 336803537	0 0481	1 983110415	13 68741	4 343640964	0 077539451	
Hydrogen			3 227E 02	2 533E+01	7 285E 04	1 810E 05	0 000E+00	
Methane			1 614E 02	5 466E+01	9 609E 04	1 106E 05	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	9 026E 02	0 25	1 60	
0 0183	66	1 633E 01	0 45	2 89	
0 0333	120	2 898E 01	0 80	5 13	
0 0617	222	5 126E 01	1 41	9 07	
0 1033	372	8 053E 01	2 21	14 25	
0 1750	630	1 225E+00	3 36	21 67	
0 332	1194	1 863E+00	5 11	32 97	
0 620	2232	2 448E+00	6 71	43 32	
1 035	3726	2 727E+00	7 48	48 26	
2 27	8154	2 823E+00	7 74	49 97	
3 35	12060	2 825E+00	7 75	50 00	
5 38	19362	2 825E+00	7 75	50 00	
8 27	29784	2 825E+00	7 75	50 00	
9 68	34860	2 825E+00	7 75	50 00	
10 9	39300	2 825E+00	7 75	50 00	
13 2	47640	2 825E+00	7 75	50 00	
16 6	59580	2 825E+00	7 75	50 00	
67 6	243444	2 825E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 825E+00	7 75	50 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	11473	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	140			

Author D C Hedengren Date 1/26/00 Checked by J D R[illegible] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36474		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				11473
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 673665792
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		60						140
								Temperature
								deg C
								60
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 673665792	0 0481	1 983110415	13 68741	4 343640964	0 155092421	
Hydrogen			3 227E 02	2 533E+01	7 285E 04	1 810E 05	0 000E+00	
Methane			1 614E 02	5 466E+01	9 609E 04	1 106E 05	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	1 805E 01	**0 50**	**3 20**	
0 0183	66	3 266E 01	**0 90**	**5 78**	
0 0333	120	5 797E 01	**1 59**	**10 26**	
0 0617	222	1 025E+00	**2 81**	**18 15**	
0 1033	372	1 611E+00	**4 42**	**28 51**	
0 1750	630	2 449E+00	**6 72**	**43 35**	
0 332	1194	3 726E+00	**10 22**	**65 94**	
0 620	2232	4 896E+00	**13 43**	**86 65**	
1 035	3726	5 454E+00	**14 96**	**96 53**	
2 27	8154	5 647E+00	**15 49**	**99 94**	
3 35	12060	5 650E+00	**15 50**	**100 00**	
5 38	19362	5 650E+00	**15 50**	**100 00**	
8 27	29784	5 650E+00	**15 50**	**100 00**	
9 68	34860	5 650E+00	**15 50**	**100 00**	
10 9	39300	5 650E+00	**15 50**	**100 00**	
13 2	47640	5 650E+00	**15 50**	**100 00**	
16 6	59580	5 650E+00	**15 50**	**100 00**	
67 6	243444	5 650E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 650E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Rfmm Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2324	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	150			

Author DC Hedengren Date 1/26/00 Checked by JD Rogers Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36504		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2324
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 136459453
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 136459453	0 0481	1 983110415	11 09126307	3 519764852	0 03876948	
Hydrogen			3 393E 02	2 340E+01	7 338E 04	1 974E 05	0 000E+00	
Methane			1 905E 02	4 757E+01	9 331E 04	1 234E 05	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	3 869E 02	0 11	0 70	
0 0183	66	7 011E 02	0 20	1 26	
0 0333	120	1 248E 01	0 35	2 25	
0 0617	222	2 221E 01	0 62	4 00	
0 1033	372	3 517E 01	0 98	6 33	
0 1750	630	5 418E 01	1 51	9 75	
0 332	1194	8 448E 01	2 36	15 20	
0 620	2232	1 148E+00	3 20	20 66	
1 035	3726	1 315E+00	3 67	23 65	
2 27	8154	1 387E+00	3 87	24 95	
3 35	12060	1 389E+00	3 87	24 99	
5 38	19362	1 389E+00	3 87	25 00	
8 27	29784	1 389E+00	3 87	25 00	
9 68	34860	1 389E+00	3 87	25 00	
10 9	39300	1 389E+00	3 87	25 00	
13 2	47640	1 389E+00	3 87	25 00	
16 6	59580	1 389E+00	3 87	25 00	
67 6	243444	1 389E+00	3 87	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 389E+00	3 87	25 00	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. R... Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	4649	Percent Fill of Receiving Tank	%	80
Na^{+1}	μg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	μg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	μg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	μCi/ml	384			
Temperature	°F	150			

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 36526		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				4649
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 272977623
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 272977623	0 0481	1 983110415	11 09126307	3 519764852	0 077555642	
Hydrogen			3 393E 02	2 340E+01	7 338E 04	1 974E 05	0 000E+00	
Methane			1 905E 02	4 757E+01	9 331E 04	1 234E 05	0 000E+00	

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**$\%NH_{3(Max)}$**	**7 76**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	7 740E 02	**0 22**	**1 39**	
0 0183	66	1 403E 01	**0 39**	**2 52**	
0 0333	120	2 497E 01	**0 70**	**4 49**	
0 0617	222	4 443E 01	**1 24**	**7 99**	
0 1033	372	7 035E 01	**1 96**	**12 66**	
0 1750	630	1 084E+00	**3 02**	**19 50**	
0 332	1194	1 690E+00	**4 71**	**30 41**	
0 620	2232	2 297E+00	**6 41**	**41 33**	
1 035	3726	2 630E+00	**7 33**	**47 32**	
2 27	8154	2 774E+00	**7 74**	**49 92**	
3 35	12060	2 779E+00	**7 75**	**50 00**	
5 38	19362	2 779E+00	**7 75**	**50 00**	
8 27	29784	2 779E+00	**7 75**	**50 00**	
9 68	34860	2 779E+00	**7 75**	**50 00**	
10 9	39300	2 779E+00	**7 75**	**50 00**	
13 2	47640	2 779E+00	**7 75**	**50 00**	
16 6	59580	2 779E+00	**7 75**	**50 00**	
67 6	243444	2 779E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 779E+00	**7 75**	**50 00**	Steady state with continuous addition

Author D C Hedengren 1/26 Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	9297	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	150			

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 37179		Revision	0	NH_3	
Dilution Ratio	0 1							ug/ml	
Ion	M W	ci (moles/L)	hi	hi*ci				9297	
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L	
Al^{3}	26 98	1 63	0 2174	0 35486642				0 545896528	
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05					
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)		
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05					
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481		
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	-0 299	0 0218		
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022		
NO_2^{1}	46 0055	3 10	0 0795	0 246775523					
CO_3^{2}	60 0092	0 24	0 1423	0 033508286					
PO_4^{3}	94 9676	0 03	0 2119	0 007286383					
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295					
F^{1}	19	5 466E 03	0 092	0 000502894					
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632					
Li^{1}	6 94	0 00	0 0754	0					
Br^{1}	79 916	0 000E+00	0 0269	0					
								Average	
		20 71872705		2 072068917					
Mass fraction water in liq		0 43						Temperature	
Liquid density (kg/m3)		1468 000						deg F	
T (C)		66						150	
								Temperature	
								deg C	
								65 55555556	
					PNL 10785				
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3		
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm		
Ammonia		0 545896528	0 0481	1 983110415	11 09126307	3 519764852	0 155094602		
Hydrogen			3 393E 02	2 340E+01	7 338E 04	1 974E 05	0 000E+00		
Methane			1 905E 02	4 757E+01	9 331E 04	1 234E 05	0 000E+00		

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	%$NH_{3(Max)}$	15 51	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**%NH_3**	**% LFL NH_3**	
0 0100	36	1 548E 01	**0 43**	**2 79**	
0 0183	66	2 805E 01	**0 78**	**5 05**	
0 0333	120	4 994E 01	**1 39**	**8 99**	
0 0617	222	8 884E 01	**2 48**	**15 99**	
0 1033	372	1 407E+00	**3 92**	**25 31**	
0 1750	630	2 167E+00	**6 05**	**39 00**	
0 332	1194	3 380E+00	**9 43**	**60 81**	
0 620	2232	4 593E+00	**12 81**	**82 64**	
1 035	3726	5 259E+00	**14 67**	**94 62**	
2 27	8154	5 548E+00	**15 47**	**99 83**	
3 35	12060	5 557E+00	**15 50**	**99 99**	
5 38	19362	5 557E+00	**15 50**	**100 00**	
8 27	29784	5 557E+00	**15 50**	**100 00**	
9 68	34860	5 557E+00	**15 50**	**100 00**	
10 9	39300	5 557E+00	**15 50**	**100 00**	
13 2	47640	5 557E+00	**15 50**	**100 00**	
16 6	59580	5 557E+00	**15 50**	**100 00**	
67 6	243444	5 557E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 557E+00	**15 50**	**100 00**	Steady state with continuous addition

Author D E Hedengren Date 1/26/00 Checked by J D R[illegible] Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1895	Percent Fill of Receiving Tank	%	80
Na^{+1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	160			

Author D E Hedengren Date 1/26/00 Checked by J D Rollins Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8 18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 37212		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1895
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 111269648
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 636E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 111269648	0 0481	1 983110415	9 043660443	2 869966924	0 038770359	
Hydrogen			3 559E 02	2 161E+01	7 422E 04	2 161E 05	0 000E+00	
Methane			2 196E 02	4 140E+01	9 126E 04	1 387E 05	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	3 317E 02	0 09	0 61	
0 0183	66	6 020E 02	0 17	1 10	
0 0333	120	1 075E 01	0 30	1 97	
0 0617	222	1 922E 01	0 54	3 51	
0 1033	372	3 065E 01	0 87	5 60	
0 1750	630	4 777E 01	1 35	8 74	
0 332	1194	7 618E 01	2 16	13 93	
0 620	2232	1 069E+00	3 03	19 55	
1 035	3726	1 259E+00	3 57	23 03	
2 27	8154	1 362E+00	3 86	24 90	
3 35	12060	1 366E+00	3 87	24 99	
5 38	19362	1 367E+00	3 87	24 99	
8 27	29784	1 367E+00	3 87	24 99	
9 68	34860	1 367E+00	3 87	24 99	
10 9	39300	1 367E+00	3 87	24 99	
13 2	47640	1 367E+00	3 87	24 99	
16 6	59580	1 367E+00	3 87	24 99	
67 6	243444	1 367E+00	3 87	24 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 367E+00	3 87	24 99	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by JD Rhoads Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3791	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	160			

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX 105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 37249		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3791
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 222598014
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 222598014	0 0481	1 983110415	9 043660443	2 869966924	0 077561178	
Hydrogen			3 559E 02	2 161E+01	7 422E 04	2 161E 05	0 000E+00	
Methane			2 196E 02	4 140E+01	9 126E 04	1 387E 05	0 000E+00	

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DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	7 76	%		Max NH3 Conc Based on Henry s Law Constant
		Variable Delta C	Variable Delta C	Variable Delta C	
Time hours	T sec	NH_3 mole/m³	$\%NH_3$	% LFL NH_3	
0 0100	36	6 637E 02	0 19	1 21	
0 0183	66	1 204E 01	0 34	2 20	
0 0333	120	2 150E 01	0 61	3 93	
0 0617	222	3 845E 01	1 09	7 03	
0 1033	372	6 131E 01	1 74	11 21	
0 1750	630	9 556E 01	2 71	17 48	
0 332	1194	1 524E+00	4 32	27 87	
0 620	2232	2 138E+00	6 06	39 10	
1 035	3726	2 519E+00	7 14	46 07	
2 27	8154	2 724E+00	7 72	49 81	
3 35	12060	2 733E+00	7 75	49 99	
5 38	19362	2 734E+00	7 75	50 00	
8 27	29784	2 734E+00	7 75	50 00	
9 68	34860	2 734E+00	7 75	50 00	
10 9	39300	2 734E+00	7 75	50 00	
13 2	47640	2 734E+00	7 75	50 00	
16 6	59580	2 734E+00	7 75	50 00	
67 6	243444	2 734E+00	7 75	50 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 734E+00	7 75	50 00	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by J D Rifes Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	7582	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m²	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
$\%H_2O$	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	160			

Author D C Hedengren Date 1/26/00 Checked by J D Bright Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 37266		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				7582
Na^{1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 445196028
Fe^{3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{+1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 445196028	0 0481	1 983110415	9 043660443	2 869966924	0 155122355	
Hydrogen			3 559E 02	2 161E+01	7 422E 04	2 161E 05	0 000E+00	
Methane			2 196E 02	4 140E+01	9 126E 04	1 387E 05	0 000E+00	

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DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable Delta C	**Variable Delta C**	**Variable Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 327E 01	**0 38**	**2 43**	
0 0183	66	2 409E 01	**0 68**	**4 41**	
0 0333	120	4 301E 01	**1 22**	**7 86**	
0 0617	222	7 689E 01	**2 18**	**14 06**	
0 1033	372	1 226E+00	**3 48**	**22 43**	
0 1750	630	1 911E+00	**5 42**	**34 95**	
0 332	1194	3 048E+00	**8 64**	**55 74**	
0 620	2232	4 277E+00	**12 12**	**78 21**	
1 035	3726	5 039E+00	**14 28**	**92 14**	
2 27	8154	5 447E+00	**15 44**	**99 62**	
3 35	12060	5 467E+00	**15 50**	**99 98**	
5 38	19362	5 468E+00	**15 50**	**100 00**	
8 27	29784	5 468E+00	**15 50**	**100 00**	
9 68	34860	5 468E+00	**15 50**	**100 00**	
10 9	39300	5 468E+00	**15 50**	**100 00**	
13 2	47640	5 468E+00	**15 50**	**100 00**	
16 6	59580	5 468E+00	**15 50**	**100 00**	
67 6	243444	5 468E+00	**15 50**	**100 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 468E+00	**15 50**	**100 00**	Steady state with continuous addition

Author DC Hedengren Date 1/26/00 Checked by J.D. [signature] Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1555	Percent Fill of Receiving Tank	%	80
Na^{1}	µg/ml	235679	Volume of Vapor Space	L	15359
Al^{+3}	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	142805	Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	µg/ml	14131	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl^{1}	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	170			

Author D C Hedengren Date 1/26/00 Checked by J D B[illegible] Date 1/26/00

DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 37495		Revision	0	NH_3	
Dilution Ratio	0 1							ug/ml	
Ion	M W	ci (moles/L)	hi	hi ci				1555	
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L	
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 091305701	
Fe^{3}	55 85	0 00	0 1161	6 24862E 05					
Cr^{3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)		
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05					
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481		
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218		
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022		
NO_2^{1}	46 0055	3 10	0 0795	0 246775523					
CO_3^{2}	60 0092	0 24	0 1423	0 033508286					
PO_4^{3}	94 9676	0 03	0 2119	0 007286383					
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295					
F^{1}	19	5 466E 03	0 092	0 000502894					
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632					
Li^{+1}	6 94	0 00	0 0754	0					
Br^{1}	79 916	0 000E+00	0 0269	0					
								Average	
		20 71872705		2 072068917					
Mass fraction water in liq		0 43						Temperature	
Liquid density (kg/m3)		1468 000						deg F	
T (C)		77						170	
								Temperature	
								deg C	
								76 66666667	
					PNL 10785				
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3		
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm		
Ammonia		0 091305701	0 0481	1 983110415	7 417920838	2 35404542	0 03878672		
Hydrogen			3 725E 02	1 997E+01	7 536E 04	2 375E 05	0 000E+00		
Methane			2 487E 02	3 604E+01	8 985E 04	1 569E 05	0 000E+00		

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DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	2 849E 02	0 08	0 53	
0 0183	66	5 176E 02	0 15	0 96	
0 0333	120	9 263E 02	0 27	1 72	
0 0617	222	1 663E 01	0 48	3 09	
0 1033	372	2 669E 01	0 77	4 96	
0 1750	630	4 203E 01	1 21	7 81	
0 332	1194	6 838E 01	1 97	12 71	
0 620	2232	9 885E 01	2 85	18 37	
1 035	3726	1 199E+00	3 45	22 27	
2 27	8154	1 335E+00	3 84	24 81	
3 35	12060	1 344E+00	3 87	24 98	
5 38	19362	1 345E+00	3 88	25 00	
8 27	29784	1 346E+00	3 88	25 00	
9 68	34860	1 346E+00	3 88	25 00	
10 9	39300	1 346E+00	3 88	25 00	
13 2	47640	1 346E+00	3 88	25 00	
16 6	59580	1 346E+00	3 88	25 00	
67 6	243444	1 346E+00	3 88	25 00	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	1 346E+00	3 88	25 00	Steady state with continuous addition

Author *[signature]* Date 1/26/00 Checked by *[signature]* Date 1/26/00

DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet						
				244-S		
Source Tank	SX 105					
Dilution Ratio	0 1			Correction Factor for Schumpe Model 6		
Receiving Tank	244 S					
Liquid Waste Characteristics (Source Tank)				Tank Characteristics (Receiving Tank)		
Parameter	Units	Value		Parameter	Units	Value
NH_3	μg/ml	3110		Percent Fill of Receiving Tank	%	80
Na^{1}	μg/ml	235679		Volume of Vapor Space	L	15359
Al^{+3}	μg/ml	44040		Length of Waste Fall	ft	3 1
Fe^{+3}	μg/ml	30		Inside Diameter of Receiving Tank	ft	15
Cr^{+3}	μg/ml	338		Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	12		Total Pressure in Vapor Space	atm	1
K^{1}	μg/ml	3375		Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	40939		Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	164776		Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	142805		Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	μg/ml	14131		Stream Diameter	inches	1
PO_4^{3}	μg/ml	3266		Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4194		Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	104		Surface Area of Still Waste	m^2	16 417
Cl^{1}	μg/ml	8998		Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0		Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0		Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87				
Specific Gravity	unitless	1 468				
Total Organic Carbon	g/l	3 228				
Cs 137	μCi/ml	384				
Temperature	°F	170				

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DCRT **244-S**
Case **8 (Story 1)**

Table S8-18 (Cont d) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 37518		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3110
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 63	0 2174	0 35486642				0 182611402
Fe^{+3}	55 85	0 00	0 1161	6 24862E-05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E 05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 182611402	0 0481	1 983110415	7 417920838	2 35404542	0 07757344	
Hydrogen			3 725E 02	1 997E+01	7 536E 04	2 375E 05	0 000E+00	
Methane			2 487E 02	3 604E+01	8 985E 04	1 569E 05	0 000E+00	

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DCRT **244 S**
Case **8 (Story 1)**

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	**%NH$_{3(Max)}$**	**7 76**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**%NH_3**	**% LFL NH_3**	
0 0100	36	5 697E 02	**0 16**	**1 06**	
0 0183	66	1 035E 01	**0 30**	**1 92**	
0 0333	120	1 853E 01	**0 53**	**3 44**	
0 0617	222	3 327E 01	**0 96**	**6 18**	
0 1033	372	5 338E 01	**1 54**	**9 92**	
0 1750	630	8 405E 01	**2 42**	**15 62**	
0 332	1194	1 368E+00	**3 94**	**25 41**	
0 620	2232	1 977E+00	**5 69**	**36 74**	
1 035	3726	2 397E+00	**6 90**	**44 54**	
2 27	8154	2 670E+00	**7 69**	**49 61**	
3 35	12060	2 689E+00	**7 74**	**49 97**	
5 38	19362	2 691E+00	**7 75**	**50 00**	
8 27	29784	2 691E+00	**7 75**	**50 00**	
9 68	34860	2 691E+00	**7 75**	**50 00**	
10 9	39300	2 691E+00	**7 75**	**50 00**	
13 2	47640	2 691E+00	**7 75**	**50 00**	
16 6	59580	2 691E+00	**7 75**	**50 00**	
67 6	243444	2 691E+00	**7 75**	**50 00**	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	2 691E+00	**7 75**	**50 00**	Steady state with continuous addition

Author D C Hedengren Date 1/26/00 Checked by JD Fyhn Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-S		
Source Tank	SX 105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 6		
Receiving Tank	244 S				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	6219	Percent Fill of Receiving Tank	%	80
Na 1	µg/ml	235679	Volume of Vapor Space	L	15359
Al 3	µg/ml	44040	Length of Waste Fall	ft	3 1
Fe^{+3}	µg/ml	30	Inside Diameter of Receiving Tank	ft	15
Cr 3	µg/ml	338	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	12	Total Pressure in Vapor Space	atm	1
K 1	µg/ml	3375	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH 1	µg/ml	40939	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 1	µg/ml	164776	Total Bubbler Flow Rate	cfh	3
NO_2 1	µg/ml	142805	Temperature of Air in Vapor Space	°F	171 8
CO_3 2	µg/ml	14131	Stream Diameter	inches	1
PO_4 3	µg/ml	3266	Tortuosity Factor	unitless	1
SO_4 2	µg/ml	4194	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F 1	µg/ml	104	Surface Area of Still Waste	m^2	16 417
Cl 1	µg/ml	8998	Fumigation Divisor at 100 meters	unitless	1
Li 1	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br 1	µg/ml	0	Correction Factor for Schumpe Model	unitless	6
%H_2O	%	42 87			
Specific Gravity	unitless	1 468			
Total Organic Carbon	g/l	3 228			
Cs 137	µCi/ml	384			
Temperature	°F	170			

Author D C Hedengren Date 1/26/00 Checked by J D Rogers Date 1/26/00

DCRT 244-S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Source Tank	SX 105	INPUT DATA	Date	36539 3753		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				6219
Na^{+1}	22 99	10 251352	0 1143	1 171729581	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 63	0 2174	0 35486642				0 365164086
Fe^{+3}	55 85	0 00	0 1161	6 24862E 05				
Cr^{+3}	52	6 491E 03	0 0648	0 000420627	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 041E 04	0 1654	3 37609E-05				
K^{1}	39 09	8 635E 02	0 0922	0 007961423	Ammonia	0	0 0481	
OH^{1}	17 0074	2 41	0 0839	0 201958095	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 66	0 0128	0 034015512	Methane	0 524	0 0022	
NO_2^{1}	46 0055	3 10	0 0795	0 246775523				
CO_3^{2}	60 0092	0 24	0 1423	0 033508286				
PO_4^{3}	94 9676	0 03	0 2119	0 007286383				
SO_4^{2}	96 0576	4 366E 02	0 1117	0 004877295				
F^{1}	19	5 466E 03	0 092	0 000502894				
Cl^{1}	35 453	2 538E 01	0 0318	0 008070632				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 71872705		2 072068917				
Mass fraction water in liq		0 43						Temperature
Liquid density (kg/m3)		1468 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 365164086	0 0481	1 983110415	7 417920838	2 35404542	0 155121937	
Hydrogen			3 725E 02	1 997E+01	7 536E 04	2 375E 05	0 000E+00	
Methane			2 487E 02	3 604E+01	8 985E 04	1 569E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J.D. Ryan Date 1/26/00

DCRT 244 S
Case 8 (Story 1)

Table S8-18 (Cont'd) SX-105 Ammonia Calculations for WSU Model Worst Case (99 pages)

Equil NH3 Conc in Vapor Spa	$\%NH_{3(Max)}$	15 51	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 139E 01	0 33	2 12	
0 0183	66	2 070E 01	0 60	3 85	
0 0333	120	3 705E 01	1 07	6 88	
0 0617	222	6 652E 01	1 92	12 36	
0 1033	372	1 067E+00	3 07	19 84	
0 1750	630	1 681E+00	4 84	31 23	
0 332	1194	2 735E+00	7 88	50 82	
0 620	2232	3 953E+00	11 39	73 46	
1 035	3726	4 794E+00	13 81	89 07	
2 27	8154	5 339E+00	15 38	99 21	
3 35	12060	5 377E+00	15 49	99 92	
5 38	19362	5 381E+00	15 50	99 99	
8 27	29784	5 381E+00	15 50	99 99	
9 68	34860	5 381E+00	15 50	99 99	
10 9	39300	5 381E+00	15 50	99 99	
13 2	47640	5 381E+00	15 50	99 99	
16 6	59580	5 381E+00	15 50	99 99	
67 6	243444	5 381E+00	15 50	99 99	Time to fill from 0% to 80% at 4gpm
27777 8	100000000	5 381E+00	15 50	99 99	Steady state with continuous addition

This document was too large to scan as a single document. It has been divided into smaller sections.

