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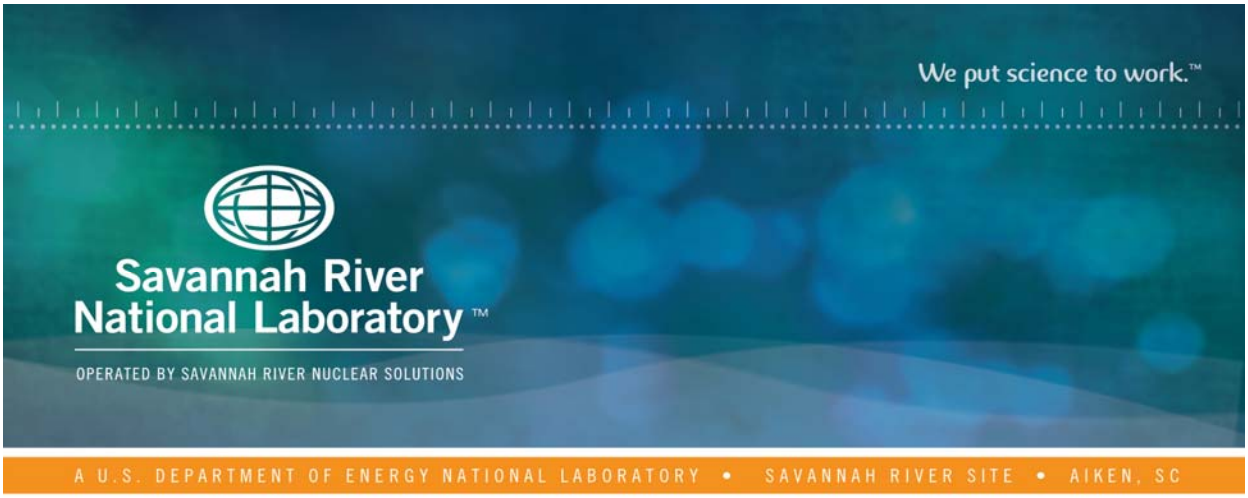

Estimated Vapor Pressure for WTP Process Streams

J. A. Pike
M. R. Poirier

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LIST OF ABBREVIATIONS

BNI	Bechtel National Incorporated
DOE	Department of Energy
EDTA	ethylenediaminetetraacetic acid
HEDTA	n-(2-Hydroxyethyl)ethylenediaminetriacetic acid
HLW	high level waste
IDA	iminodiacetate
MSE	Mixed Solvent Electrolyte
PJM	Pulsed Jet Mixer
SRNL	Savannah River National Laboratory
TBP	tri-n-butyl phosphate
WTP	Hanford Tank Waste Treatment and Immobilization Plant

1.0 Summary

Design assumptions during the vacuum refill phase of the Pulsed Jet Mixers (PJMs) in the Hanford Waste Treatment and Immobilization Plant (WTP) equate the vapor pressure of all process streams to that of water when calculating the temperature at which the vacuum refill is reduced or eliminated. WTP design authority asked the authors to assess this assumption by performing calculations on proposed feed slurries to calculate the vapor pressure as a function of temperature.

The vapor pressure was estimated for each WTP waste group. The vapor pressure suppression caused by dissolved solids is much greater than the increase caused by organic components such that the vapor pressure for all of the waste group compositions is less than that of pure water. The vapor pressure for each group at 145°F ranges from 81% to 98% of the vapor pressure of water. If desired, the PJM could be operated at higher temperatures for waste groups with high dissolved solids that suppress vapor pressure. The SO4 group with the highest vapor pressure suppression could be operated up to 153°F before reaching the same vapor pressure of water at 145°F. However, most groups would reach equivalent vapor pressure at 147 to 148°F.

If any of these waste streams are diluted, the vapor pressure can exceed the vapor pressure of water at mass dilution ratios greater than 10, but the overall effect is less than 0.5%.

2.0 Introduction

Vessels in the Hanford Waste Treatment and Immobilization Plant (WTP) are mixed with Pulsed Jet Mixers (PJMs). The PJMs mix vessels by drawing feed slurry into the PJM and discharging the contents into the vessel. The PJMs operate in three phases: drive, vent, and vacuum refill. In the drive phase, the PJM vessel is pressurized causing its contents to be expelled into the vessel. Following the drive phase, the PJMs are vented to relieve the pressure. After the vent phase, feed slurry is drawn into the PJM by pulling a vacuum.

At some temperature above 145°F, the vacuum will cause the feed slurry to flash. When the feed temperature exceeds this value, the vacuum is reduced to prevent flashing and mitigate transfer of liquid to the air link lines. As the temperature increases further, the vacuum refill is replaced by a gravity refill. Bechtel National Incorporated (BNI) design authority has calculated the temperature at which the vacuum refill is reduced or eliminated by assuming the feed slurry has the vapor pressure of water. BNI design authority asked the authors to assess this assumption by performing calculations on proposed feed slurries to calculate the vapor pressure as a function of temperature.

Previously, the tank farm sludge slurry inventory was categorized into 13 groups that correspond to the constituents aluminum-low leach, aluminum-high leach, chromium, bismuth, fluoride, iron-aluminum, phosphate, iron, zirconium-aluminum, sodium, calcium, uranium, and sulfate.[3] The actual feed to the WTP will consistent of a blend of one or more of these groups. Therefore, calculating the vapor pressure as a function of temperature for each of these groups should provide an assessment of the impact of temperature on expected WTP feed streams and an assessment of the use of the vapor pressure of water to determine when the PJMs need to employ a gravity refill. Vapor pressure calculations are performed for each composition. In addition, an extreme composition of the fluoride group, extreme fluoride and oxalate, was evaluated.

3.0 Objective

Estimate the vapor pressure of each waste group of the WTP process feed slurry.

4.0 Approach

Vapor pressure was estimated using OLI Analyzer™ version 9.1.2 for each waste group. OLI Analyzer™ calculates thermodynamic equilibrium compositions from all possible compounds in its database that could form from the input composition including solids precipitation and the possibility of a secondary liquid phase before calculating the resulting vapor pressure. OLI Analyzer™ includes two user selectable thermodynamic frameworks: aqueous or Mixed Solvent Electrolyte (MSE). The public Aqueous model database was chosen over the public MSE model database because most of the organic compounds were not yet available in the later. The MSE model has proven to provide more accurate equilibrium compositions than the Aqueous model, but the Aqueous model should still be sufficient for estimating water vapor pressure suppression from dissolved solids. Lack of organic components in the MSE model database precludes its use. The Aqueous model is a mature and well-studied model with parameters for approximately 6,000 species covering over 80 elements of the periodic table. The electrolyte thermodynamic model is based on the HKF (Helgeson-Kirkham-Flowers) Equation of State. Vapor phase properties are calculated at equilibrium conditions, i.e., Gibbs free energy for the vapor phase is equal to the Gibbs free energy of the aqueous phase. Vapor pressure for non-aqueous species is calculated from the Soave – Redlich – Kwong (SRK) Equation of State. The Department of Energy (DOE) funded development of enhancements to the database for chemical species typically found in the DOE high level waste (HLW) and used the software for thermodynamic simulation extensively. Example uses include references 1 and 2. In addition, OLI software was used in the original source reference for the WTP waste feed compositions.[3]

The waste composition data for each waste group was extracted from reference 3. The separately characterized compositions for insoluble and dissolved solids are mathematically combined based on proportions of insoluble solids, dissolved solids, and water to obtain a total composition estimate for each of the waste stream groups. Vapor pressure of the slurry is estimated using the composite total composition.

5.0 Quality Assurance

The calculations presented in this report are performed consistent with SRS procedure E7 Conduct of Engineering, 2.31 Engineering calculations including technical review design verification per procedure E7 2.60 by document review. The software used in these calculations is compliant with engineering calculation procedure E7 2.31 section 5.5.1 for exemption from the software quality assurance procedure 1Q 20-1. The calculations presented in this report cannot be in complete compliance with procedure E7 2.31 without a functional classification determined by the Design Authority. However, the calculations and review were performed consistent with a safety significant or safety class designation.

The error between OLI Stream Analyzer and experimental/literature data can be approximated from OLI literature as well as comparison to readily available literature. OLI Systems literature presents a vapor pressure calculation for the four-component system water-ammonia-carbon dioxide-hydrogen sulfide.[4] Traditional vapor pressure estimation of this system can be off by 2 to 3 orders of magnitude without accounting for all the actual components formed in solution. When the full OLI model is applied to the same problem, nominal error is reduced to less than 10% with variation up to 37%.

Figure 5-1 shows literature vapor pressure measurements for saturated salt solutions. The reference literature contained a variety of salts. However, only salts that are in or related to the WTP simulated

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waste in this assessment are selected from the reference. Generally the calculated values are very close, average variance of 4%, to the literature values except for $FeSO_4$. The $FeSO_4$ simulation varies from literature about 10% to high. Calculated water vapor pressure varies from literature values up to 0.6%. For reference, Table 5-1 shows the saturation concentrations calculated for each salt solution.

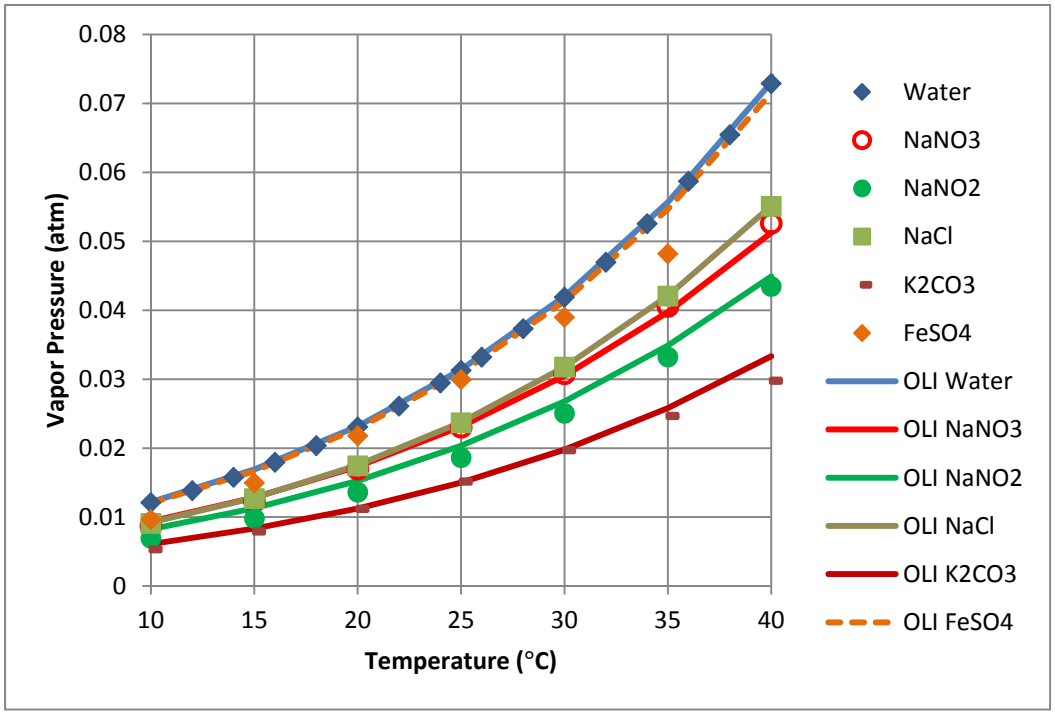

Figure 5-1: Comparison of Calculated Vapor Pressure to Literature Vapor Pressure Measurements – 10 to 40°C[5, 6]

Table 5-1: Calculated Saturation Concentrations for Salt Solutions Shown in Figure 5-1

Temperature	$FeSO_4$ mol/L	K_2CO_3 mol/L	NaCl mol/L	$NaNO_2$ mol/L	$NaNO_3$ mol/L
10 °C	1.33	6.11	5.49	8.76	7.09
15 °C	1.50	6.11	5.47	8.87	7.32
20 °C	1.68	6.11	5.45	8.99	7.55
25 °C	1.86	6.11	5.44	9.12	7.78
30 °C	2.03	6.11	5.43	9.26	8.00
35 °C	2.21	6.12	5.42	9.41	8.23
40 °C	2.39	6.13	5.42	9.57	8.46

6.0 Results and Discussion

This section first discusses the calculation of the input compositions to the OLI Analyzer™ database and then discusses the vapor pressure calculation and results.

6.1 Calculating Input Slurry Compositions

Table 6-1 shows the composition for each waste group[3] as well as the specific compound identified in the OLI Analyzer™ database. The following discussion details how the source composition data was treated to determine an input composition for the OLI Analyzer™ computations.

6.1.1 Identification of Representative Components in OLI Analyzer™ Database

6.1.1.1 Characterizing/Categorizing the Components

Categorizing the materials in the following manner assists in identifying adequate surrogate components if OLI Analyzer™ does not have the component in the database.

Considering that the objective is to determine vapor pressures, all organic salts, inorganic compounds, and organic components that are normally solid at nominal temperatures are considered as one group: not expected to affect vapor pressure. As will be discussed in Section 6.1.2, this category consists mostly of inorganic compounds and some organic solids in the insoluble solids not otherwise identified in this analysis and are considered "inert" relative to their effect on vapor pressure. These components exhibit very low or negligible aqueous solubility. All components that affect vapor pressure are part the second or third group.

A second group consists of the following water soluble components that will likely suppress the water vapor pressure as dissolved solids:

- $Na_2C_2O_4$ (sodium oxalate)
- $Na_3C_6H_5O_7$ (sodium citrate)
- CH_3COONa (sodium acetate)
- HCOONa (sodium formate)
- sodium succinate
- dodecane sulphonic acid
- glycolate
- $Na_2C_4H_5NO_4$ (IDA)
- ethylenediaminetetraacetic acid (EDTA)
- n-(2-Hydroxyethyl)ethylenediaminetriacetic acid (HEDTA)
- nitrilitriacetate
- 15 dissolved solids:
    - $NaAlO_2$
    - $CaCl_2•6H_2O$
    - $FeCl_3•6H_2O$
    - NaCl
    - $SrCl_2•6H_2O$
    - Na_2CO_3
    - $Na_2Cr_2O_7$
    - NaF
    - KOH

- $NaOH$
- $NaNO_3$
- $NaNO_2$
- $Na_3PO_4 \cdot 12H_2O$
- Na_4SiO_4
- $Na_2SO_4 \cdot 10H_2O$

A third group consists of organic components that are normally liquid at nominal ambient temperatures. These may or may not form secondary organic phases depending on the total amount and solubility or miscibility in the aqueous phase. Conceptually these materials were identified as solids in the composition table though they likely would be present as a second liquid phase rather than a solid. In this analysis, it does not matter. This group of organic liquids includes the following:

- $(CH_3CH_2CH_2CH_2O)_3PO$ (tributyl phosphate)
- $CH_3(CH_2)_{11}CH_3$ (tridecane)
- $CH_3(CH_2)_{12}CH_3$ (tetradecane)
- $CH_3(CH_2)_{10}CH_3$ (dodecane)
- $Na[CH_3(CH_2)_3CH(C_2H_5)CH_2O]_2PO_2$ (sodium bis(2-entylhexyl)phosphate)
- acetone
- 1-butanol

6.1.1.2 Identification of Representative Components in Variance from Source Data

Most components in the waste group composition data are the same as those in the OLI Analyzer™ public Aqueous model database. The following discussion details specific variants from those identified in the source data.