3 Section of 3

Document Information			
Document #	**RPP-4941**	**Revision**	**0**
Title	METHODOLOGY FOR PREDICTING FLAMMABLE GAS MIXTURES IN DCRT		
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Recipient		**Recipient Co**	
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Keywords	**AMMONIA, HYDROGEN, METHANE**		
Projects			
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244-S-DCRT

CASE 9

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S Calculations based on tank 241-S-107
CASE 9
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate of 4 gpm Initial fill to 40% at a pumping rate of 4 gpm
- immediate change in pumping rate with no chance to come to steady state H2 concentration (3 cfh vent rate)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 238$

Radiolytic Power of Waste $wastepower = 0\ 000 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\, ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ no

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\, \%LFL$

DCRT Waste Temperature $T = 314\ 250\, K$

Nitrate Concentration $NO_3 = 1\ 510 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1\ 020 \frac{mole}{liter}$

Aluminum Concentration $Al = 0\ 290 \frac{mole}{liter}$

TOC Concentration $TOC = 0\ 000 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\ 000\, \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\, \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\ 471 \times 10^{-4} \frac{mole}{liter}$

or $gr_{sol} = 0\ 122 \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 34\ 000\, hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\, \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 122 \frac{ft^3}{hr}$

Time pumped at Second flow rate $lim2 = 35\ 000\, hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\, \%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 39\,825\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8160\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 4\,804\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 4\,804\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 3\,224\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 3\,224\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 35\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$

Final Fill Factor $fff2 = 80\,821\,\%$

Initial Fill Volume $tvol_{init2} = 8160\,gal$

Final Fill Volume $ffv2 = 16560\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 4\,804\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 15\,004\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 15\,004\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 5\,284\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 5\,284\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 151\,492\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 15\,877\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 61\,845\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 203\,497\,day$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S Calculations based on tank 241-S-107
CASE 9
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate of 4 gpm Initial fill to 40% at a pumping rate of 4 gpm
- immediate change in pumping rate with no chance to come to steady state H2 concentration (vent rate equals 5cfh)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\ 000\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 1\ 510\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 238$	Nitrite Concentration	$NO_2 = 1\ 020\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 000\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 290\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 0\ 000\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no	Ammonia Concentration	$NH_3 = 0\ 000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 314\ 250\,K$		

Period 1

Initial Flow Rate $flow = 4\ 000\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 1\ 471 \times 10^{-4}\frac{mole}{liter}$ or $gr_{sol} = 0\ 122\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 35\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 122\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 825\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/0

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 34\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 39\,825\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 8160\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 4\,729\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 4\,729\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 1\,935\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 1\,935\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time pumped at Second Flow Rate $lim2 = 35\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,825\,\%$

Final Fill Factor $fff2 = 80\,821\,\%$

Initial Fill Volume $tvol_{init2} = 8160\,gal$

Final Fill Volume $ffv2 = 16560\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 4\,729\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 14\,282\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 14\,282\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 3\,173\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 3\,173\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 151\,492\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 16\,979\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 62\,947\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 204\,598\,day$

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244-S-DCRT

CASE 10

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

CH2MHILL
Hanford Group, Inc

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d)

DCRT 244-S CASE 10a

Modified for 244-S DCRT Vault Case (Ventilation rate of 5 cfh) Use Vertical DCRT for model Wetted surface area set at 1764 sq ft (SX-105 H2 & SX-102 NH3)

$d := 15\,ft$

Input length of DCRT (L)

$L := 37.23\,ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10^{-6})

$flow := 1 \cdot 10^{-6}\,\frac{gal}{min}$ $\quad flow = 2.228 \times 10^{-9}\,ft^3\,sec^{-1}$ $\quad \frac{flow}{\left(\frac{ft^3}{hr}\right)} = 8.021 \times 10^{-6}$

Higher Input flow rate

$flow_2 := 1 \cdot 10^{-6}\,\frac{gal}{min}$ $\quad flow_2 = 2.228 \times 10^{-9}\,ft^3\,sec^{-1}$ $\quad \frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 8.021 \times 10^{-6}$

Calculate total DCRT volume (tvol)

$$tvol := L\,\pi\left(\frac{d}{2}\right)^2$$

Assume DCRT has flat ends [Eqn 1]

$tvol = 6579\,ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.333 \cdot tvol + 0\,hr \cdot 0\,\frac{gal}{min}$ $\quad tvol_{init} = 2.191 \times 10^3\,ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 1\,hr$

Time at pumping rate 2

$time_2 := 1\,hr$

Volume of fill at start of pumping rate 2

$tvol_2 := tvol_{init} + time \cdot flow$ $\quad tvol_2 = 2191\,ft^3$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

$vol_{H2_0} = if[flag_{cgm} = "yes", conc_{H2\_cgm} (tvol - tvol_{init}) \; vol_{H2_0}]$

$vol_{H2_0} = 0\ 000\,ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 72.0\ \%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 0\ 0\ \%LFL_{CH4}$ (Reference)

End of Input Section

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) = tvol - flow\ t - tvol_{init}$ $hvol(lim) = 4\ 388 \times 10^3\,ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft^2) $2\pi\left(\frac{d}{2}\right)^2 + \pi\, d\, L = 2108\,ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\, d\, \frac{flow\ t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\,(flow\ t + tvol_{init})}{d}$$ [Eqn 8]

$Awet(t) = 1764\,ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim) = 1\ 764 \times 10^3\,ft^2$

$Awet(0\ hr) = 1\ 764 \times 10^3\,ft^2$ Check the answers

$Awet(1\ hr) = 1\ 764 \times 10^3\,ft^2$ $Awet(lim) = 1\ 764 \times 10^3\,ft^2$

Author D. C. Hedengren Date 1/26/06 Checked by [signature] Date 1/26/06

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$$hvol2(time) = tvol - flow_2\, time - tvol_{init2} \qquad hvol2(lim2) = 4.388 \times 10^3\, ft^3$$ [Eqn 4]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi \left(\frac{d}{2}\right)^2 + \pi\, d\, \frac{flow_2\, t + tvol_{init2}}{\pi \left(\frac{d}{2}\right)^2}\right] = \pi \left(\frac{d}{2}\right)^2 + \frac{4\,(flow_2\, t + tvol_{init2})}{d}$$ [Eqn 8]

$$Awet(tt2) = 1764\, ft^2$$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim2) = 1.764 \times 10^3\, ft^2$

$Awet(0\, hr) = 1.764 \times 10^3\, ft^2$ Check the answers

$Awet(1\, hr) = 1.764 \times 10^3\, ft^2$

$Awet(lim2) = 1764.000\, ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 2.660 \qquad \frac{NO_2}{\left(\frac{mole}{liter}\right)} = 3.100 \qquad \frac{Al}{\left(\frac{mole}{liter}\right)} = 1.630 \qquad \frac{TOC}{\left(\frac{gm}{liter}\right)} = 3.228$$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S CASE 10a — Modified for 244-S DCRT Vault Case (Ventilation rate of 5 cfh) Use Vertical DCRT for model Wetted surface area set
at 1764 sq ft (SX-105 H2 & SX-102 NH3)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 5\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 2\,660\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,468$	Nitrite Concentration	$NO_2 = 3\,100\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,218\,\frac{lb}{ft\,sec^3}$	Aluminum Concentration	$Al = 1\,630\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 3\,228\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no	Ammonia Concentration	$NH_3 = 72\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 348\,150\,K$		

Period 1

Initial Flow Rate $flow = 1\,000 \times 10^{-6}\,\frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 1\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\,000\,\frac{mole}{liter}$ or $gr_{sol} = 0\,000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\,300\,\%$

Period 2

Second Flow Rate $flow_2 = 1\,000 \times 10^{-6}\,\frac{gal}{min}$

Time pumped at Second flow rate $lim2 = 1\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 33\,300\,\%$

Author D. C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 1.000 \times 10^{-6}\,\frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33.300\,\%$ Final Fill Factor $fff = 33.300\,\%$

Initial Fill Volume $tvol_{init} = 16389\,gal$ Final Fill Volume $ffv = 16389\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0.043\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 72.043\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 37.217\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 109.217\,\%$

Period 2

Second Flow Rate $flow_2 = 1.000 \times 10^{-6}\,\frac{gal}{min}$ Time pumped at Second Flow Rate $tim2 = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 33.300\,\%$ Final Fill Factor $fff2 = 33.300\,\%$

Initial Fill Volume $tvol_{init2} = 16389\,gal$ Final Fill Volume $ffv2 = 16389\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0.043\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0.086\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 72.086\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 37.217\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 109.217\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 221.061\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0.000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0.000\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 0.000\,day$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

CH2MHILL
Hanford Group, Inc

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d)

DCRT 244-S CASE 10b

Modified for 244-S DCRT Vault Case (Ventilation rate of 5 cfh) Use Vertical DCRT for model Wetted surface area set at 1764 sq ft (Heel in 244-S DCRT)

$d := 15\,ft$

Input length of DCRT (L)

$L := 37.23\,ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e. 1x10^{-6})

$flow := 1\cdot 10^{-6}\cdot\frac{gal}{min}$ $\quad flow = 2.228\times 10^{-9}\,ft^3\,sec^{-1}$ $\quad \frac{flow}{\left(\frac{ft^3}{hr}\right)} = 8.021\times 10^{-6}$

Higher Input flow rate

$flow_2 := 1\cdot 10^{-6}\cdot\frac{gal}{min}$ $\quad flow_2 = 2.228\times 10^{-9}\,ft^3\,sec^{-1}$ $\quad \frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 8.021\times 10^{-6}$

Calculate total DCRT volume (tvol)

$$tvol = L\cdot\pi\left(\frac{d}{2}\right)^2$$

Assume DCRT has flat ends [Eqn 1]

$tvol = 6579\,ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.333\cdot tvol + 0\cdot hr\cdot 0\cdot\frac{gal}{min}$ $\quad tvol_{init} = 2.191\times 10^{3}\,ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 1\cdot hr$

Time at pumping rate 2

$time_2 := 1\cdot hr$

Volume of fill at start of pumping rate 2

$tvol_2 = tvol_{init} + time\cdot flow$ $\quad tvol_2 = 2191\,ft^3$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

$$vol_{H2_0} = if\left[flag_{cgm} = \text{"yes"}, conc_{H2\_cgm}\left(tvol - tvol_{init}\right), vol_{H2_0}\right]$$

$vol_{H2_0} = 0\ 000\,ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 0\ 29\cdot\%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 0\ 0\cdot\%LFL_{CH4}$ (Reference)

End of Input Section

Calculations.

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow\ t - tvol_{init}$ $hvol(lim) = 4\ 388 \times 10^3\,ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft²) $2\,\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,L = 2108\,ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft²)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,\frac{flow\ t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(flow\ t + tvol_{init}\right)}{d}$$ [Eqn 8]

$Awet(t) := 1764\,ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft²) $Awet(lim) = 1\ 764 \times 10^3\,ft^2$

$Awet(0\ hr) = 1\ 764 \times 10^3\,ft^2$ Check the answers

$Awet(1\ hr) = 1\ 764 \times 10^3\,ft^2$ $Awet(lim) = 1\ 764 \times 10^3\,ft^2$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol2(time) = tvol - flow_2\ time - tvol_{init2}$ $hvol2(lim2) = 4\ 388 \times 10^3\ ft^3$ [Eqn 4]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\ d\ \frac{flow_2\ t + tvol_{init2}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\ (flow_2\ t + tvol_{init2})}{d}$$ [Eqn 8]

$Awet(tt2) = 1764\ ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim2) = 1\ 764 \times 10^3\ ft^2$

$Awet(0\ hr) = 1\ 764 \times 10^3\ ft^2$ Check the answers

$Awet(1\ hr) = 1\ 764 \times 10^3\ ft^2$

$Awet(lim2) = 1764\ 000\ ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 1\ 260$ $\frac{NO_2}{\left(\frac{mole}{liter}\right)} = 1\ 030$ $\frac{Al}{\left(\frac{mole}{liter}\right)} = 0\ 000$ $\frac{TOC}{\left(\frac{gm}{liter}\right)} = 1\ 380$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-S CASE 10b

Modified for 244-S DCRT Vault Case (Ventilation rate of 5 cfh) Use Vertical DCRT for model Wetted surface area set at 1764 sq ft (Heel in 244-S DCRT)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 5\ 000\,\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 150$

Radiolytic Power of Waste $wastepower = 0\ 422\,\frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\,\%LFL$

DCRT Waste Temperature $T = 313\ 150\,K$

Nitrate Concentration $NO_3 = 1\ 260\,\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 1\ 030\,\frac{mole}{liter}$

Aluminum Concentration $Al = 0\ 000\,\frac{mole}{liter}$

TOC Concentration $TOC = 1\ 380\,\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\ 290\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 1\ 000 \times 10^{-6}\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\,\frac{mole}{liter}$

or $gr_{sol} = 0\ 000\,\frac{ft^3}{hr}$

Time Pumped at Initial Flow Rate $time = 1\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33\ 300\,\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6}\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\,\frac{ft^3}{hr}$

Time pumped at Second flow rate $tim2 = 1\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 33\ 300\,\%$

Author D. C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 1.000 \times 10^{-6} \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 33.300\%$ Final Fill Factor $fff = 33.300\%$

Initial Fill Volume $tvol_{init} = 16389\,gal$ Final Fill Volume $ffv = 16389\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\%$

Final H2 Concentration (%LFL) $fh2c = 8.364 \times 10^{-3}\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 0.298\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7.324\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 7.614\%$

Period 2

Second Flow Rate $flow_2 = 1.000 \times 10^{-6} \frac{gal}{min}$ Time pumped at Second Flow Rate $tim2 = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 33.300\%$ Final Fill Factor $fff2 = 33.300\%$

Initial Fill Volume $tvol_{init2} = 16389\,gal$ Final Fill Volume $ffv2 = 16389\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 8.364 \times 10^{-3}\%$

Final H2 Concentration (%LFL) $fh2c2 = 0.017\%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 0.307\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 7.324\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 7.614\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 43.896\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 141.075\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 10.000 \times 10^{8}\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 10.000 \times 10^{8}\,day$

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244-TX-DCRT

CASE 1

Author D. C. Hedengren Date 1/26/00 Checked by J. D. Berglin Date 1/26/00

SUMMARY:

DCRT 244-TX
CASE 1

Calculations based on tank 241-T-110
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\,300\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,060$	Nitrite Concentration	$NO_2 = 0\,000\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,065 \times 10^{-5}\,\frac{lb}{ft\,sec^3}$	Aluminum Concentration	$Al = 0\,000\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 0\,045\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 4\,681 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\,361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D Bu[illegible] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\%$

Final Fill Factor $fff = 40\ 240\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\%$

Final H2 Concentration (%LFL) $fh2c = 14\ 251\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 14\ 251\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 4\ 519\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 4\ 519\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\%$

Final Fill Factor $fff2 = 80\ 479\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 14\ 251\%$

Final H2 Concentration (%LFL) $fh2c2 = 42\ 965\%$

Final Flammable Gas Concentration $ffgc2 = 42\ 965\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 7\ 101\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 7\ 101\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 133\ 281\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 17\ 061\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 210\ 025\,day$

Author D. C. Hedengren Date 1/26/00 Checked by J. D. Bryan Date 1/26/00

SUMMARY:

DCRT 244-TX Calculations based on tank 241-T-110
CASE 1
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate of 4 gpm to 80% full Time is adjusted on second step at negligible flow to obtain 105% of steady state %LFL

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\,300 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,060$	Nitrite Concentration	$NO_2 = 0\,000 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,065 \times 10^{-5} \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\,000 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 0\,045 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 104\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 4\,681 \times 10^{-4} \frac{mole}{liter}$ or $gr_{sol} = 0\,361 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 1\,000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 1\,242 \times 10^3\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 9\,026 \times 10^{-8} \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\,479\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D Bigler Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 104\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 80\ 479\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 42\ 965\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 42\ 965\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 7\ 101\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 7\ 101\ \%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 1\ 242 \times 10^3\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 479\ \%$

Final Fill Factor $fff2 = 80\ 479\ \%$

Initial Fill Volume $tvol_{init2} = 24960\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 42\ 965\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 7\ 456\ \%$

Final Flammable Gas Concentration $ffgc2 = 7\ 456\ \%$

Ultimate (ss) H2 Concentration (%LFL)
$uhh2c2 = 7\ 101\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL)
$uhfgc2 = 7\ 101\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 133\ 283\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 31\ 590\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 86\ 815\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 279\ 772\ day$

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244-TX-DCRT

CASE 2

Author D C Hedengren Date 1/26/00 Checked by J D Bigham Date 1/26/00

SUMMARY:

DCRT 244-TX
CASE 2

Calculations based on tank 241-T-110
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\,300 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,060$	Nitrite Concentration	$NO_2 = 0\,000 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,065 \times 10^{-5} \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\,000 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 0\,045 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 4\,681 \times 10^{-4} \frac{mole}{liter}$ or $gr_{sol} = 0\,361 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,361 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 40\ 240\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12480\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 14\ 251\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 14\ 251\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 4\ 519\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 4\ 519\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Final Fill Factor $fff2 = 80\ 479\ \%$

Initial Fill Volume $tvol_{init2} = 12480\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 14\ 251\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 42\ 965\ \%$

Final Flammable Gas Concentration $ffgc2 = 42\ 965\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 7\ 101\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 7\ 101\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 133\ 281\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 17\ 061\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 210\ 025\ day$

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244-TX-DCRT

CASE 3

Author ______ Date 1/26/00 Checked by ______ Date 1/26/00

DCRT 244-TX
Case 3

Table TX-1 T-110 Ammonia Calculations from Schumpe Model (3 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-TX		
Source Tank	T-110				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-TX				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	36950	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	5	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	5	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	35	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	2	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	327	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	0	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	18300	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	59	Temperature of Air in Vapor Space	°F	119 8
CO_3^{2}	µg/ml	0	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	17000	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4360	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	4220	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	958	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	86 78			
Specific Gravity	unitless	1 06			
Total Organic Carbon	g/l	0 045			
Cs-137	µCi/ml	0 00336			
Temperature	°F	68			

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244 TX**
Case **3**

Table TX-1 (Cont'd) T-110 Ammonia Calculations from Schumpe Model (3 pages)

Source Tank	T-110	INPUT DATA	Date	36546 48277		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1
Na^{+1}	22 99	1 607221	0 1143	0 183705356	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 00	0 2174	4 02891E-05				5 87175E-05
Fe^{+3}	55 85	0 00	0 1161	1 03939E-05				
Cr^{+3}	52	6 644E 04	0 0648	4 30546E-05	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	3 407E 05	0 1654	5 63447E-06				
K^{+1}	39 09	8 365E 03	0 0922	0 000771283	Ammonia	0	-0 0481	
OH^{1}	17 0074	0 00	0 0839	0	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	0 30	0 0128	0 003777777	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	0 00	0 0795	0 000101955				
CO_3^{2}	60 0092	0 00	0 1423	0				
PO_4^{-3}	94 9676	0 18	0 2119	0 037931799				
SO_4^{2}	96 0576	4 539E 02	0 1117	0 005070003				
F^{-1}	19	2 221E 01	0 092	0 020433674				
Cl^{-1}	35 453	2 702E 02	0 0318	0 00085929				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		2 386505214		0 252750509				
Mass fraction water in liq		0 87						Temperature
Liquid density (kg/m3)		1060 000						deg F
T (C)		20						68
								Temperature
								deg C
								20
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		5 87175E-05	-0 0481	1 373914187	77 21353786	51 69628738	1 13582E-06	
Hydrogen			2 031E-02	1 601E+00	8 084E-04	4 646E-04	0 000E+00	
Methane			4 820E-03	1 838E+00	1 572E-03	7 868E-04	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Bigler Date 1/26/00