$Na_3C_6H_5O_7$ (Sodium Citrate)

Sodium citrate was not found in the public Aqueous model database, although the database does contain the conjugate acid, citric acid. Citric acid was chosen to represent sodium citrate as both are soluble in aqueous solutions. The simulated slurry composition results in the same dissolved solid composition as measured if the sodium hydroxide concentration is increased with a stoichiometric amount to compensate for the acid-base reaction that would occur in solution. The sodium hydroxide concentration was not adjusted to compensate as the potential effect on acid-base balance is negligible.

$Na_2C_4H_5NO_4$ (IDA)

IDA is iminodiacetic acid whereas iminodiacetate is the conjugate base; thus, the identified compound is not clear. It is assumed that the compound is intended to be iminodiacetate in such strongly basic solutions; however, iminodiacetate is not in the public Aqueous model database. The database does contain the conjugate acid, IDA. IDA was chosen to represent sodium iminodiacetate as both are soluble in aqueous solutions. The sodium hydroxide concentration was not adjusted to compensate as the potential effect on acid-base balance is negligible.

$Na[CH_3(CH_2)_3CH(C_2H_5)CH_2O]_2PO_2$ (sodium bis(2-entylhexyl)phosphate)

Neither sodium bis(2-ethylhexyl)phosphate nor the conjugate acid, bis(2-ethylhexyl) phosphoric acid, was found in the public Aqueous model database. No surrogate compound was identified. This compound is

a liquid organic at ambient conditions (miscibility in water unidentified). As such, it may contribute to vapor pressure. The low vapor pressure of sodium bis(2-ethylhexyl)phosphate, estimated at 4.65E-008 mm Hg at 25°C[7], likely makes insignificant contribution to the total vapor pressure because other organic compounds have significantly higher vapor pressures. Therefore, the potential error introduced by neglecting this component is very small.

Other Minor Components (Organic Species)

Several minor organic components are represented by a single lumped mass. Each of the identified compounds that make up the "other minor components" was evaluated for potential contribution to vapor pressure. Table 6-2 indicates which components tend to be liquid and likely produce a vapor pressure. Of those listed, only acetone and 1-butanol are normally liquid at ambient conditions. The component with the higher vapor pressure in OLI Analyzer™ public database was selected as a surrogate to represent all of the other minor components. As pure components, acetone has a vapor pressure around 3 times greater than 1-butanol; thus, acetone was selected. If both compounds are present in any one waste group, the vapor pressure may be additive or partially suppressed if miscible in a second liquid phase. The total "other minor components" is around 10^{-3} wt % or 10 ppm. At this low concentration, the total error introduced by using this lumped surrogate component is minimal. The total volatile portion of these components will tend to reach vapor-liquid equilibrium at lower liquid concentrations than initial input values, contributing less to the total pressure, resulting in a calculated pressure that estimates the highest possible vapor pressure contribution for these components.

No adjustment to the weight percent was attempted since there is no breakdown in composition of the minor constituents. However, there is a lumped mass for both the solids and the liquid. One might assume that the lumped sum for the liquid does not include any of the organic liquids and thus the total quantity of potential acetone available is effectively reduced. This would make a difference when calculating a vapor pressure for a given vapor volume ratio to liquid volume or mass. Since this calculation is based on a vanishingly small vapor volume, the estimate is calculated for the maximum vapor pressure possible. Vapor pressure in a real system with finite vapor volume is expected to be lower.

$Na_3PO_4 \cdot 12H_2O$ (sodium phosphate dodecahydrate)

As a dissolved solid, this component will suppress the water vapor pressure; thus, any hydrate form can readily by used as a substitute for this compound. The OLI Analyzer™ public database has several other hydrate forms and sodium phosphate octahydrate was chosen as a surrogate for sodium phosphate dodecahydrate. As a different hydrate form, the molecular weight difference causes an adjustment to the composition as a weight percent of the total using the following formula:

$$\text{wt \% solid}_{Na3PO3\cdot 8H2O} = \text{wt \% solid}_{Na3PO3\cdot 12H2O} * MW_{Na3PO3\cdot 8H2O} / MW_{Na3PO3\cdot 12H2O}$$

where MW is the molecular weight for each indicated solid hydrate. The entire solids composition was renormalized as described later.

6.1.2 Determination of Slurry Composition of Each Waste Group

The composition described in the source data for each waste group consists of liquid phase dissolved solids and solid phase insoluble solids. The solid phase solids, other than organic compounds, were identified as insoluble solids even if the solid phase solids contained excess soluble components. Dissolved and insoluble solids are characterized on a dry basis and separately.[3] The composition description needed for the vapor pressure calculation input requires a total slurry composition without

differentiating between dissolved and insoluble. The OLI Analyzer™ will automatically determine equilibrium concentrations and calculate the amount of precipitated excess solids or determine the composition of a second liquid phase if needed. Vapor pressure is then estimated by adjusting the pressure (i.e., energy added or removed) until the mixture output contains a small amount of vapor (i.e., $1/10^8$ mole vapor/mole slurry). This method estimates the vapor pressure while minimizing any calculated changes to the slurry composition.

Table 6-1 shows the final slurry composition as well as the composition of the dissolved and insoluble solids. Table 6-1 does not show the complete composition of the insoluble solids. All the unspecified solids are considered inert for this analysis though the mass of the solids need to be accounted in the normalization of the total slurry composition. Without the representation of the inert solids, the identified organic liquids would be over represented in the slurry composition.

In Table 6-1, the source composition is followed by the mathematically combined slurry solids that are normalized and then diluted uniformly with water such that the total slurry composition matches the solids content for each waste group. The normalized wt % slurry is the input composition to OLI Analyzer™ for each waste group. The wt % slurry solids column is calculated by:

wt % slurry solids/100 = wt % total insoluble solids/100 * wt % insoluble solids/100
+ wt % total dissolved solids/100 * wt % dissolved solids/100

The summation for the reported insoluble and dissolved solids composition is above 100% so normalization to 100% reduced all components of the slurry composition uniformly to 100% such that the relative amounts are preserved. The slurry solids are mathematically diluted with water as follows:

normalized wt % slurry/100 = wt % slurry solids/Σ(wt % slurry solids)
* (wt % total insoluble solids/100 + wt % total dissolved solids/100)
+ wt % water/100

where Σ(wt % slurry solids) is the sum of the wt% slurry solids for all components.

Table 6-1: WTP Waste Group Compositions

Identified Species	Observable State at Ambient Conditions			Species Idenfied in OLI Database	Waste Streams											
					Al - LL				Al - HL				Cr Group			
	Powder/ Crystal	Water Soluble Solid	Liquid		wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry
Organic Species																
$Na_2C_2O_4$				Na2C2O4	2.58	0.41	8.00E-01	2.17E-01	3.18	0.45	6.23E-01	1.47E-01	9.67	0.93	2.66E+00	7.43E-01
$Na_3C_6H_5O_7$ (Sodium Citrate)	X	X		H3[C6H5O7]		0.49	3.68E-01	9.99E-02		0.51	4.42E-01	1.04E-01		0.3	2.27E-01	6.35E-02
$Na_2C_4H_5NO_4$ (IDA)	X	X		HN(CH2CO2H)2		0.31	2.33E-01	6.32E-02		0.32	2.78E-01	6.54E-02		0.19	1.44E-01	4.02E-02
CH_3COONa (Sodium Acetate)	X	X		Na[C2H3O2]		0.27	2.03E-01	5.50E-02		0.29	2.52E-01	5.92E-02		0.17	1.29E-01	3.60E-02
HCOONa (Sodium Formate)	X	X		NaCOOH		0.28	2.10E-01	5.71E-02		0.29	2.52E-01	5.92E-02		0.17	1.29E-01	3.60E-02
$(CH_3CH_2CH_2CH_2O)_3PO$ (Tributyl Phosphate)			X	(C4H9)3PO4	0.311		5.93E-02	1.61E-02	0.292		2.14E-02	5.04E-03	0.59		1.19E-01	3.33E-02
$CH_3(CH_2)_{11}CH_3$ (Tridecane)			X	C13H28	0.278		5.30E-02	1.44E-02	0.261		1.91E-02	4.50E-03	0.53		1.07E-01	2.99E-02
$CH_3(CH_2)_{12}CH_3$ (Tetradecane)			X	C14H30	0.198		3.78E-02	1.03E-02	0.185		1.35E-02	3.19E-03	0.38		7.68E-02	2.15E-02
$CH_3(CH_2)_{10}CH_3$ (Dodecane)			X	C12H26	0.116		2.21E-02	6.01E-03	0.109		7.98E-03	1.88E-03	0.22		4.45E-02	1.24E-02
$Na[CH_3(CH_2)_3CH(C_2H_5)CH_2O]_2PO_2$ (Sodium Bis(2-entylhexyl) phosphate)	X	slightly	A	none identified	0.332		6.33E-02	1.72E-02	0.312		2.28E-02	5.38E-03	0.63		1.27E-01	3.56E-02
Other Minor Components				CH3COCH3	0.37	0.30	2.96E-01	8.03E-02	0.36	0.32	3.04E-01	7.16E-02	0.6	0.15	2.35E-01	6.56E-02
Soluble Salts																
$NaAlO_2$	X	X		NaALO2		6.84	5.14E+00	1.39E+00		8.3	7.20E+00	1.70E+00		9.27	7.03E+00	1.96E+00
$CaCl_2 \bullet 6H_2O$	X	X		CaCl2.6H2O		0.11	8.26E-02	2.24E-02		0.11	9.54E-02	2.25E-02		0.13	9.86E-02	2.75E-02
$FeCl_3 \bullet 6H_2O$	X	X		FeCl3.6H2O										0.11	8.34E-02	2.33E-02
NaCl	X	X		NaCl		0.64	4.81E-01	1.30E-01		0.66	5.72E-01	1.35E-01		0.59	4.47E-01	1.25E-01
$SrCl_2 \bullet 6H_2O$	X	X		SrCl2.6H2O												
Na_2CO_3	X	X		Na2CO3		10.35	7.77E+00	2.11E+00		10.16	8.81E+00	2.08E+00		15.13	1.15E+01	3.20E+00
$Na_2Cr_2O_7$	X	X		Na2CrO4		0.48	3.60E-01	9.78E-02		0.44	3.82E-01	8.99E-02		0.49	3.72E-01	1.04E-01
NaF	X	X		NaF		1.28	9.61E-01	2.61E-01		1.4	1.21E+00	2.86E-01		1.45	1.10E+00	3.07E-01
KOH	X	X		KOH		0.41	3.08E-01	8.36E-02		0.45	3.90E-01	9.19E-02		0.43	3.26E-01	9.10E-02
NaOH	X	X		NAOH										1.27	9.63E-01	2.69E-01
$NaNO_3$	X	X		NaNO3		59.45	4.46E+01	1.21E+01		55.57	4.82E+01	1.14E+01		45.64	3.46E+01	9.66E+00
$NaNO_2$	X	X		NaNO2		8.71	6.54E+00	1.78E+00		9.42	8.17E+00	1.92E+00		10.45	7.92E+00	2.21E+00
$Na_3PO_4 \bullet 12H_2O$	X	X		Na3PO4.8H2O		10.02	6.10E+00	1.66E+00		11.11	7.81E+00	1.84E+00		10.05	6.18E+00	1.72E+00
Na_4SiO_4	X	X		Na2SiO3		0.10	7.51E-02	2.04E-02		0.14	1.21E-01	2.86E-02		0.26	1.97E-01	5.50E-02
$Na_2SO_4 \bullet 10H_2O$	X	X		Na2SO4.10H2O		9.21	6.92E+00	1.88E+00		9.02	7.82E+00	1.84E+00		9.95	7.54E+00	2.11E+00
wt % Other Solids					95.82		1.83E+01	4.96E+00	95.30		6.98E+00	1.64E+00	87.38		1.77E+01	4.93E+00
TDS (wt %)								21.6%				21.7%				22.0%
TIS (wt %)								5.5%				1.8%				5.9%
Water (wt%)								72.9%				76.4%				72.1%

A - conjugate acid

Table 6-1: WTP Waste Group Compositions (continued)