DCRT **244 TX**
Case **3**

Table TX-1 (Cont'd) T-110 Ammonia Calculations from Schumpe Model (3 pages)

Equil NH3 Conc in Vapor Space	**%$NH_{3(Max)}$**	**0 00**	**%**		Max NH3 Conc Based on Henry's Law Constant
		Variable Delta C	**Variable Delta C**	**Variable Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**%NH_3**	**% LFL, NH_3**	
0 0100	36	2 529E 06	**0 00**	**0 00**	
0 0183	66	4 522E 06	**0 00**	**0 00**	
0 0333	120	7 865E 06	**0 00**	**0 00**	
0 0617	222	1 341E 05	**0 00**	**0 00**	
0 1033	372	2 001E 05	**0 00**	**0 00**	
0 1750	630	2 810E 05	**0 00**	**0 00**	
0 332	1194	3 722E 05	**0 00**	**0 00**	
0 620	2232	4 197E 05	**0 00**	**0 00**	
1 035	3726	4 289E 05	**0 00**	**0 00**	
2 27	8154	4 297E 05	**0 00**	**0 00**	
3 35	12060	4 297E 05	**0 00**	**0 00**	
5 38	19362	4 297E 05	**0 00**	**0 00**	
8 27	29784	4 297E 05	**0 00**	**0 00**	
9 68	34860	4 297E 05	**0 00**	**0 00**	
10 9	39300	4 297E 05	**0 00**	**0 00**	
13 2	47640	4 297E 05	**0 00**	**0 00**	
16 6	59580	4 297E 05	**0 00**	**0 00**	
41 7	150000	4 297E 05	**0 00**	**0 00**	
64 6	232605	4 297E 05	**0 00**	**0 00**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Bryan Date 1/26/00

SUMMARY:

DCRT 244-TX
CASE 3

Calculations based on tank 241-T-110
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration Ammonia and methane added in

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\ 300\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 060$	Nitrite Concentration	$NO_2 = 0\ 000\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 065 \times 10^{-5}\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 000\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 0\ 045\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} = $ "no"	Ammonia Concentration	$NH_3 = 0\ 000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 9\ 930\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\ 150\,K$		

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 4\ 681 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D Bugher Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 40\ 240\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12480\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 14\ 251\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 24\ 181\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 4\ 519\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 4\ 519\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Final Fill Factor $fff2 = 80\ 479\ \%$

Initial Fill Volume $tvol_{init2} = 12480\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 14\ 251\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 42\ 965\ \%$

Final Flammable Gas Concentration $ffgc2 = 52\ 895\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 7\ 101\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 7\ 101\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 133\ 281\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 0\ 000\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 155\ 094\ day$

244-TX-DCRT

CASE 4

Author D C Hedengren Date 1/26/00 Checked by J D B[illegible] Date 1/26/00

SUMMARY:

DCRT 244-TX Calculations based on PFP waste
CASE 4
- the initial condition of the tank is 3% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 50 gpm to 42% full
- immediate change in pumping rate of 50 gpm with no chance to come to steady state H2 concentration Ammonia and methane are zero
- PFP waste modeled as water since that is the most conservative for this case s dominating mechanism (corrosion)

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\ 000\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 000$	Nitrite Concentration	$NO_2 = 0\ 000\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 000\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 000\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 0\ 000\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no"	Ammonia Concentration	$NH_3 = 0\ 000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\ 150\,K$		

Period 1

Initial Flow Rate $flow = 50\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 4\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 3\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 50\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 4\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 41\ 692\,\%$

Author ____________ Date 1/26/00 Checked by ____________ Date 1/26/00

OUTPUT SUMMARY.

Period 1

Initial Flow Rate $flow = 50\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 4\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 3\ 000\,\%$

Final Fill Factor $fff = 41\ 692\,\%$

Initial Fill Volume $tvol_{init} = 930\,gal$

Final Fill Volume $ffv = 12930\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 0\ 013\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 0\ 013\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 4\ 606\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 4\ 606\,\%$

Period 2

Second Flow Rate $flow_2 = 50\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 4\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 41\ 692\,\%$

Final Fill Factor $fff2 = 80\ 384\,\%$

Initial Fill Volume $tvol_{init2} = 12930\,gal$

Final Fill Volume $ffv2 = 24930\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 0\ 013\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 0\ 062\,\%$

Final Flammable Gas Concentration $ffgc2 = 0\ 062\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 7\ 093\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 7\ 093\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 132\ 530\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 32\ 414\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 88\ 099\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 284\ 021\,day$

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244-TX-DCRT

CASE 5

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

SUMMARY:

DCRT 244-TX
CASE 5

Calculations based on tank 241-T-110
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 10% full with pumping rate initially of 4 gpm to 10% full

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\,300\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,060$	Nitrite Concentration	$NO_2 = 0\,000\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,065 \times 10^{-5}\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\,000\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 0\,045\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} = \text{"no}$	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 9\,930\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 6\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 4\,681 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\,361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 7\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 4\,643\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D Rfen Date 1/26/00

OUTPUT SUMMARY

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 6\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 4\,643\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 1440\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,340\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 11\,270\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 1\,766\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 1\,766\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 7\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 4\,643\,\%$

Final Fill Factor $fff2 = 10\,060\,\%$

Initial Fill Volume $tvol_{init2} = 1440\,gal$

Final Fill Volume $ffv2 = 3120\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,340\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 2\,984\,\%$

Final Flammable Gas Concentration $ffgc2 = 12\,914\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 2\,394\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 2\,394\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 10\,240\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 10\,000 \times 10^{8}\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 10\,000 \times 10^{8}\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 10\,000 \times 10^{8}\,day$

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244-TX-DCRT

CASE 6

Author D C Hedengren Date 1/26/00 Checked by J D B[illegible] Date 1/26/00

SUMMARY:

DCRT 244-TX Calculations based on tank 241-T-110
CASE 6
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 0\,300\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,060$	Nitrite Concentration	$NO_2 = 0\,000\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,065 \times 10^{-5}\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\,000\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 0\,045\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 293\,150\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 4\,681 \times 10^{-4}\,\frac{mole}{liter}$ or $gr_{sol} = 0\,361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,361\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author DC Hedengren Date 1/26/00 Checked by J.D.B[illegible] Date 1/26/00

OUTPUT SUMMARY·

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 14\,251\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 14\,251\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 4\,519\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 4\,519\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 14\,251\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 42\,965\,\%$

Final Flammable Gas Concentration $ffgc2 = 42\,965\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 7\,101\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 7\,101\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 133\,281\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 17\,061\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 210\,025\,day$

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244-TX-DCRT

CASE 7

Author D C Hedengren Date 1/26/00 Checked by J D Bryan Date 1/26/00

CH2MHILL
Hanford Group, Inc

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

Input diameter of DCRT (d)

DCRT 244-TX
CASE 7

Modified for 244-TX DCRT Vault Case (Ventilation rate of 3 cfh) Use Vertical DCRT for model Wetted surface area set at 2570 sq ft

$d = 12\,ft$

Input length of DCRT (L)

$L = 100.47\,ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10^{-6})

$flow := 1 \cdot 10^{-6} \cdot \frac{gal}{min}$ $\quad flow = 2\,228 \times 10^{-9}\,ft^3\,sec^{-1}$ $\quad \frac{flow}{\left(\frac{ft^3}{hr}\right)} = 8\,021 \times 10^{-6}$

Higher Input flow rate

$flow_2 := 1 \cdot 10^{-6} \cdot \frac{gal}{min}$ $\quad flow_2 = 2\,228 \times 10^{-9}\,ft^3\,sec^{-1}$ $\quad \frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 8\,021 \times 10^{-6}$

Calculate total DCRT volume (tvol)

$$tvol = L\,\pi \left(\frac{d}{2}\right)^2$$ Assume DCRT has flat ends [Eqn 1]

$tvol = 11363\,ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.292 \cdot tvol + 0 \cdot hr \cdot 0 \cdot \frac{gal}{min}$ $\quad tvol_{init} = 3\,318 \times 10^3\,ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 1 \cdot hr$

Time at pumping rate 2

$time_2 := 1 \cdot hr$

Volume of fill at start of pumping rate 2

$tvol_2 = tvol_{init} + time\ flow$ $\quad tvol_2 = 3318\,ft^3$

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$vol_{H2_0} = if\left[flag_{cgm} = \text{"yes"}, conc_{H2\_cgm}\left(tvol - tvol_{init}\right), vol_{H2_0}\right]$

$vol_{H2_0} = 0.000\,ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 \equiv 0.0 \cdot \%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 \equiv 0.0 \cdot \%LFL_{CH4}$ (Reference)

End of Input Section

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow \cdot t - tvol_{init}$ $hvol(lim) = 8.045 \times 10^3\,ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft²) $2\,\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,L = 4014\,ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft²)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,\frac{flow \cdot t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(flow \cdot t + tvol_{init}\right)}{d}$$ [Eqn 8]

$Awet(t) := 2570\,ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft²) $Awet(lim) = 2.570 \times 10^3\,ft^2$

$Awet(0\,hr) = 2.570 \times 10^3\,ft^2$ Check the answers

$Awet(1\,hr) = 2.570 \times 10^3\,ft^2$ $Awet(lim) = 2.570 \times 10^3\,ft^2$

Author D C Hedengren Date 1/26/00 Checked by J D Rogers Date 1/26/00

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol2(time) = tvol - flow_2\ time - tvol_{init2}$ $hvol2(lim2) = 8\ 045 \times 10^3\ ft^3$ [Eqn 4]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\ d\ \frac{flow_2\ t + tvol_{init2}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(flow_2\ t + tvol_{init2}\right)}{d}$$ [Eqn 8]

$Awet(tt2) = 2570\ ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim2) = 2\ 570 \times 10^3\ ft^2$

$Awet(0\ hr) = 2\ 570 \times 10^3\ ft^2$ Check the answers

$Awet(1\ hr) = 2\ 570 \times 10^3\ ft^2$

$Awet(lim2) = 2570\ 000\ ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 0\ 300$ $\frac{NO_2}{\left(\frac{mole}{liter}\right)} = 0\ 000$ $\frac{Al}{\left(\frac{mole}{liter}\right)} = 0\ 000$ $\frac{TOC}{\left(\frac{gm}{liter}\right)} = 0\ 045$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-TX
CASE 7

Modified for 244-TX DCRT Vault Case (Ventilation rate of 3 cfh) Use Vertical DCRT for model Wetted surface area set at 2570 sq ft

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\,000\,\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\,060$

Radiolytic Power of Waste $wastepower = 1\,065 \times 10^{-5}\,\frac{lb}{ft\,sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\,000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ 'no'

CGM Measurement $conc_{LFL\_cgm0} = 0\,000\,\%LFL$

DCRT Waste Temperature $T = 293\,150\,K$

Nitrate Concentration $NO_3 = 0\,300\,\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 0\,000\,\frac{mole}{liter}$

Aluminum Concentration $Al = 0\,000\,\frac{mole}{liter}$

TOC Concentration $TOC = 0\,045\,\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\,000\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\,000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 1\,000 \times 10^{-6}\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\,000\,\frac{mole}{liter}$

or $gr_{sol} = 0\,000\,\frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 1\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 29\,200\,\%$

Period 2

Second Flow Rate $flow_2 = 1\,000 \times 10^{-6}\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\,000\,\frac{ft^3}{hr}$

Time pumped at Second flow rate $lim2 = 1\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 29\,200\,\%$

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OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 1.000 \times 10^{-6} \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 29.200\,\%$ Final Fill Factor $fff = 29.200\,\%$

Initial Fill Volume $tvol_{init} = 24820\,gal$ Final Fill Volume $ffv = 24820\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 6.170 \times 10^{-3}\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 6.170 \times 10^{-3}\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 16.440\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 16.440\,\%$

Period 2

Second Flow Rate $flow_2 = 1.000 \times 10^{-6} \frac{gal}{min}$ Time pumped at Second Flow Rate $tim2 = 1.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 29.200\,\%$ Final Fill Factor $fff2 = 29.200\,\%$

Initial Fill Volume $tvol_{init2} = 24820\,gal$ Final Fill Volume $ffv2 = 24820\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 6.170 \times 10^{-3}\,\%$
Final H2 Concentration (%LFL) $fh2c2 = 0.012\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc2 = 0.012\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 16.440\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 16.440\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 32.486\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 167.228\,day$
Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 10.000 \times 10^{8}\,day$
Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 10.000 \times 10^{8}\,day$

244-U-DCRT

CASE 1

Author *[signature]* Date 1/26/00 Checked by *[signature]* Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 1

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\,180\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,410$	Nitrite Concentration	$NO_2 = 3\,020\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,481\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,200\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 12\,781\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\,250\,K$		

Period 1

Initial Flow Rate $flow = 4\,000\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\,297 \times 10^{-5}\frac{mole}{liter}$ or $gr_{sol} = 0\,026\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,026\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

OUTPUT SUMMARY·

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$ Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$ Final Fill Factor $fff = 40\ 240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$ Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\ 245\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 245\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 769\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$ Time Pumped at Second Flow Rate $tim2 = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$ Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$ Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 245\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4\ 255\,\%$ Final Flammable Gas Concentration $ffgc2 = 4\ 255\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\ 517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 11\ 517\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209\ 558\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 14\ 356\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 43\ 990\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 120\ 533\,day$

Author D C Hedengren Date 1/26/00 Checked by J D [signature] Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 1

Calculations based on worst case hydrogen generation 241-U-103 and worst case dissolved hydrogen 241-U-106
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 80% full

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000\ \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 410$

Radiolytic Power of Waste $wastepower = 1\ 481\ \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} = $ "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 304\ 250\ K$

Nitrate Concentration $NO_3 = 3\ 180\ \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 020\ \frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 200\ \frac{mole}{liter}$

TOC Concentration $TOC = 12\ 781\ \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\ 000\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\ 000\ \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\ \frac{mole}{liter}$

or $gr_{sol} = 0\ 026\ \frac{ft^3}{hr}$

Time Pumped at Initial Flow Rate $time = 104\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6}\ \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 6\ 598 \times 10^{-9}\ \frac{ft^3}{hr}$

Time Pumped at Second Flow Rate $lim2 = 680\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 479\ \%$

Author D C Hedengren Date 1/26/00 Checked by J D Rifer Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 104\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 80\ 479\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 4\ 255\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 4\ 255\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 11\ 517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 11\ 517\,\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 680\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 80\ 479\,\%$

Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 24960\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 4\ 255\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 10\ 940\,\%$

Final Flammable Gas Concentration $ffgc2 = 10\ 940\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\ 517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 11\ 517\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209\ 560\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 14\ 356\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 43\ 990\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 120\ 531\,day$

Author D C Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 1
Note

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 gpm

---

INPUT SUMMARY.

General Data

DCRT Ventilation Rate	$vr = 3\,000\,\frac{ft^3}{hr}$
Saltwell Waste Specific Gravity	$\rho = 1\,410$
Radiolytic Power of Waste	$wastepower = 1\,481\,\frac{lb}{ft\,sec^3}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$
DCRT Waste Temperature	$T = 304\,250\,K$
Nitrate Concentration	$NO_3 = 3\,180\,\frac{mole}{liter}$
Nitrite Concentration	$NO_2 = 3\,020\,\frac{mole}{liter}$
Aluminum Concentration	$Al = 1\,200\,\frac{mole}{liter}$
TOC Concentration	$TOC = 12\,781\,\frac{gm}{liter}$
Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\,297 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,026\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,026\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4.000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52.000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0.000\,\%$

Final Fill Factor $fff = 40.240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0.000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1.245\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1.245\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6.769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6.769\,\%$

Period 2

Second Flow Rate $flow_2 = 4.000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52.000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40.240\,\%$

Final Fill Factor $fff2 = 80.479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1.245\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4.255\,\%$

Final Flammable Gas Concentration $ffgc2 = 4.255\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11.517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 11.517\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209.558\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 14.356\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 43.990\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 120.533\,day$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-U CASE 1 Note

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 8 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\ \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180\ \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020\ \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481\ \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200\ \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\ ft^3$	TOC Concentration	$TOC = 12\ 781\ \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} = "no"$	Ammonia Concentration	$NH_3 = 0\ 000\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 0\ 000\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\ K$		

Period 1

Initial Flow Rate $flow = 8\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 26\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\ \frac{mole}{liter}$ or $gr_{sol} = 0\ 053\ \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 8\ 000\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 26\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 053\ \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Author *[signature]* Date 1/26/00 Checked by *[signature]* Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 8\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 26\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,153\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\,153\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\,769\,\%$

Period 2

Second Flow Rate $flow_2 = 8\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 26\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,153\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\,821\,\%$

Final Flammable Gas Concentration $ffgc2 = 3\,821\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\,517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 11\,517\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209\,558\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 14\,356\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 43\,990\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 120\,533\,day$

Author D C Hedengren Date 1/26/00 Checked by J D Rhen Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 1
Note

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 12 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\ ft^3$	TOC Concentration	$TOC = 12\ 781 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no	Ammonia Concentration	$NH_3 = 0\ 000\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 0\ 000\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\ K$		

Period 1

Initial Flow Rate $flow = 12\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 17\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5} \frac{mole}{liter}$ or $gr_{sol} = 0\ 079 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 12\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 18\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 079 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 466\ \%$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 12\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 17\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 39\ 466\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12240\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 1\ 093\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 093\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 681\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 681\ \%$

Period 2

Second Flow Rate $flow_2 = 12\ 000\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 18\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 466\ \%$

Final Fill Factor $fff2 = 81\ 253\ \%$

Initial Fill Volume $tvol_{init2} = 12240\ gal$

Final Fill Volume $ffv2 = 25200\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 093\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 3\ 763\ \%$

Final Flammable Gas Concentration $ffgc2 = 3\ 763\ \%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\ 622\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 11\ 622\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 219\ 280\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 13\ 500\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 41\ 425\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 112\ 397\ day$

Author DC Helgerson Date 1/26/00 Checked by J.D. [signature] Date 1/26/00

SUMMARY: DCRT 244-U CASE 1 Note

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 16 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 410$

Radiolytic Power of Waste $wastepower = 1\ 481\frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm}$ = "no

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\,\%LFL$

DCRT Waste Temperature $T = 304\ 250\,K$

Nitrate Concentration $NO_3 = 3\ 180\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 020\frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 200\frac{mole}{liter}$

TOC Concentration $TOC = 12\ 781\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 0\ 000\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 16\ 000\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 13\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\frac{mole}{liter}$

or $gr_{sol} = 0\ 106\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 16\ 000\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 13\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 106\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 16\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 13\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 40\ 240\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12480\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 1\ 106\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 106\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 769\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 769\ \%$

Period 2

Second Flow Rate $flow_2 = 16\ 000\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 13\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Final Fill Factor $fff2 = 80\ 479\ \%$

Initial Fill Volume $tvol_{init2} = 12480\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 106\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 3\ 593\ \%$

Final Flammable Gas Concentration $ffgc2 = 3\ 593\ \%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\ 517\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 11\ 517\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209\ 558\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 14\ 356\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 43\ 990\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 120\ 533\ day$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 1
Note

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 20 gpm

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\,180\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,410$	Nitrite Concentration	$NO_2 = 3\,020\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,481\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,200\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 12\,781\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\,250\,K$		

Period 1

Initial Flow Rate $flow = 20\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 10\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\,297 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,132\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 20\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 11\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,132\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 38\,692\,\%$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 10\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 38\ 692\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12000\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 1\ 041\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 041\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 592\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 592\ \%$

Period 2

Second Flow Rate $flow_2 = 20\ 000\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 11\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 38\ 692\ \%$

Final Fill Factor $fff2 = 81\ 253\ \%$

Initial Fill Volume $tvol_{init2} = 12000\ gal$

Final Fill Volume $ffv2 = 25200\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 041\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 3\ 635\ \%$

Final Flammable Gas Concentration $ffgc2 = 3\ 635\ \%$

Ultimate (ss) H2 Concentration (%LFL)
$uhh2c2 = 11\ 622\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL)
$uhfgc2 = 11\ 622\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 219\ 280\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 13\ 500\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 41\ 425\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 112\ 397\ day$

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 1
Note

Calculations based on worst case hydrogen generation tank 241-U-103 and highest hydrogen concentration in liquid waste from tank 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 30 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 12\ 781\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no"	Ammonia Concentration	$NH_3 = 0\ 000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\,K$		

Period 1

Initial Flow Rate $flow = 30\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 7\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 198\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 30\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 7\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 198\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 627\,\%$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 30\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 7\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 40\ 627\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12600\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\ 098\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 098\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 813\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 813\,\%$

Period 2

Second Flow Rate $flow_2 = 30\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 7\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 627\,\%$

Final Fill Factor $fff2 = 81\ 253\,\%$

Initial Fill Volume $tvol_{init2} = 12600\,gal$

Final Fill Volume $ffv2 = 25200\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 098\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\ 571\,\%$

Final Flammable Gas Concentration $ffgc2 = 3\ 571\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\ 622\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 11\ 622\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 219\ 280\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 13\ 500\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 41\ 425\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 112\ 397\,day$

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244-U-DCRT

CASE 2

Author D C Hedengren Date 1/26/00 Checked by JD Ryan Date 1/26/00

SUMMARY: DCRT 244-U CASE 2

Calculations based on worst case hydrogen generation 241-U-103 and worst case dissolved hydrogen 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 80% full