Identified Species	waste streams															
	Bi Group				F Group				extreme F and oxalate				Fe-Al Group			
	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry
Organic Species																
$Na_2C_2O_4$	3.4	1.1	1.59E+00	4.72E-01	12.77	1.66	3.00E+00	8.59E-01	22.47	1.99	3.96E+00	1.03E+00	1.21	0.42	5.29E-01	2.36E-01
$Na_3C_6H_5O_7$ (Sodium Citrate)		1.07	7.04E-01	2.09E-01		0.15	1.20E-01	3.44E-02		0.19	1.62E-01	4.21E-02		0.92	6.91E-01	3.07E-01
$Na_2C_4H_5NO_4$ (IDA)		0.68	4.48E-01	1.33E-01		0.09	7.20E-02	2.06E-02		0.12	1.02E-01	2.66E-02		0.58	4.35E-01	1.94E-01
CH_3COONa (Sodium Acetate)		0.6	3.95E-01	1.17E-01		0.08	6.40E-02	1.83E-02		0.11	9.35E-02	2.44E-02		0.52	3.90E-01	1.74E-01
HCOONa (Sodium Formate)		0.61	4.02E-01	1.19E-01		0.08	6.40E-02	1.83E-02		0.11	9.35E-02	2.44E-02		0.52	3.90E-01	1.74E-01
$(CH_3CH_2CH_2CH_2O)_3PO$ (Tributyl Phosphate)	0.16		4.08E-02	1.21E-02	0.194		2.54E-02	7.27E-03	0.355		3.58E-02	9.32E-03	0.335		5.93E-02	2.64E-02
$CH_3(CH_2)_{11}CH_3$ (Tridecane)	0.23		5.86E-02	1.74E-02	0.173		2.26E-02	6.48E-03	0.317		3.19E-02	8.32E-03	0.299		5.29E-02	2.36E-02
$CH_3(CH_2)_{12}CH_3$ (Tetradecane)	0.16		4.08E-02	1.21E-02	0.123		1.61E-02	4.61E-03	0.226		2.28E-02	5.93E-03	0.213		3.77E-02	1.68E-02
$CH_3(CH_2)_{10}CH_3$ (Dodecane)	0.1		2.55E-02	7.56E-03	0.072		9.42E-03	2.70E-03	0.133		1.34E-02	3.49E-03	0.125		2.21E-02	9.85E-03
$Na[CH_3(CH_2)_3CH(C_2H_5)CH_2O]_2PO_2$ (Sodium Bis(2-entylhexyl)	0.18		4.58E-02	1.36E-02	0.207		2.71E-02	7.76E-03	0.38		3.83E-02	9.97E-03	0.358		6.34E-02	2.82E-02
Other Minor Components	0.58	0.29	3.39E-01	1.00E-01	0.55	0.11	1.60E-01	4.58E-02	0.66	0.12	1.69E-01	4.39E-02	0.57	0.33	3.49E-01	1.55E-01
Soluble Salts																
$NaAlO_2$		4.06	2.67E+00	7.93E-01		8.23	6.58E+00	1.89E+00		8.82	7.50E+00	1.95E+00		6.38	4.79E+00	2.13E+00
$CaCl_2 \cdot 6H_2O$		0.22	1.45E-01	4.30E-02		0.3	2.40E-01	6.87E-02		0.33	2.81E-01	7.31E-02		0.1	7.51E-02	3.34E-02
$FeCl_3 \cdot 6H_2O$		0.1	6.58E-02	1.95E-02		0.12	9.60E-02	2.75E-02		0.1	8.50E-02	2.21E-02			0.00E+00	
NaCl		0.29	1.91E-01	5.66E-02		0.2	1.60E-01	4.58E-02		0.2	1.70E-01	4.43E-02		0.48	3.60E-01	1.60E-01
$SrCl_2 \cdot 6H_2O$		0.12	7.90E-02	2.34E-02			0.00E+00				0.00E+00				0.00E+00	
Na_2CO_3		11.11	7.31E+00	2.17E+00		19.27	1.54E+01	4.41E+00		22.23	1.89E+01	4.92E+00		14.43	1.08E+01	4.82E+00
$Na_2Cr_2O_7$		0.31	2.04E-01	6.05E-02		0.58	4.64E-01	1.33E-01		0.58	4.93E-01	1.28E-01		0.44	3.30E-01	1.47E-01
NaF		2.28	1.50E+00	4.45E-01		2.95	2.36E+00	6.76E-01		1.88	1.60E+00	4.16E-01		3.36	2.52E+00	1.12E+00
KOH		0.39	2.57E-01	7.62E-02		0.49	3.92E-01	1.12E-01		0.71	6.04E-01	1.57E-01		1.23	9.23E-01	4.11E-01
NaOH			0.00E+00			2.34	1.87E+00	5.36E-01			0.00E+00			4.04	3.03E+00	1.35E+00
$NaNO_3$		54.17	3.57E+01	1.06E+01		40.95	3.27E+01	9.38E+00		44.27	3.76E+01	9.80E+00		34.94	2.62E+01	1.17E+01
$NaNO_2$		8.89	5.85E+00	1.74E+00		6.02	4.81E+00	1.38E+00		6.2	5.27E+00	1.37E+00		16.74	1.26E+01	5.59E+00
$Na_3PO_4 \cdot 12H_2O$		17.24	9.20E+00	2.73E+00		13.78	8.93E+00	2.56E+00		11.07	7.63E+00	1.99E+00		15.71	9.56E+00	4.25E+00
Na_4SiO_4		0.37	2.44E-01	7.22E-02		0.38	3.04E-01	8.71E-02		0.24	2.04E-01	5.31E-02		0.31	2.33E-01	1.04E-01
$Na_2SO_4 \cdot 10H_2O$		12.6	8.29E+00	2.46E+00		13.52	1.08E+01	3.10E+00		8.57	7.29E+00	1.90E+00		11.16	8.38E+00	3.73E+00
wt % Other Solids	95.19		2.42E+01	7.19E+00	85.91		1.12E+01	3.22E+00	75.46		7.61E+00	1.98E+00	96.89		1.72E+01	7.63E+00
TDS (wt %)				21.4%				24.6%				23.3%				36.0%
TIS (wt %)				8.3%				4.0%				2.8%				8.5%
Water (wt%)				70.3%				71.4%				74.0%				55.5%

Table 6-1: WTP Waste Group Compositions (continued)

Identified Species	waste streams															
	PO4 Group				Fe Group				Zr-Al Group				Na Group			
	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry
Organic Species																
$Na_2C_2O_4$	1.45	0.63	8.24E-01	3.04E-01	1.28	0.83	8.33E-01	3.02E-01	1.11	0.6	7.47E-01	2.65E-01	10.75	1.19	2.22E+00	6.61E-01
$Na_3C_6H_5O_7$ (Sodium Citrate)		0.48	3.05E-01	1.13E-01		0.41	3.23E-01	1.17E-01		0.58	3.35E-01	1.19E-01		0.3	2.63E-01	7.80E-02
$Na_2C_4H_5NO_4$ (IDA)		0.3	1.91E-01	7.03E-02		0.26	2.05E-01	7.44E-02		0.37	2.14E-01	7.59E-02		0.19	1.66E-01	4.94E-02
CH_3COONa (Sodium Acetate)		0.27	1.72E-01	6.33E-02		0.23	1.81E-01	6.58E-02		0.33	1.91E-01	6.77E-02		0.17	1.49E-01	4.42E-02
HCOONa (Sodium Formate)		0.27	1.72E-01	6.33E-02		0.23	1.81E-01	6.58E-02		0.33	1.91E-01	6.77E-02		0.17	1.49E-01	4.42E-02
$(CH_3CH_2CH_2CH_2O)_3PO$ (Tributyl Phosphate)	0.225		6.57E-02	2.42E-02	0.11		1.53E-02	5.55E-03	0.23		8.31E-02	2.95E-02	0.607		6.68E-02	1.98E-02
$CH_3(CH_2)_{11}CH_3$ (Tridecane)	0.202		5.89E-02	2.17E-02	0.1		1.39E-02	5.04E-03	0.2		7.22E-02	2.57E-02	0.542		5.96E-02	1.77E-02
$CH_3(CH_2)_{12}CH_3$ (Tetradecane)	0.144		4.20E-02	1.55E-02	0.07		9.74E-03	3.53E-03	0.14		5.06E-02	1.80E-02	0.386		4.25E-02	1.26E-02
$CH_3(CH_2)_{10}CH_3$ (Dodecane)	0.084		2.45E-02	9.03E-03	0.04		5.56E-03	2.02E-03	0.09		3.25E-02	1.15E-02	0.227		2.50E-02	7.41E-03
$Na[CH_3(CH_2)_3CH(C_2H_5)CH_2O]_2PO_2$ (Sodium Bis(2-entylhexyl) phosphate)	0.241		7.03E-02	2.59E-02	0.12		1.67E-02	6.05E-03	0.24		8.67E-02	3.08E-02	0.649		7.14E-02	2.12E-02
Other Minor Components	0.68	0.32	4.02E-01	1.48E-01	0.36	0.23	2.32E-01	8.39E-02	0.64	0.18	3.35E-01	1.19E-01	0.72	0.14	2.02E-01	5.99E-02
Soluble Salts																
$NaAlO_2$		5.63	3.58E+00	1.32E+00		6.15	4.85E+00	1.76E+00		5.62	3.24E+00	1.15E+00		12.31	1.08E+01	3.20E+00
$CaCl_2 \cdot 6H_2O$		0.25	1.59E-01	5.86E-02		0.17	1.34E-01	4.86E-02		0.21	1.21E-01	4.31E-02		0.04	3.50E-02	1.04E-02
$FeCl_3 \cdot 6H_2O$			0.00E+00			0.22	1.74E-01	6.29E-02			0.00E+00			0.15	1.31E-01	3.90E-02
NaCl		0.16	1.02E-01	3.75E-02		0.33	2.60E-01	9.44E-02		0.25	1.44E-01	5.13E-02		1.14	9.98E-01	2.96E-01
$SrCl_2 \cdot 6H_2O$																
Na_2CO_3		8.22	5.23E+00	1.93E+00		16.56	1.31E+01	4.74E+00		10.13	5.85E+00	2.08E+00		19.53	1.71E+01	5.08E+00
$Na_2Cr_2O_7$		0.26	1.65E-01	6.10E-02		0.49	3.87E-01	1.40E-01		0.27	1.56E-01	5.54E-02		0.3	2.63E-01	7.80E-02
NaF		3.46	2.20E+00	8.11E-01		1.33	1.05E+00	3.80E-01		4.05	2.34E+00	8.30E-01		1.06	9.28E-01	2.76E-01
KOH		0.78	4.96E-01	1.83E-01		3.67	2.90E+00	1.05E+00		0.97	5.60E-01	1.99E-01		0.67	5.87E-01	1.74E-01
NaOH			0.00E+00			2.95	2.33E+00	8.44E-01		0.35	2.02E-01	7.18E-02		1.6	1.40E+00	4.16E-01
$NaNO_3$		54.06	3.44E+01	1.27E+01		36.34	2.87E+01	1.04E+01		50.12	2.89E+01	1.03E+01		33.78	2.96E+01	8.78E+00
$NaNO_2$		6.86	4.36E+00	1.61E+00		14.85	1.17E+01	4.25E+00		8.75	5.05E+00	1.79E+00		15.38	1.35E+01	4.00E+00
$Na_3PO_4 \cdot 12H_2O$		31.97	1.65E+01	6.08E+00		14.46	9.24E+00	3.35E+00		28.83	1.35E+01	4.79E+00		6.93	4.92E+00	1.46E+00
Na_4SiO_4		0.42	2.67E-01	9.85E-02		0.39	3.08E-01	1.12E-01		0.43	2.48E-01	8.82E-02				
$Na_2SO_4 \cdot 10H_2O$		3.04	1.93E+00	7.13E-01		11.77	9.29E+00	3.37E+00		3.75	2.16E+00	7.69E-01		7.89	6.91E+00	2.05E+00
wt % Other Solids	96.97		2.83E+01	1.04E+01	97.92		1.36E+01	4.94E+00	97.35		3.52E+01	1.25E+01	86.12		9.47E+00	2.81E+00
TDS (wt %)				25.3%				30.8%				21.8%				26.4%
TIS (wt %)				11.6%				5.4%				13.7%				3.3%
Water (wt%)				63.1%				63.7%				64.5%				70.3%

Table 6-1: WTP Waste Group Compositions (continued)

Identified Species	waste streams											
	Ca Group				U Group				SO4 Group			
	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry	wt % Insoluble Solid	wt % Dissolved Solids	Normalized wt% Solids	Normalized wt% Slurry
Organic Species												
$Na_2C_2O_4$	10.32	0.82	1.41E+00	5.29E-01	3.59	0.81	1.56E+00	2.21E-01	8.41	0.4	4.68E-01	2.03E-01
$Na_3C_6H_5O_7$ (Sodium Citrate)		0.42	3.93E-01	1.47E-01		0.87	5.56E-01	7.90E-02		0.83	8.09E-01	3.51E-01
$Na_2C_4H_5NO_4$ (IDA)		0.27	2.53E-01	9.48E-02		0.55	3.52E-01	4.99E-02		0.53	5.17E-01	2.24E-01
CH_3COONa (Sodium Acetate)		0.24	2.25E-01	8.42E-02		0.49	3.13E-01	4.45E-02		0.47	4.58E-01	1.98E-01
HCOONa (Sodium Formate)		0.24	2.25E-01	8.42E-02		0.49	3.13E-01	4.45E-02		0.47	4.58E-01	1.98E-01
$(CH_3CH_2CH_2CH_2O)_3PO$ (Tributyl Phosphate)	0.38		2.37E-02	8.88E-03	0.573		1.66E-01	2.35E-02	1.21		1.12E-02	4.83E-03
$CH_3(CH_2)_{11}CH_3$ (Tridecane)	0.34		2.12E-02	7.95E-03	0.512		1.48E-01	2.10E-02	1.081		9.97E-03	4.32E-03
$CH_3(CH_2)_{12}CH_3$ (Tetradecane)	0.242		1.51E-02	5.66E-03	0.364		1.05E-01	1.49E-02	0.769		7.09E-03	3.07E-03
$CH_3(CH_2)_{10}CH_3$ (Dodecane)	0.142		8.85E-03	3.32E-03	0.214		6.19E-02	8.78E-03	0.452		4.17E-03	1.80E-03
$Na[CH_3(CH_2)_3CH(C_2H_5)CH_2O]_2PO_2$ (Sodium Bis(2-entylhexyl)	0.406		2.53E-02	9.49E-03	0.613		1.77E-01	2.52E-02	1.292		1.19E-02	5.16E-03
Other Minor Components	0.72	0.17	2.04E-01	7.65E-02	0.33	0.24	2.49E-01	3.53E-02	0.59	0.28	2.78E-01	1.21E-01
Soluble Salts												
$NaAlO_2$		11.65	1.09E+01	4.09E+00		7.03	4.50E+00	6.38E-01		11.31	1.10E+01	4.78E+00
$CaCl_2 \bullet 6H_2O$		0.26	2.43E-01	9.12E-02		0.12	7.67E-02	1.09E-02		0.05	4.88E-02	2.11E-02
$FeCl_3 \bullet 6H_2O$			0.00E+00			0.21	1.34E-01	1.91E-02		0.01	9.75E-03	4.22E-03
NaCl		0.89	8.33E-01	3.12E-01		0.39	2.49E-01	3.54E-02		1.41	1.38E+00	5.95E-01
$SrCl_2 \bullet 6H_2O$												
Na_2CO_3		11.92	1.12E+01	4.18E+00		12.04	7.70E+00	1.09E+00		9.59	9.35E+00	4.05E+00
$Na_2Cr_2O_7$		0.39	3.65E-01	1.37E-01		1.04	6.65E-01	9.44E-02		0.65	6.34E-01	2.75E-01
NaF		0.78	7.30E-01	2.74E-01		1.63	1.04E+00	1.48E-01		1.33	1.30E+00	5.62E-01
KOH		0.76	7.11E-01	2.67E-01		0.42	2.69E-01	3.81E-02		1.32	1.29E+00	5.57E-01
NaOH		4.07	3.81E+00	1.43E+00		0.32	2.05E-01	2.90E-02		10.85	1.06E+01	4.58E+00
$NaNO_3$		41.76	3.91E+01	1.47E+01		46.35	2.96E+01	4.21E+00		33.81	3.30E+01	1.43E+01
$NaNO_2$		15.41	1.44E+01	5.41E+00		8.81	5.63E+00	8.00E-01		19.33	1.89E+01	8.16E+00
$Na_3PO_4 \bullet 12H_2O$		6.16	4.67E+00	1.75E+00		21.77	1.13E+01	1.60E+00		3.55	2.81E+00	1.21E+00
Na_4SiO_4		0.19	1.78E-01	6.67E-02		0.66	4.22E-01	5.99E-02			0.00E+00	
$Na_2SO_4 \bullet 10H_2O$		4.96	4.64E+00	1.74E+00		11.06	7.07E+00	1.00E+00		6.08	5.93E+00	2.57E+00
wt % Other Solids	87.45		5.45E+00	2.04E+00	93.80		2.71E+01	3.85E+00	86.20		7.95E-01	3.44E-01
TDS (wt %)				35.2%				9.8%				42.9%
TIS (wt %)				2.3%				4.4%				0.4%
Water (wt%)				62.5%				85.8%				56.7%