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\,000 \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\,180 \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\,410$	Nitrite Concentration	$NO_2 = 3\,020 \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\,481 \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\,200 \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\,000\,ft^3$	TOC Concentration	$TOC = 12\,781 \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no"	Ammonia Concentration	$NH_3 = 0\,000\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\,000\,\%LFL$	Methane Concentration	$CH_4 = 0\,000\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\,250\,K$		

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\,297 \times 10^{-5} \frac{mole}{liter}$ or $gr_{sol} = 0\,026 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\,026 \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author D C Hedengren Date 1/26/00 Checked by J D R... Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\ \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Final Fill Factor $fff = 40\ 240\ \%$

Initial Fill Volume $tvol_{init} = 0\ gal$

Final Fill Volume $ffv = 12480\ gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\ \%$

Final H2 Concentration (%LFL) $fh2c = 1\ 245\ \%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 245\ \%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 769\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 769\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Final Fill Factor $fff2 = 80\ 479\ \%$

Initial Fill Volume $tvol_{init2} = 12480\ gal$

Final Fill Volume $ffv2 = 24960\ gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 245\ \%$

Final H2 Concentration (%LFL) $fh2c2 = 4\ 255\ \%$

Final Flammable Gas Concentration $ffgc2 = 4\ 255\ \%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\ 517\ \%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 11\ 517\ \%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209\ 558\ \%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 14\ 356\ day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 43\ 990\ day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 120\ 533\ day$

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244-U-DCRT

CASE 3

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-U
Case 3

Table U3-1 Henry's Law Constant Calculation for Tank U-103 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 103				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1400	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	224000	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32500	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	28	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	190	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	180	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4320	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	34613	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	197000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	139000	Temperature of Air in Vapor Space	°F	89 8
CO_3^{2}	µg/ml	17200	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3430	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	3840	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	1730	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	10900	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non-Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	48 67			
Specific Gravity	unitless	1 41			
Total Organic Carbon	g/l	12 781			
Cs-137	µCi/ml	467			
Temperature	°F	88			

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244 U**
Case **3**

Table U3 1 (Cont d) Henry's Law Constant Calculation for Tank U 103 (2 pages)

Source Tank	U 103	INPUT DATA	Date	36547 78746		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1400
Na^{+1}	22 99	9 7433515	0 1143	1 113665072	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 20	0 2174	0 261878654				0 08220449
Fe^{+3}	55 85	0 00	0 1161	5 84139E-05				
Cr^{+3}	52	3 654E 03	0 0648	0 00023677	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	3 066E 03	0 1654	0 000507104				
K^{+1}	39 09	1 105E 01	0 0922	0 01018941	Ammonia	0	-0 0481	
OH^{-1}	17 0074	2 04	0 0839	0 170751008	Hydrogen	-0 299	-0 0218	
$NO_3^{\ 1}$	62 0049	3 18	0 0128	0 040667663	Methane	-0 524	0 0022	
$NO_2^{\ 1}$	46 0055	3 02	0 0795	0 240199638				
$CO_3^{\ 2}$	60 0092	0 29	0 1423	0 040786474				
PO_4^{-3}	94 9676	0 04	0 2119	0 007653303				
$SO_4^{\ 2}$	96 0576	3 998E 02	0 1117	0 004465314				
F^{1}	19	9 105E 02	0 092	0 00837684				
Cl^{1}	35 453	3 074E 01	0 0318	0 009776892				
Li^{+1}	6 94	0 00	0 0754	0				
$Br^{\ 1}$	79 916	0 000E+00	0 0269	0				
								Average
		20 06061405		1 909212555				
Mass fraction water in liq		0 49						Temperature
Liquid density (kg/m3)		1410 000						deg F
T (C)		31						88
								Temperature
								deg C
								31 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part. P atm	
Ammonia		0 08220449	-0 0481	8 796238969	45 77208045	3 570952654	0 023020325	
Hydrogen			-2 363E-02	2 724E+01	7 610E-04	1 917E-05	0 000E+00	
Methane			-1 002E-03	7 747E+01	1 292E-03	1 145E-05	0 000E+00	

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Total Generation Rate of NH_3	G_r	0 5084	L/s		
Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	2 30	%		Max NH3 Conc Based on Henry's Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3-mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	1 236E 02	0 03	0 20	
0 0183	66	2 253E-02	0 06	0 36	
0 0333	120	4 055E-02	0 10	0 66	
0 0617	222	7 360E-02	0 18	1 19	
0 1033	372	1 200E-01	0 30	1 94	
0 1750	630	1 938E-01	0 49	3 13	
0 332	1194	3 324E-01	0 83	5 37	
0 620	2232	5 218E-01	1 31	8 44	
1 035	3726	6 923E 01	1 74	11 19	
2 27	8154	8 755E 01	2 19	14 16	
3 35	12060	9 084E-01	2 28	14 69	
5 38	19362	9 176E-01	2 30	14 84	
8 27	29784	9 182E-01	2 30	14 85	
9 68	34860	9 182E-01	2 30	14 85	
10 9	39300	9 182E-01	2 30	14 85	
13 2	47640	9 182E-01	2 30	14 85	
16 6	59580	9 182E-01	2 30	14 85	
41 7	150000	9 182E-01	2 30	14 85	
64 6	232605	9 182E-01	2 30	14 85	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D R[illegible] Date 1/26/00

SUMMARY:

DCRT 244-U CASE 3

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 12\ 781\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ "no"	Ammonia Concentration	$NH_3 = 14\ 850\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 300\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\,K$		

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\,\frac{mole}{liter}$ or $gr_{sol} = 0\ 026\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 026\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Author D C Hedengren Date 1/26/00 Checked by J A Rh Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 40\ 240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\ 245\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\ 395\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\ 619\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 245\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4\ 255\,\%$

Final Flammable Gas Concentration $ffgc2 = 19\ 405\,\%$

Ultimate (ss) H2 Concentration (%LFL)
$uhh2c2 = 11\ 517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)
$uhfgc2 = 26\ 367\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 211\ 786\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 25\ 872\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 94\ 653\,day$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 3
WSU

Calculations based on worst case hydrogen generation and ammonia (WSU) tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106

- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\ \frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180\ \frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020\ \frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481\ \frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200\ \frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\ ft^3$	TOC Concentration	$TOC = 12\ 781\ \frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no	Ammonia Concentration	$NH_3 = 2\ 480\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 0\ 300\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\ K$		

Period 1

Initial Flow Rate $flow = 4\ 000\ \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 52\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\ \frac{mole}{liter}$

or $gr_{sol} = 0\ 026\ \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\ \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 026\ \frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Author ____________ Date 1/26/00 Checked by ____________ Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000\,\frac{gal}{min}$ — Time Pumped at Inital Flow Rate $time = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$ — Final Fill Factor $fff = 40\ 240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$ — Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\ 245\,\%$ — Final Flammable Gas Concentration (%LFL) $ffgc = 4\ 025\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 9\ 249\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\,\frac{gal}{min}$ — Time Pumped at Second Flow Rate $tim2 = 52\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$ — Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$ — Final Fill Volume $fv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 245\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4\ 255\,\%$ — Final Flammable Gas Concentration $ffgc2 = 7\ 035\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\ 517\,\%$ — Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 13\ 997\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 209\ 930\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 11\ 638\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 40\ 850\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 115\ 975\,day$

244-U-DCRT

CASE 4

Author D C Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

SUMMARY: DCRT 244-U CASE 4

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 8 12, 16 20 or 30 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\,000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\,410$

Radiolytic Power of Waste $wastepower = 1\,481 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\,000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm}$ = "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\,000\,\%LFL$

DCRT Waste Temperature $T = 304\,250\,K$

Nitrate Concentration $NO_3 = 3\,180 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\,020 \frac{mole}{liter}$

Aluminum Concentration $Al = 1\,200 \frac{mole}{liter}$

TOC Concentration $TOC = 12\,781 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\,850\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\,300\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 4\,000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\,297 \times 10^{-5} \frac{mole}{liter}$

or $gr_{sol} = 0\,026 \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\,026 \frac{ft^3}{hr}$

Time Pumped at Second Flow Rate $lim2 = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\,000\,\frac{gal}{min}$ Time Pumped at Initial Flow Rate $time = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$ Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$ Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,245\,\%$ Final Flammable Gas Concentration (%LFL) $ffgc = 16\,395\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\,619\,\%$

Period 2

Second Flow Rate $flow_2 = 4\,000\,\frac{gal}{min}$ Time Pumped at Second Flow Rate $tim2 = 52\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$ Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$ Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,245\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4\,255\,\%$ Final Flammable Gas Concentration $ffgc2 = 19\,405\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\,517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 26\,367\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 211\,786\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 25\,872\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 94\,653\,day$

Author D C Hedengren Date 1/26/00 Checked by J D Bergman Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 4

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106

- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 8 12 16 20 or 30 gpm

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 410$

Radiolytic Power of Waste $wastepower = 1\ 481 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm}$ = "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 304\ 250\ K$

Nitrate Concentration $NO_3 = 3\ 180 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 020 \frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 200 \frac{mole}{liter}$

TOC Concentration $TOC = 12\ 781 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\ 850\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 300\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 8\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5} \frac{mole}{liter}$

or $gr_{sol} = 0\ 053 \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 26\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 8\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 053 \frac{ft^3}{hr}$

Time Pumped at Second Flow Rate $lim2 = 26\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Author *DC Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 8\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 26\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,153\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\,303\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\,619\,\%$

Period 2

Second Flow Rate $flow_2 = 8\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 26\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,153\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\,821\,\%$

Final Flammable Gas Concentration $ffgc2 = 18\,971\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\,517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 26\,367\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 211\,786\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 25\,872\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 94\,653\,day$

Author D C Hedengren Date 1/26/00 Checked by J D R[illegible] Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 4

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 8 12 16, 20 or 30 gpm

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000\ \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 410$

Radiolytic Power of Waste $wastepower = 1\ 481\ \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm}$ = "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 304\ 250\ K$

Nitrate Concentration $NO_3 = 3\ 180\ \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 020\ \frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 200\ \frac{mole}{liter}$

TOC Concentration $TOC = 12\ 781\ \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\ 850\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 300\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 12\ 000\ \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\ \frac{mole}{liter}$

or $gr_{sol} = 0\ 079\ \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 17\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 12\ 000\ \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 079\ \frac{ft^3}{hr}$

Time Pumped at Second Flow Rate $lim2 = 18\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\ 466\ \%$

Author D C Hedengren Date 1/26/00 Checked by J D R Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 12\,000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 17\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 39\,466\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12240\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,093\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\,243\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,681\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\,531\,\%$

Period 2

Second Flow Rate $flow_2 = 12\,000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 18\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 39\,466\,\%$

Final Fill Factor $fff2 = 81\,253\,\%$

Initial Fill Volume $tvol_{init2} = 12240\,gal$

Final Fill Volume $ffv2 = 25200\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,093\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\,763\,\%$

Final Flammable Gas Concentration $ffgc2 = 18\,913\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\,622\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 26\,472\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 221\,508\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 24\,378\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 88\,610\,day$

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

SUMMARY: DCRT 244-U CASE 4

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 8, 12 16 20 or 30 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 410$

Radiolytic Power of Waste $wastepower = 1\ 481 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\ ft^3$

H_2 Inventory Based on CGM? $flag_{cgm}$ = "no"

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\ \%LFL$

DCRT Waste Temperature $T = 304\ 250\ K$

Nitrate Concentration $NO_3 = 3\ 180 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 020 \frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 200 \frac{mole}{liter}$

TOC Concentration $TOC = 12\ 781 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\ 850\ \%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 300\ \%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 16\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5} \frac{mole}{liter}$

or $gr_{sol} = 0\ 106 \frac{ft^3}{hr}$

Time Pumped at Initial Flow Rate $time = 13\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 16\ 000 \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 106 \frac{ft^3}{hr}$

Time Pumped at Second Flow Rate $lim2 = 13\ 000\ hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Author D C Hedengren Date 1/26/00 Checked by J.D. R... Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 16\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 13\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 40\,240\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12480\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,106\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\,256\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,769\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\,619\,\%$

Period 2

Second Flow Rate $flow_2 = 16\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 13\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,240\,\%$

Final Fill Factor $fff2 = 80\,479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\,gal$

Final Fill Volume $ffv2 = 24960\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,106\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\,593\,\%$

Final Flammable Gas Concentration $ffgc2 = 18\,743\,\%$

Ultimate (ss) H2 Concentration (%LFL)

$uhh2c2 = 11\,517\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL)

$uhfgc2 = 26\,367\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 211\,786\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 25\,872\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 94\,653\,day$

Author *D. C. Hedengren* Date *1/26/00* Checked by *J D Rogers* Date *1/26/00*

SUMMARY:

DCRT 244-U
CASE 4

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 8 12 16 20 or 30 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\,\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 180\,\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 410$	Nitrite Concentration	$NO_2 = 3\ 020\,\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 1\ 481\,\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 1\ 200\,\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000\,ft^3$	TOC Concentration	$TOC = 12\ 781\,\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm}$ = "no'	Ammonia Concentration	$NH_3 = 14\ 850\,\%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\,\%LFL$	Methane Concentration	$CH_4 = 0\ 300\,\%LFL_{CH4}$
DCRT Waste Temperature	$T = 304\ 250\,K$		

Period 1

Initial Flow Rate $flow = 20\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 10\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\ 132\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Period 2

Second Flow Rate $flow_2 = 20\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 11\ 000\,hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 132\,\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 38\ 692\,\%$

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 20\,000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 10\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Final Fill Factor $fff = 38\,692\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12000\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\,000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\,041\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\,191\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\,592\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\,442\,\%$

Period 2

Second Flow Rate $flow_2 = 20\,000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 11\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 38\,692\,\%$

Final Fill Factor $fff2 = 81\,253\,\%$

Initial Fill Volume $tvol_{init2} = 12000\,gal$

Final Fill Volume $ffv2 = 25200\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\,041\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\,635\,\%$

Final Flammable Gas Concentration $ffgc2 = 18\,785\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\,622\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 26\,472\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 221\,508\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\,000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 24\,378\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 88\,610\,day$

Author D C Hedengren Date 1/26/00 Checked by J D Bragg Date 1/26/00

SUMMARY:

DCRT 244-U
CASE 4

Calculations based on worst case hydrogen generation and ammonia tank 241-U-103 and worst case dissolved hydrogen and methane 241-U-106
- the initial condition of the tank is 0% full
- this model calulates the remainder until fill is hit at 80% full with pumping rate of 4 8 12, 16 20 or 30 gpm

---

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\,000\,\frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\,410$

Radiolytic Power of Waste $wastepower = 1\,481\,\frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\,000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ no"

CGM Measurement $conc_{LFL\_cgm0} = 0\,000\,\%LFL$

DCRT Waste Temperature $T = 304\,250\,K$

Nitrate Concentration $NO_3 = 3\,180\,\frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\,020\,\frac{mole}{liter}$

Aluminum Concentration $Al = 1\,200\,\frac{mole}{liter}$

TOC Concentration $TOC = 12\,781\,\frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\,850\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\,300\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 30\,000\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\,297 \times 10^{-5}\,\frac{mole}{liter}$

or $gr_{sol} = 0\,198\,\frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 7\,000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\,000\,\%$

Period 2

Second Flow Rate $flow_2 = 30\,000\,\frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\,198\,\frac{ft^3}{hr}$

Time Pumped at Second Flow Rate $tim2 = 7\,000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\,627\,\%$

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 30\ 000\,\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 7\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 40\ 627\,\%$

Initial Fill Volume $tvol_{init} = 0\,gal$

Final Fill Volume $ffv = 12600\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\ 098\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 16\ 248\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 813\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 21\ 663\,\%$

Period 2

Second Flow Rate $flow_2 = 30\ 000\,\frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 7\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 627\,\%$

Final Fill Factor $fff2 = 81\ 253\,\%$

Initial Fill Volume $tvol_{init2} = 12600\,gal$

Final Fill Volume $ffv2 = 25200\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 098\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 3\ 571\,\%$

Final Flammable Gas Concentration $ffgc2 = 18\ 721\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 11\ 622\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 26\ 472\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 221\ 508\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 0\ 000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 24\ 378\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 88\ 610\,day$

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244-U-DCRT

CASE 5

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-U 1/12/00 15 02

Case 5 (Story 1)

Worst Case Tank Waste U-108
Ammonia in liquid waste in U 108 -25%, 50%, and 100% LFL
at various temperatures between 70 and 170 deg F

Table U5 1 Shumpe Model for U 108 Ammonia Values

Model	Temperature (° F)	Ammonia in Vapor Space (% LFL)	Ammonia in liquid waste (µg/mL)
Schumpe	70	25	3079
Schumpe	70	50	6158
Schumpe	70	100	12315
Schumpe	80	25	2364
Schumpe	80	50	4728
Schumpe	80	100	9457
Schumpe	90	25	1832
Schumpe	90	50	3664
Schumpe	90	100	7328
Schumpe	100	25	1431
Schumpe	100	50	2863
Schumpe	100	100	5726
Schumpe	110	25	1128
Schumpe	110	50	2255
Schumpe	110	100	4511
Schumpe	120	25	895
Schumpe	120	50	1790
Schumpe	120	100	3581
Schumpe	130	25	716
Schumpe	130	50	1432
Schumpe	130	100	2863
Schumpe	140	25	576
Schumpe	140	50	1153
Schumpe	140	100	2305
Schumpe	150	25	467
Schumpe	150	50	934
Schumpe	150	100	1868
Schumpe	160	25	381
Schumpe	160	50	762
Schumpe	160	100	1524
Schumpe	170	25	312
Schumpe	170	50	625
Schumpe	170	100	1250

Author D C Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244-U
Case 5 (Story 1)

Table U5 2 U farm Ammonia Data

Tank	Ammonia in liquid waste (µg/mL)	Temperature (° F)	Ionic Strength (molarity)	Henry s Law Constant, K[NH_3] (mole/L liquid atm)	Ammonia in Vapor Space (% LFL)
U 102	745	86	20 28	4 118	6 85
U-103	1400	88	20 06	3 571	14 85
U 105	1600	90	18 5	4 833	12 54
U 106	1	82	16 44	7 111	0 01
U 107	403	79	19 19	5 869	2 6
U 108	1	88	21 29	2 918	0 01
U 109	1100	84	20 17	4 29	9 71

Note 15 5% NH3 = 100% LFL

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-3 Henry's Law Constant Calculation for Tank U-102 (2 pages)

Input Data for Henry s Law Constant Calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-102				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	745	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	243000	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	18000	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	20	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	279	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	126	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3770	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	26630	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	244001	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	104000	Temperature of Air in Vapor Space	°F	87 8
CO_3^{2}	µg/ml	46800	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3800	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	7050	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	706	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8810	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	47 85			
Specific Gravity	unitless	1 38			
Total Organic Carbon	g/l	12 75			
Cs 137	µCi/ml	436			
Temperature	°F	86			

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-3 (Cont d) Henry s Law Constant Calculation for Tank U 102 (2 pages)

Source Tank	U 102	INPUT DATA	Date	01/13/00		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				745
Na^{+1}	22 99	10 57	0 1143	1 20812992	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 67	0 2174	0 145041013				0 043744532
Fe^{+3}	55 85	3 599E 04	0 1161	4 17835E 05				
Cr^{+3}	52	5 365E 03	0 0648	0 000347677	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	2 146E 03	0 1654	0 000354972				
K^{+1}	39 09	0 10	0 0922	0 008892133	Ammonia	0	0 0481	
OH^{1}	17 0074	1 57	0 0839	0 131369698	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	3 94	0 0128	0 050370328	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 26	0 0795	0 179717598				
CO_3^{2}	60 0092	0 78	0 1423	0 110976841				
PO_4^{-3}	94 9676	4 001E 02	0 2119	0 008478882				
SO_4^{2}	96 0576	7 339E 02	0 1117	0 008198057				
F^{1}	19	3 716E 02	0 092	0 003418526				
Cl^{1}	35 453	0 25	0 0318	0 007902239				
Li^{+1}	6 94	0 000E+00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 28		1 863				
Mass fraction water in liq		0 479						Temperature
Liquid density (kg/m3)		1380						deg F
T (C)		30 0						86
								Temperature
								deg C
								30 0
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		4 374E 02	4 810E 02	7 721E+00	4 815E+01	4 118E+00	1 062E 02	
Hydrogen			2 330E 02	2 459E+01	7 647E 04	2 053E 05	0 000E+00	
Methane			4 200E 04	7 157E+01	1 315E 03	1 213E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-4 Henry's Law Constant Calculation for Tank U-103 (2 pages)

Input Data for Henrys K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-103				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1400	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	224000	Volume of Vapor Space	L	58700
Al^{+3}	μg/ml	32500	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	28	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	190	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	180	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	4320	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	34613	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	197000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	139000	Temperature of Air in Vapor Space	°F	89 8
CO_3^{2}	μg/ml	17200	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3430	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	3840	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	1730	Surface Area of Still Waste	m^2	39 02
Cl^{1}	μg/ml	10900	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	48 67			
Specific Gravity	unitless	1 41			
Total Organic Carbon	g/l	12 781			
Cs 137	μCi/ml	467			
Temperature	°F	88			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-4 (Cont d) Henry s Law Constant Calculation for Tank U 103 (2 pages)