Table 6-2: Organic Compounds Identified in the Minor Components

	Observable State at Ambient Conditions			Species Idenfied in OLI Database
	Powder/ Crystal	Water Soluble Solid	Liquid	
sodium succinate*	X	X		C4H6O4
EDTA (Ethylenediaminetetraacetic acid)*	X	X		H4C10H12N2O8
dodecane sulphonic acid	X	X		none identified
glycolate	A	A		Na[C2H3O3]
HEDTA ((2-Hydroxyethyl) ethylenedi-aminetriacetic	X			none identified
nitrilitriacetate	A	A		Na[H2C6H6NO6]
acetone			X	CH3COCH3
1-butanol			X	C4H10O

A - conjugate acid

6.2 Vapor Pressure Estimates

There are several options in OLI Stream Analyzer to produce an estimate of vapor pressure (bubble point, dew point, vapor amount, vapor fraction), depending on what kind of conditions are desired to be simulated. For a given liquid phase composition, the bubble point and dew point options calculate a condition where a very small mole fraction ($1/10^8$ mole vapor/mole slurry) of volatile components produce a vapor phase, thus, minimizing the change to the overall slurry composition to approximately convergence criteria or less. In both of these options, one can fix the temperature and calculate the resulting pressure or fix the pressure and calculate temperature. Testing using one of the waste group compositions shows that both options calculate the same vapor pressure. The vapor amount and vapor fraction calculations determine conditions necessary to produce a vapor phase that meet a quantity criteria that the user specifies. For the latter two calculation methods, the input composition of the liquid is altered by vaporizing a substantial fraction of the volatile components until the specified criteria are met. These later methods would be useful for mapping or tracing the effect of evaporating the volatile species for given slurry vapor ratio, though this analysis does not do so.

Table 6-3 show total vapor pressure estimated for each waste group by temperature. Figure 6-1 and Figure 6-2 show the data graphically for 20 to 60°C and 60 to 120°C, respectively. These two ranges show similar behavior for an order of magnitude increase in pressure.

Water is the largest fraction of the volatile species and dominates the total calculated vapor pressure as can be seen in the vapor phase composition shown in Appendix A. The organic species account for only a small fraction of the total pressure, about 2-4%. Vapor pressure suppression of water due to the dissolved solids causes the primary differences between waste groups. Most notably, the Ca group and the SO4 group have higher dissolved solids content thereby suppressing the water vapor pressure more than other groups, about 86% and 81% of water vapor pressure respectively. The vapor pressure of the U group is most similar to water, about 98% of the water vapor pressure, because of the lowest dissolved solids content. This indicates that PJM may be operated at higher temperatures while exhibiting less than design vapor pressure. For example, the calculated vapor pressure for the SO4 group indicates the PJM may be operated up to about 153°F (67.4°C) before reaching the same vapor pressure of water at 145°F (62.8°C). Most groups reach equivalent vapor pressure at 147 – 148°F.

The pressure generated from the organic species is less than the suppression of water vapor pressure such that it never exceeds that of pure water. One may observe that as any solution is diluted, the vapor pressure could exceed that of water due to the organics present; however, the effect is small, around 0.2-

0.4% of the water vapor pressure. Figure 6-3 illustrates the calculated vapor pressure with progressively more dilute uranium group slurry. The graph shows how the vapor pressure increases with progressively higher mass ratios of water to slurry. As can be seen, the vapor pressure exceeds that of water around a mass dilution ratio of 10 and approaches a maximum of about 1.003 times that of water. At these high dilutions, the final pressure measured depends on the vapor to slurry ratio. Regardless, the total effect is less than 0.5 percent. Since all other waste groups have higher dissolved solids content, the ratio where vapor pressure exceeds that of water alone is higher.