Source Tank	U 103	INPUT DATA	Date	36538 36822		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1400
Na^{+1}	22 99	9 7433515	0 1143	1 113665072	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 20	0 2174	0 261878654				0 08220449
Fe^{3}	55 85	0 00	0 1161	5 84139E 05				
Cr^{+3}	52	3 654E 03	0 0648	0 00023677	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	3 066E 03	0 1654	0 000507104				
K^{+1}	39 09	1 105E 01	0 0922	0 01018941	Ammonia	0	0 0481	
OH^{1}	17 0074	2 04	0 0839	0 170751008	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	3 18	0 0128	0 040667663	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	3 02	0 0795	0 240199638				
CO_3^{2}	60 0092	0 29	0 1423	0 040786474				
PO_4^{3}	94 9676	0 04	0 2119	0 007653303				
SO_4^{2}	96 0576	3 998E 02	0 1117	0 004465314				
F^{1}	19	9 105E 02	0 092	0 00837684				
Cl^{1}	35 453	3 074E 01	0 0318	0 009776892				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 06061405		1 909212555				
Mass fraction water in liq		0 49						Temperature
Liquid density (kg/m3)		1410 000						deg F
T (C)		31						88
								Temperature
								deg C
								31 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 08220449	0 0481	8 796238969	45 77208045	3 570952654	0 023020325	
Hydrogen			2 363E 02	2 724E+01	7 610E 04	1 917E 05	0 000E+00	
Methane			1 002E 03	7 747E+01	1 292E 03	1 145E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-5 Henry's Law Constant Calculation for Tank U-105 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-105				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1600	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	226999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	29800	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	31	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	201	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	248	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3980	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	20933	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181001	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	108000	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	27850	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3923	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	8010	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	1310	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8920	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	62 56			
Specific Gravity	unitless	1 46			
Total Organic Carbon	g/l	11 441			
Cs 137	µCi/ml	386			
Temperature	°F	90			

Author D C Hedengren Date 1/26/00 Checked by JDR Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-5 (Cont d) Henry s Law Constant Calculation for Tank U 105 (2 pages)

Source Tank	U 105	INPUT DATA	Date	36538 38204		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1600
Na^{+1}	22 99	9 8738295	0 1143	1 128578711	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 10	0 2174	0 240123538				0 093947988
Fe^{+3}	55 85	0 00	0 1161	6 44423E-05				
Cr^{+3}	52	3 865E 03	0 0648	0 000250476	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	4 224E 03	0 1654	0 000698675				
K^{+1}	39 09	1 018E 01	0 0922	0 009387474	Ammonia	0	-0 0481	
OH^{1}	17 0074	1 23	0 0839	0 103265561	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364909	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	2 35	0 0795	0 186629853				
CO_3^{2}	60 0092	0 46	0 1423	0 066040643				
PO_4^{3}	94 9676	0 04	0 2119	0 008752407				
SO_4^{2}	96 0576	8 339E 02	0 1117	0 009314378				
F^{1}	19	6 895E 02	0 092	0 006343156				
Cl^{1}	35 453	2 516E 01	0 0318	0 008000904				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		18 49564501		1 804815126				
Mass fraction water in liq		0 63						Temperature
Liquid density (kg/m3)		1460 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 093947988	0 0481	8 225732864	43 52508667	4 832976005	0 019438952	
Hydrogen			2 396E 02	2 300E+01	7 576E 04	3 009E-05	0 000E+00	
Methane			1 584E 03	5 964E+01	1 271E 03	1 947E-05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-6 Henry s Law Constant Calculation for Tank U-106 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet						
				244-U		
Source Tank	U 106					
Dilution Ratio	0 1			Correction Factor for Schumpe Model 1		
Receiving Tank	244-U					
Liquid Waste Characteristics (Source Tank)				Tank Characteristics (Receiving Tank)		
Parameter	Units	Value		Parameter	Units	Value
NH_3	µg/ml	1		Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	210001		Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	11300		Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	50		Inside Diameter of Receiving Tank	ft	12
Cr^{3}	µg/ml	393		Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	496		Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	1810		Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	0		Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	233001		Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	92800		Temperature of Air in Vapor Space	°F	83 8
CO_3^{2}	µg/ml	46500		Stream Diameter	inches	1
PO_4^{3}	µg/ml	3708		Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	8130		Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	60		Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	5070		Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0		Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0		Correction Factor for Schumpe Model	unitless	1
%H_2O	%	48 6				
Specific Gravity	unitless	1 35				
Total Organic Carbon	g/l	37 47				
Cs 137	µCi/ml					
Temperature	°F	82				

Author D C Hedengren Date 1/26/00 Checked by JD Bajka Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-6 (Cont d) Henry s Law Constant Calculation for Tank U 106 (2 pages)

Source Tank	U 106	INPUT DATA	Date	36538 38787		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1
Na^{+1}	22 99	9 1344324	0 1143	1 044065619	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 42	0 2174	0 091053369				5 87175E-05
Fe^{+3}	55 85	0 00	0 1161	0 000104147				
Cr^{+3}	52	7 558E 03	0 0648	0 000489738	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	8 448E 03	0 1654	0 001397348				
K^{+1}	39 09	4 630E 02	0 0922	0 004269171	Ammonia	0	0 0481	
OH^{1}	17 0074	0 00	0 0839	0	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	3 76	0 0128	0 048099538	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 02	0 0795	0 16036334				
CO_3^{2}	60 0092	0 77	0 1423	0 11026545				
PO_4^{3}	94 9676	0 04	0 2119	0 008273744				
SO_4^{2}	96 0576	8 464E 02	0 1117	0 009453918				
F^{1}	19	3 179E 03	0 092	0 000292463				
Cl^{1}	35 453	1 430E 01	0 0318	0 004547604				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		16 43614057		1 482675449				
Mass fraction water in liq		0 49						Temperature
Liquid density (kg/m3)		1350 000						deg F
T (C)		28						82
								Temperature
								deg C
								27 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		5 87175E 05	-0 0481	4 921495443	53 34394698	7 111448954	8 25676E 06	
Hydrogen			2 263E 02	1 290E+01	7 727E 04	3 929E 05	0 000E+00	
Methane			7 444E 04	3 125E+01	1 363E 03	2 861E-05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-7 Henry s Law Constant Calculation for Tank U-107 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-107				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	403	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	221001	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	26400	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	38	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	575	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	17	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	3270	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	27597	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	227000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	111000	Temperature of Air in Vapor Space	^oF	80 8
CO_3^{2}	µg/ml	26450	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3440	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	6630	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	167	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8990	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	52 14			
Specific Gravity	unitless	1 41			
Total Organic Carbon	g/l	3 907			
Cs 137	µCi/ml	352			
Temperature	^oF	79			

Author D-C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5 7 (Cont d) Henry s Law Constant Calculation for Tank U 107 (2 pages)

Source Tank	U 107	INPUT DATA	Date	36538 39707		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				403
Na^{+1}	22 99	9 6129004	0 1143	1 098754515	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	0 98	0 2174	0 212726416				0 023663149
Fe^{+3}	55 85	0 00	0 1161	7 83701E 05				
Cr^{+3}	52	1 106E 02	0 0648	0 000716538	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	2 930E 04	0 1654	4 84566E-05				
K^{+1}	39 09	8 365E 02	0 0922	0 00771282	Ammonia	0	0 0481	
OH^{1}	17 0074	1 62	0 0839	0 136140051	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	3 66	0 0128	0 046860839	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 41	0 0795	0 191814012				
CO_3^{2}	60 0092	0 44	0 1423	0 062721082				
PO_4^{3}	94 9676	0 04	0 2119	0 00767564				
SO_4^{2}	96 0576	6 902E 02	0 1117	0 007709659				
F^{1}	19	8 789E 03	0 092	0 000808634				
Cl^{1}	35 453	2 536E 01	0 0318	0 008063694				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		19 19186155		1 781830726				
Mass fraction water in liq		0 52						Temperature
Liquid density (kg/m3)		1410 000						deg F
T (C)		26						79
								Temperature
								deg C
								26 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 023663149	0 0481	7 222743396	57 65604198	5 868576617	0 004032179	
Hydrogen			2 213E-02	2 275E+01	7 793E-04	2 518E 05	0 000E+00	
Methane			1 618E 03	6 499E+01	1 402E-03	1 586E 05	0 000E+00	

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DCRT 244 U
Case 5 (Story 1)

Table U5-8 Henry's Law Constant Calculation for Tank U-108 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1	Percent Fill of Receiving Tank	%	50
Na [1]	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K [1]	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH [1]	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 [1]	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2 [1]	µg/ml	130000	Temperature of Air in Vapor Space	°F	89 8
CO_3 [2]	µg/ml	22000	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4 [2]	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F [1]	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl [1]	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br [1]	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	88			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-8 (Cont d) Henry s Law Constant Calculation for Tank U 108 (2 pages)

Source Tank	U 108	INPUT DATA	Date	36538 40271		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				5 87175E 05
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{-3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		31						88
								Temperature
								deg C
								31 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		5 87175E 05	-0 0481	10 9847483	45 77208045	2 917979694	2 01227E 05	
Hydrogen			2 363E 02	3 646E+01	7 610E 04	1 462E-05	0 000E+00	
Methane			1 002E 03	1 105E+02	1 292E 03	8 188E 06	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Bryan Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-9 Henry's Law Constant Calculation for Tank U-109 (2 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-109				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1100	Percent Fill of Receiving Tank	%	50
Na 1	μg/ml	228000	Volume of Vapor Space	L	58700
Al 3	μg/ml	29200	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	100	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	2610	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	46	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	3330	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH 1	μg/ml	44150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3 1	μg/ml	185000	Total Bubbler Flow Rate	cfh	3
NO_2 1	μg/ml	128000	Temperature of Air in Vapor Space	°F	85 8
CO_3 2	μg/ml	18700	Stream Diameter	inches	1
PO_4 3	μg/ml	3370	Tortuosity Factor	unitless	1
SO_4 2	μg/ml	5170	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F 1	μg/ml	396	Surface Area of Still Waste	m^2	39 02
Cl 1	μg/ml	8690	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br 1	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	51 93			
Specific Gravity	unitless	1 47			
Total Organic Carbon	g/l	4 433			
Cs 137	μCi/ml	366			
Temperature	°F	84			

Author DC Hedengren Date 1/26/00 Checked by JD Bogley Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5 9 (Cont d) Henry s Law Constant Calculation for Tank U 109 (2 pages)

Source Tank	U 109	INPUT DATA	Date	36538 41362		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1100
Na^{+1}	22 99	9 9173528	0 1143	1 133553421	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 08	0 2174	0 235287822				0 064589242
Fe^{+3}	55 85	0 00	0 1161	0 000207878				
Cr^{+3}	52	5 019E 02	0 0648	0 003252461	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	7 750E 04	0 1654	0 000128184				
K^{+1}	39 09	8 519E 02	0 0922	0 00785435	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 60	0 0839	0 217798429	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 98	0 0128	0 038190427	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 78	0 0795	0 221190869				
CO_3^{2}	60 0092	0 31	0 1423	0 044343408				
PO_4^{-3}	94 9676	0 04	0 2119	0 007519448				
SO_4^{2}	96 0576	5 382E 02	0 1117	0 006011909				
F^{1}	19	2 084E 02	0 092	0 001917475				
Cl^{1}	35 453	2 451E 01	0 0318	0 007794595				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		20 16629255		1 925050675				
Mass fraction water in liq		0 52						Temperature
Liquid density (kg/m3)		1470 000						deg F
T (C)		29						84
								Temperature
								deg C
								28 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 064589242	0 0481	9 016791013	50 67243163	4 289981298	0 015055833	
Hydrogen			2 296E 02	2 897E+01	7 686E 04	2 025E 05	0 000E+00	
Methane			1 622E 04	8 479E+01	1 338E 03	1 205E 05	0 000E+00	

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3079	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	70			

Author D C Hedengren Date 1/26/00 Checked by S D Bayer Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5 10 (Cont d) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 46848		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				3079
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 180791159
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{-1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 180791159	0 0481	10 9847483	73 15835385	4 663860347	0 038764274	
Hydrogen			2 064E 02	4 221E+01	8 025E 04	1 331E 05	0 000E+00	
Methane			4 238E 03	1 429E+02	1 537E 03	7 534E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	2 563E 02	**0 06**	**0 40**	
0 0183	66	4 667E 02	**0 11**	**0 73**	
0 0333	120	8 385E 02	**0 20**	**1 31**	
0 0617	222	1 517E 01	**0 37**	**2 37**	
0 1033	372	2 459E 01	**0 60**	**3 85**	
0 1750	630	3 938E 01	**0 95**	**6 16**	
0 332	1194	6 634E 01	**1 61**	**10 37**	
0 620	2232	1 012E+00	**2 45**	**15 82**	
1 035	3726	1 299E+00	**3 15**	**20 31**	
2 27	8154	1 558E+00	**3 78**	**24 36**	
3 35	12060	1 592E+00	**3 86**	**24 89**	
5 38	19362	1 598E+00	**3 87**	**25 00**	
8 27	29784	1 599E+00	**3 88**	**25 00**	
9 68	34860	1 599E+00	**3 88**	**25 00**	
10 9	39300	1 599E+00	**3 88**	**25 00**	
13 2	47640	1 599E+00	**3 88**	**25 00**	
16 6	59580	1 599E+00	**3 88**	**25 00**	
41 7	150000	1 599E+00	**3 88**	**25 00**	
64 6	232605	1 599E+00	**3 88**	**25 00**	Time to fill from 0% to 50% at 4gpm

Author D C Halongan Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	6158	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	70			

Author D C Hedengren Date 1/26/00 Checked by J D Bryan Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 48304		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				6158
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 361582319
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 361582319	-0 0481	10 9847483	73 15835385	4 663860347	0 077528548	
Hydrogen			2 064E 02	4 221E+01	8 025E 04	1 331E 05	0 000E+00	
Methane			4 238E 03	1 429E+02	1 537E 03	7 534E 06	0 000E+00	

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	5 126E 02	0 12	0 80	
0 0183	66	9 335E 02	0 23	1 46	
0 0333	120	1 677E 01	0 41	2 62	
0 0617	222	3 033E 01	0 74	4 74	
0 1033	372	4 918E 01	1 19	7 69	
0 1750	630	7 877E 01	1 91	12 32	
0 332	1194	1 327E+00	3 22	20 75	
0 620	2232	2 023E+00	4 91	31 65	
1 035	3726	2 597E+00	6 30	40 62	
2 27	8154	3 115E+00	7 55	48 72	
3 35	12060	3 183E+00	7 72	49 78	
5 38	19362	3 197E+00	7 75	50 00	
8 27	29784	3 197E+00	7 75	50 00	
9 68	34860	3 197E+00	7 75	50 00	
10 9	39300	3 197E+00	7 75	50 00	
13 2	47640	3 197E+00	7 75	50 00	
16 6	59580	3 197E+00	7 75	50 00	
41 7	150000	3 197E+00	7 75	50 00	
64 6	232605	3 197E+00	7 75	50 00	Time to fill from 0% to 50% at 4gpm

Author DC Hedengren Date 1/26/00 Checked by JD Reynolds Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	12315	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	71 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	70			

Author DC Hedengren Date 1/26/00 Checked by JD Bryan Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 49528		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				12315
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 72310592
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		21						70
								Temperature
								deg C
								21 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 72310592	0 0481	10 9847483	73 15835385	4 663860347	0 155044505	
Hydrogen			2 064E 02	4 221E+01	8 025E 04	1 331E 05	0 000E+00	
Methane			4 238E 03	1 429E+02	1 537E 03	7 534E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 50**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 025E 01	**0 25**	**1 60**	
0 0183	66	1 867E-01	**0 45**	**2 92**	
0 0333	120	3 354E 01	**0 81**	**5 24**	
0 0617	222	6 066E 01	**1 47**	**9 49**	
0 1033	372	9 835E 01	**2 38**	**15 38**	
0 1750	630	1 575E+00	**3 82**	**24 64**	
0 332	1194	2 653E+00	**6 43**	**41 49**	
0 620	2232	4 047E+00	**9 81**	**63 29**	
1 035	3726	5 194E+00	**12 59**	**81 23**	
2 27	8154	6 230E+00	**15 10**	**97 43**	
3 35	12060	6 366E+00	**15 43**	**99 55**	
5 38	19362	6 393E+00	**15 50**	**99 98**	
8 27	29784	6 394E+00	**15 50**	**100 00**	
9 68	34860	6 394E+00	**15 50**	**100 00**	
10 9	39300	6 394E+00	**15 50**	**100 00**	
13 2	47640	6 394E+00	**15 50**	**100 00**	
16 6	59580	6 394E+00	**15 50**	**100 00**	
41 7	150000	6 394E+00	**15 50**	**100 00**	
64 6	232605	6 394E+00	**15 50**	**100 00**	Time to fill from 0% to 50% at 4gpm

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2364	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	80			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 49749		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				2364
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 138808152
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{-3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 138808152	0 0481	10 9847483	56 17624453	3 581247329	0 038759722	
Hydrogen			2 230E-02	3 891E+01	7 771E-04	1 398E 05	0 000E+00	
Methane			1 327E 03	1 239E+02	1 389E 03	7 849E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 090E 02	**0 05**	**0 33**	
0 0183	66	3 810E 02	**0 09**	**0 61**	
0 0333	120	6 858E 02	**0 17**	**1 09**	
0 0617	222	1 245E 01	**0 31**	**1 98**	
0 1033	372	2 030E 01	**0 50**	**3 23**	
0 1750	630	3 282E 01	**0 81**	**5 23**	
0 332	1194	5 633E 01	**1 39**	**8 97**	
0 620	2232	8 857E 01	**2 19**	**14 11**	
1 035	3726	1 177E+00	**2 91**	**18 76**	
2 27	8154	1 494E+00	**3 69**	**23 80**	
3 35	12060	1 551E+00	**3 83**	**24 72**	
5 38	19362	1 568E+00	**3 87**	**24 98**	
8 27	29784	1 569E+00	**3 87**	**25 00**	
9 68	34860	1 569E+00	**3 87**	**25 00**	
10 9	39300	1 569E+00	**3 87**	**25 00**	
13 2	47640	1 569E+00	**3 87**	**25 00**	
16 6	59580	1 569E+00	**3 87**	**25 00**	
41 7	150000	1 569E+00	**3 87**	**25 00**	
64 6	232605	1 569E+00	**3 87**	**25 00**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	4728	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	80			

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 49965		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				4728
Na^{1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 277616305
Fe^{+3}	55 85	0 00	0 1161	6 92235E-05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E-05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 277616305	0 0481	10 9847483	56 17624453	3 581247329	0 077519445	
Hydrogen			2 230E 02	3 891E+01	7 771E 04	1 398E 05	0 000E+00	
Methane			1 327E 03	1 239E+02	1 389E 03	7 849E-06	0 000E+00	

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DCRT 244 U
Case 5 (Story 1)

Table U5 10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	4 180E 02	**0 10**	**0 67**	
0 0183	66	7 620E 02	**0 19**	**1 21**	
0 0333	120	1 372E 01	**0 34**	**2 19**	
0 0617	222	2 490E 01	**0 62**	**3 97**	
0 1033	372	4 060E 01	**1 00**	**6 47**	
0 1750	630	6 563E 01	**1 62**	**10 46**	
0 332	1194	1 127E+00	**2 78**	**17 95**	
0 620	2232	1 771E+00	**4 37**	**28 23**	
1 035	3726	2 355E+00	**5 82**	**37 52**	
2 27	8154	2 987E+00	**7 38**	**47 60**	
3 35	12060	3 103E+00	**7 66**	**49 43**	
5 38	19362	3 135E+00	**7 74**	**49 96**	
8 27	29784	3 138E+00	**7 75**	**49 99**	
9 68	34860	3 138E+00	**7 75**	**49 99**	
10 9	39300	3 138E+00	**7 75**	**49 99**	
13 2	47640	3 138E+00	**7 75**	**49 99**	
16 6	59580	3 138E+00	**7 75**	**49 99**	
41 7	150000	3 138E+00	**7 75**	**49 99**	
64 6	232605	3 138E+00	**7 75**	**49 99**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Rife Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	9457	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	μg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	130000	Temperature of Air in Vapor Space	°F	81 8
CO_3^{2}	μg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	μg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	μCi/ml	416			
Temperature	°F	80			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 50209		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				9457
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 555291327
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		27						80
								Temperature
								deg C
								26 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 555291327	0 0481	10 9847483	56 17624453	3 581247329	0 155055285	
Hydrogen			2 230E 02	3 891E+01	7 771E 04	1 398E 05	0 000E+00	
Methane			1 327E 03	1 239E+02	1 389E 03	7 849E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	8 360E 02	**0 21**	**1 33**	
0 0183	66	1 524E 01	**0 38**	**2 43**	
0 0333	120	2 744E 01	**0 68**	**4 37**	
0 0617	222	4 981E 01	**1 23**	**7 94**	
0 1033	372	8 121E 01	**2 01**	**12 94**	
0 1750	630	1 313E+00	**3 24**	**20 92**	
0 332	1194	2 253E+00	**5 56**	**35 90**	
0 620	2232	3 543E+00	**8 75**	**56 46**	
1 035	3726	4 710E+00	**11 63**	**75 04**	
2 27	8154	5 975E+00	**14 76**	**95 20**	
3 35	12060	6 206E+00	**15 33**	**98 88**	
5 38	19362	6 271E+00	**15 49**	**99 93**	
8 27	29784	6 276E+00	**15 50**	**100 00**	
9 68	34860	6 276E+00	**15 50**	**100 00**	
10 9	39300	6 276E+00	**15 50**	**100 00**	
13 2	47640	6 276E+00	**15 50**	**100 00**	
16 6	59580	6 276E+00	**15 50**	**100 00**	
41 7	150000	6 276E+00	**15 50**	**100 00**	
64 6	232605	6 276E+00	**15 50**	**100 00**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J. D Bryan Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1832	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	90			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 50367		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1832
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 107570446
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 107570446	0 0481	10 9847483	43 52508667	2 774733371	0 03876785	
Hydrogen			2 396E-02	3 587E+01	7 576E 04	1 479E 05	0 000E+00	
Methane			1 584E 03	1 074E+02	1 271E 03	8 286E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 704E 02	**0 04**	**0 28**	
0 0183	66	3 110E 02	**0 08**	**0 50**	
0 0333	120	5 607E 02	**0 14**	**0 91**	
0 0617	222	1 021E 01	**0 26**	**1 66**	
0 1033	372	1 673E 01	**0 42**	**2 71**	
0 1750	630	2 725E 01	**0 69**	**4 42**	
0 332	1194	4 753E 01	**1 20**	**7 71**	
0 620	2232	7 676E 01	**1 93**	**12 46**	
1 035	3726	1 053E+00	**2 65**	**17 09**	
2 27	8154	1 417E+00	**3 56**	**22 99**	
3 35	12060	1 503E+00	**3 78**	**24 40**	
5 38	19362	1 537E+00	**3 87**	**24 94**	
8 27	29784	1 540E+00	**3 87**	**25 00**	
9 68	34860	1 541E+00	**3 88**	**25 00**	
10 9	39300	1 541E+00	**3 88**	**25 00**	
13 2	47640	1 541E+00	**3 88**	**25 00**	
16 6	59580	1 541E+00	**3 88**	**25 00**	
41 7	150000	1 541E+00	**3 88**	**25 00**	
64 6	232605	1 541E+00	**3 88**	**25 00**	Time to fill from 0% to 50% at 4gpm

Author D. C. Hedengren Date 1/26/00 Checked by J. D. Berger Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3664	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	90			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 51012		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				3664
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 215140893
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 215140893	0 0481	10 9847483	43 52508667	2 774733371	0 077535699	
Hydrogen			2 396E 02	3 587E+01	7 576E-04	1 479E 05	0 000E+00	
Methane			1 584E 03	1 074E+02	1 271E 03	8 286E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**7 75**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	3 408E-02	**0 09**	**0 55**	
0 0183	66	6 219E 02	**0 16**	**1 01**	
0 0333	120	1 121E 01	**0 28**	**1 82**	
0 0617	222	2 042E 01	**0 51**	**3 31**	
0 1033	372	3 345E 01	**0 84**	**5 43**	
0 1750	630	5 450E 01	**1 37**	**8 84**	
0 332	1194	9 506E 01	**2 39**	**15 43**	
0 620	2232	1 535E+00	**3 86**	**24 91**	
1 035	3726	2 107E+00	**5 30**	**34 19**	
2 27	8154	2 833E+00	**7 13**	**45 98**	
3 35	12060	3 007E+00	**7 56**	**48 80**	
5 38	19362	3 073E+00	**7 73**	**49 88**	
8 27	29784	3 081E+00	**7 75**	**50 00**	
9 68	34860	3 081E+00	**7 75**	**50 00**	
10 9	39300	3 081E+00	**7 75**	**50 00**	
13 2	47640	3 081E+00	**7 75**	**50 00**	
16 6	59580	3 081E+00	**7 75**	**50 00**	
41 7	150000	3 081E+00	**7 75**	**50 00**	
64 6	232605	3 081E+00	**7 75**	**50 00**	Time to fill from 0% to 50% at 4gpm

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	7328	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	91 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	90			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 5123		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				7328
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 430281785
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		32						90
								Temperature
								deg C
								32 22222222
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 430281785	0 0481	10 9847483	43 52508667	2 774733371	0 155071399	
Hydrogen			2 396E 02	3 587E+01	7 576E 04	1 479E 05	0 000E+00	
Methane			1 584E 03	1 074E+02	1 271E 03	8 286E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**%NH$_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**%NH_3**	**% LFL NH_3**	
0 0100	36	6 816E 02	**0 17**	**1 11**	
0 0183	66	1 244E 01	**0 31**	**2 02**	
0 0333	120	2 243E 01	**0 56**	**3 64**	
0 0617	222	4 085E 01	**1 03**	**6 63**	
0 1033	372	6 691E 01	**1 68**	**10 86**	
0 1750	630	1 090E+00	**2 74**	**17 69**	
0 332	1194	1 901E+00	**4 78**	**30 85**	
0 620	2232	3 070E+00	**7 72**	**49 82**	
1 035	3726	4 213E+00	**10 60**	**68 38**	
2 27	8154	5 666E+00	**14 25**	**91 95**	
3 35	12060	6 014E+00	**15 13**	**97 59**	
5 38	19362	6 147E+00	**15 46**	**99 75**	
8 27	29784	6 162E+00	**15 50**	**99 99**	
9 68	34860	6 162E+00	**15 50**	**100 00**	
10 9	39300	6 162E+00	**15 50**	**100 00**	
13 2	47640	6 162E+00	**15 50**	**100 00**	
16 6	59580	6 162E+00	**15 50**	**100 00**	
41 7	150000	6 162E+00	**15 50**	**100 00**	
64 6	232605	6 162E+00	**15 50**	**100 00**	Time to fill from 0% to 50% at 4gpm

Author *[signature]* Date 1/26/00 Checked by *[signature]* Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1431	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	100			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 51382		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1431
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 084024732
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 084024732	0 0481	10 9847483	34 01071777	2 168190366	0 038753392	
Hydrogen			2 562E-02	3 307E+01	7 434E 04	1 574E 05	0 000E+00	
Methane			4 496E 03	9 314E+01	1 178E 03	8 854E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 391E 02	**0 04**	**0 23**	
0 0183	66	2 540E 02	**0 07**	**0 42**	
0 0333	120	4 586E 02	**0 12**	**0 76**	
0 0617	222	8 374E 02	**0 21**	**1 38**	
0 1033	372	1 377E 01	**0 35**	**2 27**	
0 1750	630	2 257E 01	**0 58**	**3 73**	
0 332	1194	3 991E 01	**1 02**	**6 59**	
0 620	2232	6 594E 01	**1 69**	**10 89**	
1 035	3726	9 310E 01	**2 38**	**15 38**	
2 27	8154	1 326E+00	**3 40**	**21 90**	
3 35	12060	1 444E+00	**3 70**	**23 86**	
5 38	19362	1 502E+00	**3 85**	**24 82**	
8 27	29784	1 512E+00	**3 87**	**24 98**	
9 68	34860	1 512E+00	**3 87**	**24 99**	
10 9	39300	1 512E+00	**3 87**	**24 99**	
13 2	47640	1 512E+00	**3 87**	**24 99**	
16 6	59580	1 512E+00	**3 87**	**24 99**	
41 7	150000	1 512E+00	**3 87**	**24 99**	
64 6	232605	1 512E+00	**3 87**	**24 99**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J. D. Berger Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2863	Percent Fill of Receiving Tank	%	50
Na^{1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	100			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 51517		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2863
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 168108181
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{-1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 168108181	0 0481	10 9847483	34 01071777	2 168190366	0 077533866	
Hydrogen			2 562E 02	3 307E+01	7 434E 04	1 574E 05	0 000E+00	
Methane			4 496E 03	9 314E+01	1 178E 03	8 854E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 782E 02	**0 07**	**0 46**	
0 0183	66	5 081E 02	**0 13**	**0 84**	
0 0333	120	9 175E 02	**0 23**	**1 52**	
0 0617	222	1 675E 01	**0 43**	**2 77**	
0 1033	372	2 755E 01	**0 71**	**4 55**	
0 1750	630	4 516E 01	**1 16**	**7 46**	
0 332	1194	7 985E 01	**2 04**	**13 19**	
0 620	2232	1 319E+00	**3 38**	**21 80**	
1 035	3726	1 863E+00	**4 77**	**30 78**	
2 27	8154	2 653E+00	**6 79**	**43 83**	
3 35	12060	2 889E+00	**7 40**	**47 73**	
5 38	19362	3 005E+00	**7 70**	**49 65**	
8 27	29784	3 025E+00	**7 75**	**49 97**	
9 68	34860	3 026E+00	**7 75**	**49 99**	
10 9	39300	3 026E+00	**7 75**	**49 99**	
13 2	47640	3 026E+00	**7 75**	**50 00**	
16 6	59580	3 026E+00	**7 75**	**50 00**	
41 7	150000	3 026E+00	**7 75**	**50 00**	
64 6	232605	3 026E+00	**7 75**	**50 00**	Time to fill from 0% to 50% at 4gpm

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	5726	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	101 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	100			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 5164		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				5726
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 336216362
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{-3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		38						100
								Temperature
								deg C
								37 77777778
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 336216362	0 0481	10 9847483	34 01071777	2 168190366	0 155067732	
Hydrogen			2 562E-02	3 307E+01	7 434E-04	1 574E 05	0 000E+00	
Methane			4 496E 03	9 314E+01	1 178E-03	8 854E 06	0 000E+00	

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	5 564E 02	**0 14**	**0 92**	
0 0183	66	1 016E 01	**0 26**	**1 68**	
0 0333	120	1 835E 01	**0 47**	**3 03**	
0 0617	222	3 351E 01	**0 86**	**5 54**	
0 1033	372	5 509E 01	**1 41**	**9 10**	
0 1750	630	9 033E 01	**2 31**	**14 92**	
0 332	1194	1 597E+00	**4 09**	**26 39**	
0 620	2232	2 639E+00	**6 76**	**43 60**	
1 035	3726	3 725E+00	**9 54**	**61 55**	
2 27	8154	5 305E+00	**13 59**	**87 65**	
3 35	12060	5 778E+00	**14 80**	**95 46**	
5 38	19362	6 010E+00	**15 39**	**99 30**	
8 27	29784	6 049E+00	**15 49**	**99 94**	
9 68	34860	6 051E+00	**15 50**	**99 98**	
10 9	39300	6 052E+00	**15 50**	**99 99**	
13 2	47640	6 052E+00	**15 50**	**99 99**	
16 6	59580	6 052E+00	**15 50**	**99 99**	
41 7	150000	6 052E+00	**15 50**	**99 99**	
64 6	232605	6 052E+00	**15 50**	**99 99**	Time to fill from 0% to 50% at 4gpm

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1128	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	μg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	31	Total Pressure in Vapor Space	atm	1
K^{1}	μg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	130000	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	μg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	μg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	μCi/ml	416			
Temperature	°F	110			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 52464		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1128
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 066233332
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 066233332	0 0481	10 9847483	26 79087387	1 707923808	0 038780027	
Hydrogen			2 728E 02	3 048E+01	7 337E 04	1 686E 05	0 000E+00	
Methane			7 407E 03	8 075E+01	1 103E 03	9 567E 06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	1 139E 02	**0 03**	**0 19**	
0 0183	66	2 082E 02	**0 05**	**0 35**	
0 0333	120	3 764E 02	**0 10**	**0 63**	
0 0617	222	6 888E 02	**0 18**	**1 16**	
0 1033	372	1 136E 01	**0 30**	**1 91**	
0 1750	630	1 873E 01	**0 49**	**3 15**	
0 332	1194	3 348E 01	**0 87**	**5 63**	
0 620	2232	5 639E 01	**1 47**	**9 48**	
1 035	3726	8 162E 01	**2 13**	**13 72**	
2 27	8154	1 226E+00	**3 20**	**20 62**	
3 35	12060	1 374E+00	**3 58**	**23 10**	
5 38	19362	1 463E+00	**3 81**	**24 60**	
8 27	29784	1 484E+00	**3 87**	**24 96**	
9 68	34860	1 486E+00	**3 87**	**24 99**	
10 9	39300	1 487E+00	**3 87**	**25 00**	
13 2	47640	1 487E+00	**3 88**	**25 00**	
16 6	59580	1 487E+00	**3 88**	**25 00**	
41 7	150000	1 487E+00	**3 88**	**25 00**	
64 6	232605	1 487E+00	**3 88**	**25 00**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2255	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	110			

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 55307		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2255
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 132407946
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{-3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 132407946	0 0481	10 9847483	26 79087387	1 707923808	0 077525675	
Hydrogen			2 728E 02	3 048E+01	7 337E 04	1 686E-05	0 000E+00	
Methane			7 407E 03	8 075E+01	1 103E 03	9 567E-06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 278E 02	**0 06**	**0 38**	
0 0183	66	4 162E 02	**0 11**	**0 70**	
0 0333	120	7 524E 02	**0 20**	**1 27**	
0 0617	222	1 377E 01	**0 36**	**2 32**	
0 1033	372	2 271E 01	**0 59**	**3 82**	
0 1750	630	3 743E 01	**0 98**	**6 30**	
0 332	1194	6 693E 01	**1 74**	**11 26**	
0 620	2232	1 127E+00	**2 94**	**18 96**	
1 035	3726	1 632E+00	**4 25**	**27 44**	
2 27	8154	2 452E+00	**6 39**	**41 23**	
3 35	12060	2 746E+00	**7 16**	**46 19**	
5 38	19362	2 925E+00	**7 62**	**49 19**	
8 27	29784	2 967E+00	**7 73**	**49 90**	
9 68	34860	2 971E+00	**7 74**	**49 96**	
10 9	39300	2 972E+00	**7 75**	**49 97**	
13 2	47640	2 972E+00	**7 75**	**49 98**	
16 6	59580	2 972E+00	**7 75**	**49 99**	
41 7	150000	2 972E+00	**7 75**	**49 99**	
64 6	232605	2 972E+00	**7 75**	**49 99**	Time to fill from 0% to 50% at 4gpm

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	4511	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	111 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	110			

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 56801		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				4511
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 264874609
Fe^{+3}	55 85	0 00	0 1161	6 92235E-05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{-3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		43						110
								Temperature
								deg C
								43 33333333
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 264874609	0 0481	10 9847483	26 79087387	1 707923808	0 155085729	
Hydrogen			2 728E 02	3 048E+01	7 337E 04	1 686E-05	0 000E+00	
Methane			7 407E 03	8 075E+01	1 103E 03	9 567E-06	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	4 556E 02	**0 12**	**0 77**	
0 0183	66	8 326E 02	**0 22**	**1 40**	
0 0333	120	1 505E 01	**0 39**	**2 53**	
0 0617	222	2 755E 01	**0 72**	**4 63**	
0 1033	372	4 543E 01	**1 18**	**7 64**	
0 1750	630	7 489E 01	**1 95**	**12 59**	
0 332	1194	1 339E+00	**3 49**	**22 52**	
0 620	2232	2 255E+00	**5 88**	**37 93**	
1 035	3726	3 264E+00	**8 51**	**54 89**	
2 27	8154	4 905E+00	**12 78**	**82 48**	
3 35	12060	5 494E+00	**14 32**	**92 39**	
5 38	19362	5 851E+00	**15 25**	**98 40**	
8 27	29784	5 936E+00	**15 47**	**99 82**	
9 68	34860	5 943E+00	**15 49**	**99 93**	
10 9	39300	5 945E+00	**15 50**	**99 97**	
13 2	47640	5 946E+00	**15 50**	**99 99**	
16 6	59580	5 946E+00	**15 50**	**99 99**	
41 7	150000	5 946E+00	**15 50**	**99 99**	
64 6	232605	5 946E+00	**15 50**	**99 99**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry's K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	895	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs-137	µCi/ml	416			
Temperature	°F	120			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 56946		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				895
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 052552156
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	-0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 052552156	0 0481	10 9847483	21 2653246	1 355668887	0 038764743	
Hydrogen			2 894E 02	2 810E+01	7 283E 04	1 815E 05	0 000E+00	
Methane			1 032E 02	7 001E+01	1 044E 03	1 044E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	9 361E 03	**0 02**	**0 16**	
0 0183	66	1 712E 02	**0 05**	**0 29**	
0 0333	120	3 097E 02	**0 08**	**0 53**	
0 0617	222	5 678E 02	**0 15**	**0 97**	
0 1033	372	9 389E 02	**0 25**	**1 61**	
0 1750	630	1 554E 01	**0 41**	**2 66**	
0 332	1194	2 805E 01	**0 74**	**4 80**	
0 620	2232	4 802E 01	**1 27**	**8 22**	
1 035	3726	7 098E 01	**1 88**	**12 15**	
2 27	8154	1 120E+00	**2 97**	**19 17**	
3 35	12060	1 291E+00	**3 42**	**22 09**	
5 38	19362	1 415E+00	**3 75**	**24 20**	
8 27	29784	1 453E+00	**3 85**	**24 87**	
9 68	34860	1 458E+00	**3 87**	**24 94**	
10 9	39300	1 459E+00	**3 87**	**24 97**	
13 2	47640	1 460E+00	**3 87**	**24 99**	
16 6	59580	1 461E+00	**3 87**	**24 99**	
41 7	150000	1 461E+00	**3 87**	**24 99**	
64 6	232605	1 461E+00	**3 87**	**24 99**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244-U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1790	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	120			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 57772		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1790
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{3}	26 98	1 22	0 2174	0 265102298				0 105104312
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 105104312	-0 0481	10 9847483	21 2653246	1 355668887	0 077529486	
Hydrogen			2 894E 02	2 810E+01	7 283E 04	1 815E-05	0 000E+00	
Methane			1 032E 02	7 001E+01	1 044E 03	1 044E-05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 75	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	1 872E 02	**0 05**	**0 32**	
0 0183	66	3 423E 02	**0 09**	**0 59**	
0 0333	120	6 194E 02	**0 16**	**1 06**	
0 0617	222	1 136E 01	**0 30**	**1 94**	
0 1033	372	1 878E 01	**0 50**	**3 21**	
0 1750	630	3 109E 01	**0 82**	**5 32**	
0 332	1194	5 610E 01	**1 49**	**9 60**	
0 620	2232	9 604E 01	**2 55**	**16 43**	
1 035	3726	1 420E+00	**3 77**	**24 29**	
2 27	8154	2 240E+00	**5 94**	**38 33**	
3 35	12060	2 582E+00	**6 85**	**44 18**	
5 38	19362	2 829E+00	**7 50**	**48 41**	
8 27	29784	2 907E+00	**7 71**	**49 74**	
9 68	34860	2 915E+00	**7 73**	**49 88**	
10 9	39300	2 918E+00	**7 74**	**49 94**	
13 2	47640	2 920E+00	**7 75**	**49 97**	
16 6	59580	2 921E+00	**7 75**	**49 98**	
41 7	150000	2 921E+00	**7 75**	**49 98**	
64 6	232605	2 921E+00	**7 75**	**49 98**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	3581	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	121 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	120			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 57828		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				3581
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 210267341
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		49						120
								Temperature
								deg C
								48 88888889
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 210267341	0 0481	10 9847483	21 2653246	1 355668887	0 155102284	
Hydrogen			2 894E-02	2 810E+01	7 283E-04	1 815E 05	0 000E+00	
Methane			1 032E 02	7 001E+01	1 044E 03	1 044E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 51**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	3 746E 02	**0 10**	**0 64**	
0 0183	66	6 849E 02	**0 18**	**1 17**	
0 0333	120	1 239E 01	**0 33**	**2 12**	
0 0617	222	2 272E 01	**0 60**	**3 89**	
0 1033	372	3 757E 01	**1 00**	**6 43**	
0 1750	630	6 219E 01	**1 65**	**10 64**	
0 332	1194	1 122E+00	**2 98**	**19 20**	
0 620	2232	1 921E+00	**5 10**	**32 88**	
1 035	3726	2 840E+00	**7 53**	**48 59**	
2 27	8154	4 482E+00	**11 89**	**76 69**	
3 35	12060	5 166E+00	**13 70**	**88 39**	
5 38	19362	5 660E+00	**15 01**	**96 84**	
8 27	29784	5 815E+00	**15 42**	**99 50**	
9 68	34860	5 832E+00	**15 47**	**99 79**	
10 9	39300	5 839E+00	**15 48**	**99 90**	
13 2	47640	5 843E+00	**15 50**	**99 97**	
16 6	59580	5 844E+00	**15 50**	**99 99**	
41 7	150000	5 844E+00	**15 50**	**99 99**	
64 6	232605	5 844E+00	**15 50**	**99 99**	Time to fill from 0% to 50% at 4gpm

Author D. C. Hedengren Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	716	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	130			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 57892		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				716
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 042041725
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 042041725	0 0481	10 9847483	17 00210138	1 083887516	0 038787904	
Hydrogen			3 060E 02	2 590E+01	7 267E 04	1 965E 05	0 000E+00	
Methane			1 323E 02	6 070E+01	9 973E 04	1 151E 05	0 000E+00	

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	7 739E 03	0 02	0 13	
0 0183	66	1 416E 02	0 04	0 25	
0 0333	120	2 563E 02	0 07	0 45	
0 0617	222	4 706E 02	0 13	0 82	
0 1033	372	7 798E 02	0 21	1 36	
0 1750	630	1 296E 01	0 35	2 26	
0 332	1194	2 356E 01	0 64	4 10	
0 620	2232	4 088E 01	1 10	7 12	
1 035	3726	6 152E 01	1 66	10 71	
2 27	8154	1 014E+00	2 74	17 65	
3 35	12060	1 201E+00	3 24	20 91	
5 38	19362	1 358E+00	3 66	23 63	
8 27	29784	1 420E+00	3 83	24 72	
9 68	34860	1 429E+00	3 85	24 87	
10 9	39300	1 433E+00	3 86	24 93	
13 2	47640	1 435E+00	3 87	24 98	
16 6	59580	1 436E+00	3 87	25 00	
41 7	150000	1 436E+00	3 88	25 00	
64 6	232605	1 436E+00	3 88	25 00	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Bigbee Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1432	Percent Fill of Receiving Tank	%	50
Na^{1}	μg/ml	242999	Volume of Vapor Space	L	58700
Al^{3}	μg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{3}	μg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{2}	μg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	130000	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	μg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	μg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	μCi/ml	416			
Temperature	°F	130			

Author DC Hedengren Date 1/24/00 Checked by JD Baker Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5 10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 57935		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1432
Na^{1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 084083449
Fe^{3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 084083449	0 0481	10 9847483	17 00210138	1 083887516	0 077575807	
Hydrogen			3 060E 02	2 590E+01	7 267E 04	1 965E 05	0 000E+00	
Methane			1 323E 02	6 070E+01	9 973E 04	1 151E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 548E 02	**0 04**	**0 27**	
0 0183	66	2 831E 02	**0 08**	**0 49**	
0 0333	120	5 127E 02	**0 14**	**0 89**	
0 0617	222	9 412E 02	**0 25**	**1 64**	
0 1033	372	1 560E 01	**0 42**	**2 71**	
0 1750	630	2 591E 01	**0 70**	**4 51**	
0 332	1194	4 712E 01	**1 27**	**8 20**	
0 620	2232	8 176E 01	**2 21**	**14 23**	
1 035	3726	1 230E+00	**3 32**	**21 41**	
2 27	8154	2 028E+00	**5 47**	**35 29**	
3 35	12060	2 403E+00	**6 48**	**41 82**	
5 38	19362	2 716E+00	**7 33**	**47 27**	
8 27	29784	2 840E+00	**7 66**	**49 43**	
9 68	34860	2 858E+00	**7 71**	**49 74**	
10 9	39300	2 865E+00	**7 73**	**49 87**	
13 2	47640	2 871E+00	**7 74**	**49 96**	
16 6	59580	2 873E+00	**7 75**	**50 00**	
41 7	150000	2 873E+00	**7 75**	**50 00**	
64 6	232605	2 873E+00	**7 75**	**50 00**	Time to fill from 0% to 50% at 4gpm

Author D C Halgren Date 1/26/00 Checked by J D Ryan Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2863	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	131 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	130			

Author ______ Date 1/26/00 Checked by ______ Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 57983		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2863
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 168108181
Fe^{3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		54						130
								Temperature
								deg C
								54 44444444
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 168108181	0 0481	10 9847483	17 00210138	1 083887516	0 155097442	
Hydrogen			3 060E 02	2 590E+01	7 267E-04	1 965E 05	0 000E+00	
Methane			1 323E 02	6 070E+01	9 973E 04	1 151E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Byrne Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 51	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL, NH_3	
0 0100	36	3 094E 02	0 08	0 54	
0 0183	66	5 660E 02	0 15	0 99	
0 0333	120	1 025E 01	0 28	1 78	
0 0617	222	1 882E 01	0 51	3 28	
0 1033	372	3 118E 01	0 84	5 43	
0 1750	630	5 181E 01	1 40	9 02	
0 332	1194	9 422E 01	2 54	16 40	
0 620	2232	1 635E+00	4 41	28 45	
1 035	3726	2 460E+00	6 64	42 81	
2 27	8154	4 054E+00	10 94	70 56	
3 35	12060	4 804E+00	12 96	83 61	
5 38	19362	5 430E+00	14 65	94 50	
8 27	29784	5 678E+00	15 32	98 83	
9 68	34860	5 713E+00	15 41	99 44	
10 9	39300	5 728E+00	15 45	99 70	
13 2	47640	5 739E+00	15 48	99 89	
16 6	59580	5 743E+00	15 49	99 96	
41 7	150000	5 744E+00	15 50	99 97	
64 6	232605	5 744E+00	15 50	99 97	Time to fill from 0% to 50% at 4gpm

Author D-C Hedengren Date 1/26/00 Checked by J D Bjelin Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	576	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	242999	Volume of Vapor Space	L	58700
Al^{3}	μg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	130000	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	μg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	μg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	μCi/ml	416			
Temperature	°F	140			

Author D C Hedengren Date 1/26/00 Checked by J D Rhe Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58038		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				576
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 033821276
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		60						140
								Temperature
								deg C
								60
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 033821276	0 0481	10 9847483	13 68741	0 872575248	0 038760297	
Hydrogen			3 227E 02	2 387E+01	7 285E 04	2 137E 05	0 000E+00	
Methane			1 614E 02	5 263E+01	9 609E 04	1 279E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	3 88	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	6 426E 03	**0 02**	**0 11**	
0 0183	66	1 176E 02	**0 03**	**0 21**	
0 0333	120	2 131E 02	**0 06**	**0 38**	
0 0617	222	3 916E 02	**0 11**	**0 69**	
0 1033	372	6 501E 02	**0 18**	**1 15**	
0 1750	630	1 083E 01	**0 30**	**1 92**	
0 332	1194	1 982E 01	**0 54**	**3 51**	
0 620	2232	3 478E 01	**0 95**	**6 16**	
1 035	3726	5 313E 01	**1 46**	**9 40**	
2 27	8154	9 093E 01	**2 49**	**16 09**	
3 35	12060	1 105E+00	**3 03**	**19 56**	
5 38	19362	1 290E+00	**3 54**	**22 83**	
8 27	29784	1 379E+00	**3 78**	**24 41**	
9 68	34860	1 394E+00	**3 83**	**24 68**	
10 9	39300	1 402E+00	**3 85**	**24 81**	
13 2	47640	1 408E+00	**3 86**	**24 92**	
16 6	59580	1 411E+00	**3 87**	**24 97**	
41 7	150000	1 411E+00	**3 87**	**24 98**	
64 6	232605	1 411E+00	**3 87**	**24 98**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1153	Percent Fill of Receiving Tank	%	50
Na [1]	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe [3]	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	140			

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 5807		Revision	0	NH_3	
Dilution Ratio	0 1							ug/ml	
Ion	M W	ci (moles/L)	hi	hi*ci				1153	
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L	
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 067701269	
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05					
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)		
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05					
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481		
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218		
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022		
NO_2^{1}	46 0055	2 83	0 0795	0 224646949					
CO_3^{2}	60 0092	0 37	0 1423	0 052168715					
PO_4^{3}	94 9676	0 03	0 2119	0 006974576					
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832					
F^{1}	19	4 158E 02	0 092	0 003825265					
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836					
Li^{+1}	6 94	0 00	0 0754	0					
Br^{1}	79 916	0 000E+00	0 0269	0					
								Average	
		21 28963822		2 064821709					
Mass fraction water in liq		0 50						Temperature	
Liquid density (kg/m3)		1400 000						deg F	
T (C)		60						140	
								Temperature	
								deg C	
								60	
					PNL 10785				
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3		
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm		
Ammonia		0 067701269	0 0481	10 9847483	13 68741	0 872575248	0 077587886		
Hydrogen			3 227E 02	2 387E+01	7 285E 04	2 137E 05	0 000E+00		
Methane			1 614E 02	5 263E+01	9 609E 04	1 279E 05	0 000E+00		

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL, NH_3**	
0 0100	36	1 286E 02	**0 04**	**0 23**	
0 0183	66	2 354E 02	**0 06**	**0 42**	
0 0333	120	4 265E 02	**0 12**	**0 75**	
0 0617	222	7 839E 02	**0 22**	**1 39**	
0 1033	372	1 301E 01	**0 36**	**2 30**	
0 1750	630	2 168E 01	**0 59**	**3 84**	
0 332	1194	3 968E 01	**1 09**	**7 02**	
0 620	2232	6 962E 01	**1 91**	**12 32**	
1 035	3726	1 064E+00	**2 92**	**18 82**	
2 27	8154	1 820E+00	**4 99**	**32 22**	
3 35	12060	2 213E+00	**6 07**	**39 16**	
5 38	19362	2 582E+00	**7 08**	**45 71**	
8 27	29784	2 760E+00	**7 57**	**48 86**	
9 68	34860	2 791E+00	**7 66**	**49 40**	
10 9	39300	2 806E+00	**7 70**	**49 66**	
13 2	47640	2 818E+00	**7 73**	**49 88**	
16 6	59580	2 824E+00	**7 75**	**49 98**	
41 7	150000	2 825E+00	**7 75**	**50 00**	
64 6	232605	2 825E+00	**7 75**	**50 00**	Time to fill from 0% to 50% at 4gpm

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DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	2305	Percent Fill of Receiving Tank	%	50
Na^{1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	141 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	140			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58236		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				2305
Na^{1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 13534382
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{-3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		60						140
								Temperature
								deg C
								60
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 13534382	0 0481	10 9847483	13 68741	0 872575248	0 15510848	
Hydrogen			3 227E 02	2 387E+01	7 285E 04	2 137E-05	0 000E+00	
Methane			1 614E 02	5 263E+01	9 609E 04	1 279E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D Berger Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 51	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	NH_3 mole/m^3	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 571E 02	**0 07**	**0 46**	
0 0183	66	4 705E 02	**0 13**	**0 83**	
0 0333	120	8 526E 02	**0 23**	**1 51**	
0 0617	222	1 567E 01	**0 43**	**2 77**	
0 1033	372	2 601E 01	**0 71**	**4 60**	
0 1750	630	4 335E 01	**1 19**	**7 67**	
0 332	1194	7 933E 01	**2 18**	**14 04**	
0 620	2232	1 392E+00	**3 82**	**24 63**	
1 035	3726	2 126E+00	**5 83**	**37 63**	
2 27	8154	3 639E+00	**9 98**	**64 40**	
3 35	12060	4 423E+00	**12 14**	**78 29**	
5 38	19362	5 163E+00	**14 16**	**91 38**	
8 27	29784	5 518E+00	**15 14**	**97 67**	
9 68	34860	5 580E+00	**15 31**	**98 76**	
10 9	39300	5 609E+00	**15 39**	**99 28**	
13 2	47640	5 634E+00	**15 46**	**99 73**	
16 6	59580	5 645E+00	**15 49**	**99 91**	
41 7	150000	5 648E+00	**15 49**	**99 96**	
64 6	232605	5 648E+00	**15 49**	99 96	Time to fill from 0% to 50% at 4gpm

Author D-C Hedengren Date 1/26/00 Checked by JD Bigbee Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	467	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	150			

Author D C Hedengren Date 1/26/00 Checked by J D Rafter Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58375		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				467
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 027421069
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 027421069	0 0481	10 9847483	11 09126307	0 707070339	0 038781246	
Hydrogen			3 393E 02	2 201E+01	7 338E 04	2 335E 05	0 000E+00	
Methane			1 905E 02	4 563E+01	9 331E 04	1 432E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by J D R... Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	5 377E 03	**0 01**	**0 10**	
0 0183	66	9 842E 03	**0 03**	**0 18**	
0 0333	120	1 784E 02	**0 05**	**0 32**	
0 0617	222	3 283E 02	**0 09**	**0 59**	
0 1033	372	5 457E 02	**0 15**	**0 98**	
0 1750	630	9 115E 02	**0 25**	**1 64**	
0 332	1194	1 677E 01	**0 47**	**3 02**	
0 620	2232	2 969E 01	**0 83**	**5 34**	
1 035	3726	4 593E 01	**1 28**	**8 26**	
2 27	8154	8 120E 01	**2 26**	**14 61**	
3 35	12060	1 010E+00	**2 82**	**18 18**	
5 38	19362	1 216E+00	**3 39**	**21 89**	
8 27	29784	1 333E+00	**3 72**	**23 98**	
9 68	34860	1 356E+00	**3 78**	**24 41**	
10 9	39300	1 369E+00	**3 82**	**24 63**	
13 2	47640	1 381E+00	**3 85**	**24 84**	
16 6	59580	1 387E+00	**3 87**	**24 95**	
41 7	150000	1 389E+00	**3 87**	**24 99**	
64 6	232605	1 389E+00	**3 87**	**24 99**	Time to fill from 0% to 50% at 4gpm

Author *DC Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	934	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	150			

Author D C Hedengren Date 1/26/00 Checked by J D Rafferty Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5 10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58406		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				934
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 054842138
Fe^{3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	-0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	-0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 054842138	0 0481	10 9847483	11 09126307	0 707070339	0 077562493	
Hydrogen			3 393E 02	2 201E+01	7 338E 04	2 335E 05	0 000E+00	
Methane			1 905E 02	4 563E+01	9 331E 04	1 432E 05	0 000E+00	

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DCRT **244 U**
Case *5 (Story 1)*

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	7 76	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 075E 02	0 03	0 19	
0 0183	66	1 968E 02	0 05	0 35	
0 0333	120	3 569E 02	0 10	0 64	
0 0617	222	6 566E 02	0 18	1 18	
0 1033	372	1 091E 01	0 30	1 96	
0 1750	630	1 823E 01	0 51	3 28	
0 332	1194	3 353E 01	0 94	6 03	
0 620	2232	5 938E 01	1 66	10 68	
1 035	3726	9 185E 01	2 56	16 53	
2 27	8154	1 624E+00	4 53	29 22	
3 35	12060	2 020E+00	5 63	36 35	
5 38	19362	2 433E+00	6 79	43 77	
8 27	29784	2 665E+00	7 43	47 96	
9 68	34860	2 713E+00	7 57	48 81	
10 9	39300	2 737E+00	7 63	49 25	
13 2	47640	2 761E+00	7 70	49 68	
16 6	59580	2 773E+00	7 73	49 90	
41 7	150000	2 778E+00	7 75	49 98	
64 6	232605	2 778E+00	7 75	49 98	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Bagby Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1868	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	μg/ml	32900	Length of Waste Fall	ft	6
Fe^{3}	μg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	130000	Temperature of Air in Vapor Space	°F	151 8
CO_3^{2}	μg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	μg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	μg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	μg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs-137	μCi/ml	416			
Temperature	°F	150			

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58438		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi*ci				1868
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 109684276
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		66						150
								Temperature
								deg C
								65 55555556
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 109684276	0 0481	10 9847483	11 09126307	0 707070339	0 155124985	
Hydrogen			3 393E-02	2 201E+01	7 338E 04	2 335E 05	0 000E+00	
Methane			1 905E 02	4 563E+01	9 331E 04	1 432E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**15 51**	**%**		Max NH3 Conc Based on Henrys Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	2 151E 02	**0 06**	**0 39**	
0 0183	66	3 937E 02	**0 11**	**0 71**	
0 0333	120	7 137E 02	**0 20**	**1 28**	
0 0617	222	1 313E 01	**0 37**	**2 36**	
0 1033	372	2 183E 01	**0 61**	**3 93**	
0 1750	630	3 646E 01	**1 02**	**6 56**	
0 332	1194	6 707E 01	**1 87**	**12 07**	
0 620	2232	1 188E+00	**3 31**	**21 37**	
1 035	3726	1 837E+00	**5 12**	**33 05**	
2 27	8154	3 248E+00	**9 06**	**58 44**	
3 35	12060	4 041E+00	**11 27**	**72 70**	
5 38	19362	4 866E+00	**13 57**	**87 55**	
8 27	29784	5 331E+00	**14 87**	**95 92**	
9 68	34860	5 425E+00	**15 13**	**97 62**	
10 9	39300	5 475E+00	**15 27**	**98 51**	
13 2	47640	5 522E+00	**15 40**	**99 37**	
16 6	59580	5 546E+00	**15 47**	**99 79**	
41 7	150000	5 555E+00	**15 49**	**99 96**	
64 6	232605	5 555E+00	**15 49**	**99 96**	Time to fill from 0% to 50% at 4gpm

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	381	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{-3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	160			

Author D C Hedengren Date 1/26/00 Checked by S D Barker Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58481		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				381
Na^{+1}	22 99	10 569787	0 1143	1 208126639	*From Weisenberger & Schumpe (1996)*			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 022371365
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 168E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 022371365	0 0481	10 9847483	9 043660443	0 576535243	0 038803117	
Hydrogen			3 559E 02	2 029E+01	7 422E 04	2 562E 05	0 000E+00	
Methane			2 196E 02	3 956E+01	9 126E 04	1 616E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 88**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	4 531E 03	**0 01**	**0 08**	
0 0183	66	8 295E 03	**0 02**	**0 15**	
0 0333	120	1 504E 02	**0 04**	**0 28**	
0 0617	222	2 770E 02	**0 08**	**0 51**	
0 1033	372	4 610E 02	**0 13**	**0 84**	
0 1750	630	7 716E 02	**0 22**	**1 41**	
0 332	1194	1 425E 01	**0 40**	**2 61**	
0 620	2232	2 543E 01	**0 72**	**4 65**	
1 035	3726	3 975E 01	**1 13**	**7 27**	
2 27	8154	7 225E 01	**2 05**	**13 21**	
3 35	12060	9 175E 01	**2 60**	**16 78**	
5 38	19362	1 138E+00	**3 22**	**20 81**	
8 27	29784	1 279E+00	**3 63**	**23 39**	
9 68	34860	1 312E+00	**3 72**	**23 99**	
10 9	39300	1 330E+00	**3 77**	**24 33**	
13 2	47640	1 350E+00	**3 83**	**24 69**	
16 6	59580	1 361E+00	**3 86**	**24 90**	
41 7	150000	1 367E+00	**3 87**	**25 00**	
64 6	232605	1 367E+00	**3 87**	**25 00**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by J D Bofer Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U-108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	762	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	160			

Author D C Hedengren Date 1/26/00 Checked by JD Bright Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58505		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				762
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 044742729
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 044742729	0 0481	10 9847483	9 043660443	0 576535243	0 077606235	
Hydrogen			3 559E 02	2 029E+01	7 422E 04	2 562E-05	0 000E+00	
Methane			2 196E 02	3 956E+01	9 126E 04	1 616E 05	0 000E+00	

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DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**7 76**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	9 062E 03	**0 03**	**0 17**	
0 0183	66	1 659E 02	**0 05**	**0 30**	
0 0333	120	3 009E 02	**0 09**	**0 55**	
0 0617	222	5 540E 02	**0 16**	**1 01**	
0 1033	372	9 220E 02	**0 26**	**1 69**	
0 1750	630	1 543E 01	**0 44**	**2 82**	
0 332	1194	2 851E 01	**0 81**	**5 21**	
0 620	2232	5 086E 01	**1 44**	**9 30**	
1 035	3726	7 950E 01	**2 25**	**14 54**	
2 27	8154	1 445E+00	**4 10**	**26 43**	
3 35	12060	1 835E+00	**5 20**	**33 56**	
5 38	19362	2 275E+00	**6 45**	**41 61**	
8 27	29784	2 559E+00	**7 25**	**46 79**	
9 68	34860	2 624E+00	**7 44**	**47 99**	
10 9	39300	2 661E+00	**7 54**	**48 66**	
13 2	47640	2 700E+00	**7 65**	**49 38**	
16 6	59580	2 723E+00	**7 72**	**49 79**	
41 7	150000	2 734E+00	**7 75**	**50 00**	
64 6	232605	2 734E+00	**7 75**	**50 00**	Time to fill from 0% to 50% at 4gpm

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	1524	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	161 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	160			

Author DC Hedengren Date 1/26/00 Checked by JD Bryan Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58547		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1524
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 089485459
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		71						160
								Temperature
								deg C
								71 11111111
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 089485459	0 0481	10 9847483	9 043660443	0 576535243	0 155212469	
Hydrogen			3 559E 02	2 029E+01	7 422E-04	2 562E 05	0 000E+00	
Methane			2 196E-02	3 956E+01	9 126E 04	1 616E 05	0 000E+00	

Author *DC Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**15 52**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	1 812E 02	**0 05**	**0 33**	
0 0183	66	3 318E 02	**0 09**	**0 61**	
0 0333	120	6 018E 02	**0 17**	**1 10**	
0 0617	222	1 108E 01	**0 31**	**2 03**	
0 1033	372	1 844E 01	**0 52**	**3 37**	
0 1750	630	3 086E 01	**0 87**	**5 64**	
0 332	1194	5 701E 01	**1 62**	**10 43**	
0 620	2232	1 017E+00	**2 88**	**18 60**	
1 035	3726	1 590E+00	**4 51**	**29 08**	
2 27	8154	2 890E+00	**8 19**	**52 85**	
3 35	12060	3 670E+00	**10 40**	**67 11**	
5 38	19362	4 551E+00	**12 90**	**83 22**	
8 27	29784	5 117E+00	**14 50**	**93 58**	
9 68	34860	5 248E+00	**14 88**	**95 98**	
10 9	39300	5 322E+00	**15 09**	**97 33**	
13 2	47640	5 400E+00	**15 31**	**98 76**	
16 6	59580	5 445E+00	**15 44**	**99 58**	
41 7	150000	5 468E+00	**15 50**	**99 99**	
64 6	232605	5 468E+00	**15 50**	**99 99**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/00 Checked by JD Bujan Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	312	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{+3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m³	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m²	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
$\%H_2O$	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	170			

Author D C Hedengren Date 1/24/00 Checked by JD Bagley Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5 10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58593		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				312
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 018319858
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	-0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{+1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 018319858	0 0481	10 9847483	7 417920838	0 472894004	0 038739882	
Hydrogen			3 725E 02	1 870E+01	7 536E 04	2 822E 05	0 000E+00	
Methane			2 487E 02	3 430E+01	8 985E 04	1 834E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by JD Bjerke Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	**$\%NH_{3(Max)}$**	**3 87**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	3 837E 03	**0 01**	**0 07**	
0 0183	66	7 027E 03	**0 02**	**0 13**	
0 0333	120	1 275E 02	**0 04**	**0 24**	
0 0617	222	2 349E 02	**0 07**	**0 44**	
0 1033	372	3 913E 02	**0 11**	**0 73**	
0 1750	630	6 559E 02	**0 19**	**1 22**	
0 332	1194	1 216E 01	**0 35**	**2 26**	
0 620	2232	2 183E 01	**0 63**	**4 06**	
1 035	3726	3 442E 01	**0 99**	**6 40**	
2 27	8154	6 405E 01	**1 84**	**11 90**	
3 35	12060	8 280E-01	**2 38**	**15 39**	
5 38	19362	1 055E+00	**3 04**	**19 60**	
8 27	29784	1 217E+00	**3 51**	**22 61**	
9 68	34860	1 259E+00	**3 63**	**23 39**	
10 9	39300	1 284E+00	**3 70**	**23 85**	
13 2	47640	1 312E+00	**3 78**	**24 39**	
16 6	59580	1 331E+00	**3 83**	**24 73**	
41 7	150000	1 343E+00	**3 87**	**24 95**	
64 6	232605	1 343E+00	**3 87**	**24 95**	Time to fill from 0% to 50% at 4gpm

Author D C Hedengren Date 1/26/06 Checked by [signature] Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	µg/ml	625	Percent Fill of Receiving Tank	%	50
Na^{+1}	µg/ml	242999	Volume of Vapor Space	L	58700
Al^{3}	µg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	µg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	µg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	µg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	µg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	µg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	µg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	µg/ml	130000	Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	µg/ml	22000	Stream Diameter	inches	1
PO_4^{3}	µg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	µg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	µg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	µg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	µg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	µg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	µCi/ml	416			
Temperature	°F	170			

Author D C Hedengren Date 1/26/00 Checked by JD Bigler Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont d) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58631		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				625
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 036698433
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 036698433	0 0481	10 9847483	7 417920838	0 472894004	0 077603929	
Hydrogen			3 725E 02	1 870E+01	7 536E 04	2 822E 05	0 000E+00	
Methane			2 487E 02	3 430E+01	8 985E 04	1 834E 05	0 000E+00	

Author D C Hedengren Date 1/26/00 Checked by JD Rogers Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	**7 76**	**%**		Max NH3 Conc Based on Henry s Law Constant
		Variable	**Variable**	**Variable**	
		Delta C	**Delta C**	**Delta C**	
Time hours	T sec	**NH_3 mole/m^3**	**$\%NH_3$**	**% LFL NH_3**	
0 0100	36	7 687E 03	**0 02**	**0 14**	
0 0183	66	1 408E 02	**0 04**	**0 26**	
0 0333	120	2 554E 02	**0 07**	**0 47**	
0 0617	222	4 705E 02	**0 14**	**0 87**	
0 1033	372	7 838E 02	**0 23**	**1 46**	
0 1750	630	1 314E 01	**0 38**	**2 44**	
0 332	1194	2 436E 01	**0 70**	**4 53**	
0 620	2232	4 373E 01	**1 26**	**8 13**	
1 035	3726	6 896E 01	**1 99**	**12 81**	
2 27	8154	1 283E+00	**3 70**	**23 84**	
3 35	12060	1 659E+00	**4 78**	**30 82**	
5 38	19362	2 113E+00	**6 09**	**39 26**	
8 27	29784	2 438E+00	**7 02**	**45 30**	
9 68	34860	2 521E+00	**7 26**	**46 85**	
10 9	39300	2 572E+00	**7 41**	**47 78**	
13 2	47640	2 629E+00	**7 57**	**48 85**	
16 6	59580	2 666E+00	**7 68**	**49 54**	
41 7	150000	2 690E+00	**7 75**	**49 98**	
64 6	232605	2 690E+00	**7 75**	**49 98**	Time to fill from 0% to 50% at 4gpm

Author [signature] Date 1/26/00 Checked by [signature] Date 1/26/00

DCRT **244 U**
Case **5 (Story 1)**

Table U5-10 (Cont'd) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Input Data for Henry s K calculation and the Dynamic Spreadsheet					
			244-U		
Source Tank	U 108				
Dilution Ratio	0 1		Correction Factor for Schumpe Model 1		
Receiving Tank	244 U				
Liquid Waste Characteristics (Source Tank)			Tank Characteristics (Receiving Tank)		
Parameter	Units	Value	Parameter	Units	Value
NH_3	μg/ml	1250	Percent Fill of Receiving Tank	%	50
Na^{+1}	μg/ml	242999	Volume of Vapor Space	L	58700
Al^{3}	μg/ml	32900	Length of Waste Fall	ft	6
Fe^{+3}	μg/ml	33	Inside Diameter of Receiving Tank	ft	12
Cr^{+3}	μg/ml	1280	Flow Rate of Waste	gpm	4
Ni^{+2}	μg/ml	31	Total Pressure in Vapor Space	atm	1
K^{+1}	μg/ml	4010	Ventilation Flow Rate for Receiving Tank	cfm	0 05
OH^{1}	μg/ml	49150	Total Ventilation Flow Rate for Stack	cfm	0 05
NO_3^{1}	μg/ml	181000	Total Bubbler Flow Rate	cfh	3
NO_2^{1}	μg/ml	130000	Temperature of Air in Vapor Space	°F	171 8
CO_3^{2}	μg/ml	22000	Stream Diameter	inches	1
PO_4^{-3}	μg/ml	3126	Tortuosity Factor	unitless	1
SO_4^{2}	μg/ml	4230	Initial Concentration of NH_3 in the Vapor Phase	mole/m^3	0
F^{1}	μg/ml	790	Surface Area of Still Waste	m^2	39 02
Cl^{1}	μg/ml	8940	Fumigation Divisor at 100 meters	unitless	1
Li^{+1}	μg/ml	0	Non Fumigation Divisor at 100 meters	unitless	1
Br^{1}	μg/ml	0	Correction Factor for Schumpe Model	unitless	1
%H_2O	%	50 02			
Specific Gravity	unitless	1 4			
Total Organic Carbon	g/l	8 95			
Cs 137	μCi/ml	416			
Temperature	°F	170			

Author D C Hedengren Date 1/26/00 Checked by S D Ogden Date 1/26/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont d) U-108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Source Tank	U 108	INPUT DATA	Date	36538 58658		Revision	0	NH_3
Dilution Ratio	0 1							ug/ml
Ion	M W	ci (moles/L)	hi	hi ci				1250
Na^{+1}	22 99	10 569787	0 1143	1 208126639	From Weisenberger & Schumpe (1996)			moles/L
Al^{+3}	26 98	1 22	0 2174	0 265102298				0 073396866
Fe^{+3}	55 85	0 00	0 1161	6 92235E 05				
Cr^{+3}	52	2 462E 02	0 0648	0 001595077	Gas	h (T)	h (G 0)	
Ni^{+2}	58 71	5 323E 04	0 1654	8 80387E 05				
K^{+1}	39 09	1 026E 01	0 0922	0 009458225	Ammonia	0	0 0481	
OH^{1}	17 0074	2 89	0 0839	0 242464163	Hydrogen	0 299	-0 0218	
NO_3^{1}	62 0049	2 92	0 0128	0 037364871	Methane	0 524	0 0022	
NO_2^{1}	46 0055	2 83	0 0795	0 224646949				
CO_3^{2}	60 0092	0 37	0 1423	0 052168715				
PO_4^{3}	94 9676	0 03	0 2119	0 006974576				
SO_4^{2}	96 0576	4 404E 02	0 1117	0 004918832				
F^{1}	19	4 158E 02	0 092	0 003825265				
Cl^{1}	35 453	2 522E 01	0 0318	0 008018836				
Li^{1}	6 94	0 00	0 0754	0				
Br^{1}	79 916	0 000E+00	0 0269	0				
								Average
		21 28963822		2 064821709				
Mass fraction water in liq		0 50						Temperature
Liquid density (kg/m3)		1400 000						deg F
T (C)		77						170
								Temperature
								deg C
								76 66666667
					PNL 10785			
			Schumpe	Schumpe	pure water K	mol/L(liq) atm	NH3	
		gmoles/L (liq)	h (G)	Kwater/Ksalt	(mol/kgwtr at	Henry s K	Part P atm	
Ammonia		0 073396866	0 0481	10 9847483	7 417920838	0 472894004	0 155207859	
Hydrogen			3 725E 02	1 870E+01	7 536E 04	2 822E 05	0 000E+00	
Methane			2 487E 02	3 430E+01	8 985E 04	1 834E 05	0 000E+00	

Author DC Hedengren Date 1/26/00 Checked by JD Berger Date 1/28/00

DCRT 244 U
Case 5 (Story 1)

Table U5-10 (Cont'd) U 108 Ammonia Calculations for Shumpe Worst Case (99 pages)

Equil NH3 Conc in Vapor Space	$\%NH_{3(Max)}$	15 52	%		Max NH3 Conc Based on Henry s Law Constant
		Variable	Variable	Variable	
		Delta C	Delta C	Delta C	
Time hours	T sec	NH_3 mole/m^3	$\%NH_3$	% LFL NH_3	
0 0100	36	1 537E 02	0 04	0 29	
0 0183	66	2 815E 02	0 08	0 52	
0 0333	120	5 107E 02	0 15	0 95	
0 0617	222	9 411E 02	0 27	1 75	
0 1033	372	1 568E 01	0 45	2 91	
0 1750	630	2 628E 01	0 76	4 88	
0 332	1194	4 871E 01	1 40	9 05	
0 620	2232	8 746E 01	2 52	16 25	
1 035	3726	1 379E+00	3 97	25 63	
2 27	8154	2 566E+00	7 39	47 68	
3 35	12060	3 317E+00	9 55	61 64	
5 38	19362	4 225E+00	12 17	78 52	
8 27	29784	4 876E+00	14 04	90 60	
9 68	34860	5 043E+00	14 52	93 71	
10 9	39300	5 143E+00	14 81	95 57	
13 2	47640	5 258E+00	15 14	97 70	
16 6	59580	5 333E+00	15 36	99 09	
41 7	150000	5 380E+00	15 49	99 96	
64 6	232605	5 380E+00	15 49	99 97	Time to fill from 0% to 50% at 4gpm

244-U-DCRT

CASE 6

Author D C Hedengren Date 1/26/00 Checked by J D Ryan Date 1/26/00

SUMMARY:

DCRT 244-U Calculations based on tank 241-U-106
CASE 6
- the initial condition of the tank is 0% full
- this model calculates the remainder until fill is hit at 80% full with pumping rate initially of 4 gpm to 40% full
- immediate change in pumping rate of 4 gpm with no chance to come to steady state H2 concentration

INPUT SUMMARY:

General Data

DCRT Ventilation Rate	$vr = 3\ 000\frac{ft^3}{hr}$	Nitrate Concentration	$NO_3 = 3\ 760\frac{mole}{liter}$
Saltwell Waste Specific Gravity	$\rho = 1\ 350$	Nitrite Concentration	$NO_2 = 2\ 020\frac{mole}{liter}$
Radiolytic Power of Waste	$wastepower = 0\ 000\frac{lb}{ft\ sec^3}$	Aluminum Concentration	$Al = 0\ 420\frac{mole}{liter}$
Initial DCRT H_2 Inventory	$vol_{H2_0} = 0\ 000 ft^3$	TOC Concentration	$TOC = 37\ 470\frac{gm}{liter}$
H_2 Inventory Based on CGM?	$flag_{cgm} =$ no	Ammonia Concentration	$NH_3 = 0\ 000\ \%LFL_{NH3}$
CGM Measurement	$conc_{LFL\_cgm0} = 0\ 000\ \%LFL$	Methane Concentration	$CH_4 = 0\ 000\ \%LFL_{CH4}$
DCRT Waste Temperature	$T = 300\ 950\ K$		

Period 1

Initial Flow Rate $flow = 4\ 000\frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol\_molar} = 3\ 297\times 10^{-5}\frac{mole}{liter}$ or $gr_{sol} = 0\ 026\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\ \%$

Period 2

Second Flow Rate $flow_2 = 4\ 000\frac{gal}{min}$

Time Pumped at Second Flow Rate $lim2 = 52\ 000\ hr$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 026\frac{ft^3}{hr}$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\ \%$

Author *D C Hedengren* Date *1/26/00* Checked by [signature] Date *1/26/00*

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 4\ 000 \frac{gal}{min}$

Time Pumped at Inital Flow Rate $time = 52\ 000\, hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 0\ 000\,\%$

Final Fill Factor $fff = 40\ 240\,\%$

Initial Fill Volume $tvol_{init} = 0\, gal$

Final Fill Volume $ffv = 12480\, gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 1\ 223\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 1\ 223\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 6\ 359\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 6\ 359\,\%$

Period 2

Second Flow Rate $flow_2 = 4\ 000 \frac{gal}{min}$

Time Pumped at Second Flow Rate $tim2 = 52\ 000\, hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 40\ 240\,\%$

Final Fill Factor $fff2 = 80\ 479\,\%$

Initial Fill Volume $tvol_{init2} = 12480\, gal$

Final Fill Volume $ffv2 = 24960\, gal$

Initial H2 Concentration (%LFL) $ih2c2 = 1\ 223\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 4\ 148\,\%$

Final Flammable Gas Concentration $ffgc2 = 4\ 148\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 10\ 720\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 10\ 720\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 196\ 139\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\_25\%LFL} = 16\ 412\, day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\_50\%LFL} = 48\ 752\, day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 134\ 509\, day$

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244-U-DCRT

CASE 7

Author *D C Hedengren* Date *1/26/00* Checked by *[signature]* Date *1/26/00*

CH2MHILL
Hanford Group Inc

Determination of Headspace Gas Concentration in a Vertically Oriented DCRT...

SA Barker

Input Data

DCRT 244-U
CASE 7

Modified for 244-U DCRT Vault Case (Ventilation rate of 3 cfh) Use Vertical DCRT for model Wetted surface area set at 1302 sq ft

Input diameter of DCRT (d)

$d := 12 \, ft$

Input length of DCRT (L)

$L := 100.47 \, ft$

Input rate at which the DCRT fills (flow) (minimum should be a touch gereater than 0, i e 1x10^-6)

$flow := 1 \cdot 10^{-6} \frac{gal}{min}$ $\quad flow = 2\,228 \times 10^{-9} ft^3 sec^{-1}$ $\quad \frac{flow}{\left(\frac{ft^3}{hr}\right)} = 8\,021 \times 10^{-6}$

Higher Input flow rate

$flow_2 := 1 \cdot 10^{-6} \frac{gal}{min}$ $\quad flow_2 = 2\,228 \times 10^{-9} ft^3 sec^{-1}$ $\quad \frac{flow_2}{\left(\frac{ft^3}{hr}\right)} = 8\,021 \times 10^{-6}$

Calculate total DCRT volume (tvol)

$$tvol := L \, \pi \left(\frac{d}{2}\right)^2$$

Assume DCRT has flat ends [Eqn 1]

$tvol = 11363 \, ft^3$

Volume of fill at start of pumping

$tvol_{init} := 0.292 \cdot tvol + 0 \, hr \cdot 0 \frac{gal}{min}$ $\quad tvol_{init} = 3\,318 \times 10^3 ft^3$

Time at start of pumping rate 2 (MUST be an INTEGER)

$time := 1 \, hr$

Time at pumping rate 2

$time_2 := 1 \, hr$

Volume of fill at start of pumping rate 2

$tvol_2 := tvol_{init} + time \cdot flow$ $\quad tvol_2 = 3318 \, ft^3$

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$vol_{H2_0} = if\left[flag_{cgm} = \text{"yes"}, conc_{H2\_cgm}\left(tvol - tvol_{init}\right), vol_{H2_0}\right]$

$vol_{H2_0} = 0.000\,ft^3$ <==== Initial volume of H2 in Headspace

Input Ammonia Concentration

$NH_3 := 14.85\ \%LFL_{NH3}$ (Reference)

Input Methane Concentration

$CH_4 := 0.0\ \%LFL_{CH4}$ (Reference)

End of Input Section

Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$hvol(t) := tvol - flow \cdot t - tvol_{init}$ $hvol(lim) = 8.045 \times 10^3\,ft^3$ [Eqn 4]

Wetted area of full DCRT (horizontal orientation) (ft²) $2\,\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,L = 4014\,ft^2$ [Eqn 8]

Wetted area of vertically oriented DCRT (ft²)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,\frac{flow \cdot t + tvol_{init}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(flow \cdot t + tvol_{init}\right)}{d}$$ [Eqn 8]

$Awet(t) := 1302\,ft^2$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft²) $Awet(lim) = 1.302 \times 10^3\,ft^2$

$Awet(0\,hr) = 1.302 \times 10^3\,ft^2$ Check the answers

$Awet(1\,hr) = 1.302 \times 10^3\,ft^2$ $Awet(lim) = 1.302 \times 10^3\,ft^2$

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Calculations:

Calculate DCRT headspace volume (hvol, a function of time)

$$hvol2(time) = tvol - flow_2\,time - tvol_{init2} \qquad hvol2(lim2) = 8\,045 \times 10^3\,ft^3$$ [Eqn 4]

Wetted area of vertically oriented DCRT (ft^2)

$$\left[\pi\left(\frac{d}{2}\right)^2 + \pi\,d\,\frac{flow_2\,t + tvol_{init2}}{\pi\left(\frac{d}{2}\right)^2}\right] = \pi\left(\frac{d}{2}\right)^2 + \frac{4\left(flow_2\,t + tvol_{init2}\right)}{d}$$ [Eqn 8]

$$Awet(tt2) = 1302\,ft^2$$ [Eqn 9]

Wetted area of full DCRT (vertical orientation) (ft^2) $Awet(lim2) = 1\,302 \times 10^3\,ft^2$

$Awet(0\,hr) = 1\,302 \times 10^3\,ft^2$ Check the answers

$Awet(1\,hr) = 1\,302 \times 10^3\,ft^2$

$Awet(lim2) = 1302\,000\,ft^2$

Average characterizations for NO_3, NO_2, Al, TOC (molar, molar, molar, grams/liter)

$$\frac{NO_3}{\left(\frac{mole}{liter}\right)} = 3\,180 \quad \frac{NO_2}{\left(\frac{mole}{liter}\right)} = 3\,020 \quad \frac{Al}{\left(\frac{mole}{liter}\right)} = 1\,200 \quad \frac{TOC}{\left(\frac{gm}{liter}\right)} = 12\,781$$

Author D C Hedengren Date 1/26/00 Checked by J D Ryhn Date 1/26/00

SUMMARY:

DCRT 244-U CASE 7 — Modified for 244-U DCRT Vault Case (Ventilation rate of 3 cfh) Use Vertical DCRT for model Wetted surface area set at 1302 sq ft

INPUT SUMMARY:

General Data

DCRT Ventilation Rate $vr = 3\ 000 \frac{ft^3}{hr}$

Saltwell Waste Specific Gravity $\rho = 1\ 410$

Radiolytic Power of Waste $wastepower = 1\ 481 \frac{lb}{ft\ sec^3}$

Initial DCRT H_2 Inventory $vol_{H2_0} = 0\ 000\,ft^3$

H_2 Inventory Based on CGM? $flag_{cgm} =$ no'

CGM Measurement $conc_{LFL\_cgm0} = 0\ 000\,\%LFL$

DCRT Waste Temperature $T = 304\ 250\,K$

Nitrate Concentration $NO_3 = 3\ 180 \frac{mole}{liter}$

Nitrite Concentration $NO_2 = 3\ 020 \frac{mole}{liter}$

Aluminum Concentration $Al = 1\ 200 \frac{mole}{liter}$

TOC Concentration $TOC = 12\ 781 \frac{gm}{liter}$

Ammonia Concentration $NH_3 = 14\ 850\,\%LFL_{NH3}$

Methane Concentration $CH_4 = 0\ 000\,\%LFL_{CH4}$

Period 1

Initial Flow Rate $flow = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol\_molar} = 0\ 000 \frac{mole}{liter}$

or $gr_{sol} = 0\ 000 \frac{ft^3}{hr}$

Time Pumped at Inital Flow Rate $time = 1\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 29\ 200\,\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Hydrogen Carryover Rate $gr_{sol2} = 0\ 000 \frac{ft^3}{hr}$

Time pumped at Second flow rate $lim2 = 1\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 29\ 200\,\%$

Author D C Hedengren Date 1/26/00 Checked by J.D. Ryan Date 1/26/00

OUTPUT SUMMARY:

Period 1

Initial Flow Rate $flow = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time Pumped at Initial Flow Rate $time = 1\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init}}{tvol} = 29\ 200\,\%$

Final Fill Factor $fff = 29\ 200\,\%$

Initial Fill Volume $tvol_{init} = 24820\,gal$

Final Fill Volume $ffv = 24820\,gal$

Initial H2 Concentration (%LFL) $ih2c = 0\ 000\,\%$

Final H2 Concentration (%LFL) $fh2c = 4\ 794 \times 10^{-3}\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc = 14\ 855\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c1 = 12\ 791\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc1 = 27\ 641\,\%$

Period 2

Second Flow Rate $flow_2 = 1\ 000 \times 10^{-6} \frac{gal}{min}$

Time pumped at Second Flow Rate $tim2 = 1\ 000\,hr$

Initial Fill Factor $\frac{tvol_{init2}}{tvol} = 29\ 200\,\%$

Final Fill Factor $fff2 = 29\ 200\,\%$

Initial Fill Volume $tvol_{init2} = 24820\,gal$

Final Fill Volume $ffv2 = 24820\,gal$

Initial H2 Concentration (%LFL) $ih2c2 = 4\ 794 \times 10^{-3}\,\%$

Final H2 Concentration (%LFL) $fh2c2 = 9\ 585 \times 10^{-3}\,\%$

Final Flammable Gas Concentration (%LFL) $ffgc2 = 14\ 860\,\%$

Ultimate (ss) H2 Concentration (%LFL) $uhh2c2 = 12\ 791\,\%$

Ultimate (ss) Flammable Gas Concentration (%LFL) $uhfgc2 = 27\ 641\,\%$

Maximum %LFL with Loss of Ventilation $LFL_{nat\_breathing} = 27\ 539\,\%$

Time to Reach 25% LFL with Loss of Ventilation $Time_{2\ 25\%LFL} = 0\ 000\,day$

Time to Reach 50% LFL with Loss of Ventilation $Time_{2\ 50\%LFL} = 10\ 000 \times 10^{8}\,day$

Time to Reach 100% LFL with Loss of Ventilation $Time_{2\_100\%LFL} = 10\ 000 \times 10^{8}\,day$