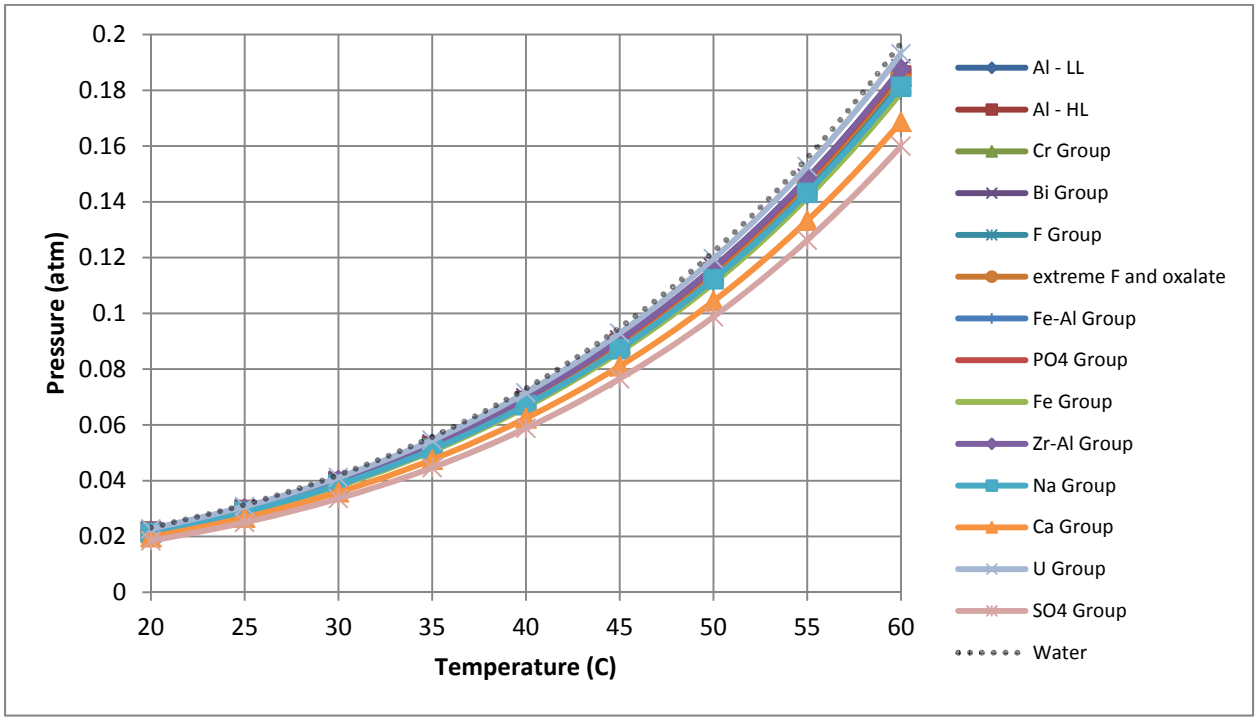

Figure 6-1: Vapor Pressure of Each Waste Group – 20 to 60°C

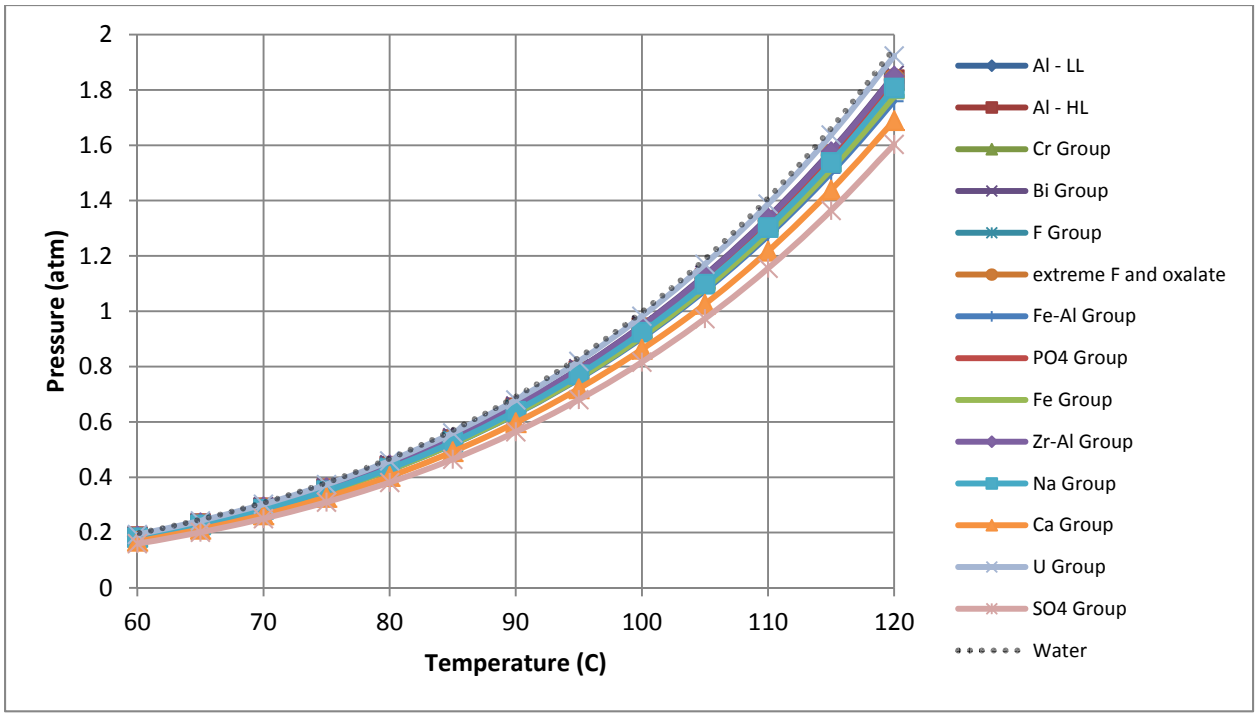

Figure 6-2: Vapor Pressure of Each Waste Group – 60 to 120°C

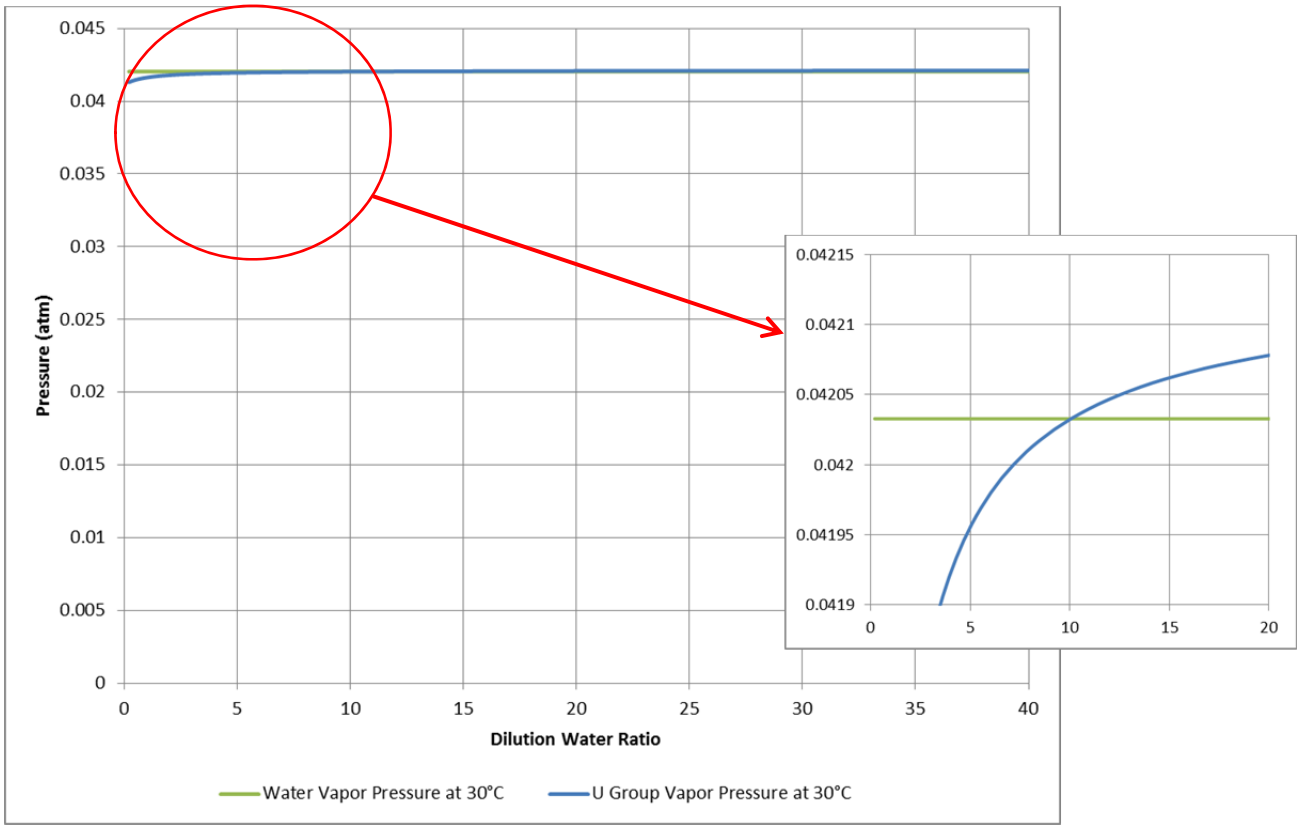

Figure 6-3: Vapor Pressure of U Group Slurry with Progressively Greater Dilution 30°C

Table 6-3: Estimated Vapor Pressure for Each Waste Group and Water

Temp °C	Al - LL Pressure atm	Al - HL Pressure atm	Cr Group Pressure atm	Bi Group Pressure atm	F Group Pressure atm	Extreme F and Oxalate Pressure atm	Fe-Al Group Pressure atm	PO4 Group Pressure atm	Fe Group Pressure atm	Zr-Al Group Pressure atm	Na Group Pressure atm	Ca Group Pressure atm	U Group Pressure atm	SO4 Group Pressure atm	Water Pressure atm
20	0.022	0.022	0.022	0.022	0.022	0.022	0.021	0.022	0.021	0.022	0.021	0.020	0.023	0.018	0.023
25	0.030	0.029	0.029	0.030	0.029	0.030	0.029	0.030	0.028	0.030	0.029	0.027	0.031	0.025	0.031
30	0.040	0.039	0.039	0.040	0.039	0.040	0.038	0.040	0.038	0.040	0.039	0.036	0.041	0.034	0.042
35	0.052	0.052	0.052	0.053	0.052	0.052	0.051	0.053	0.051	0.053	0.051	0.048	0.055	0.045	0.056
40	0.069	0.069	0.068	0.070	0.068	0.069	0.067	0.069	0.066	0.070	0.067	0.062	0.072	0.059	0.073
45	0.089	0.089	0.089	0.090	0.088	0.089	0.087	0.090	0.086	0.090	0.087	0.081	0.093	0.077	0.095
50	0.115	0.115	0.115	0.116	0.114	0.115	0.112	0.116	0.111	0.116	0.112	0.104	0.120	0.099	0.122
55	0.147	0.146	0.146	0.148	0.145	0.147	0.142	0.148	0.141	0.148	0.143	0.133	0.153	0.126	0.156
60	0.186	0.185	0.185	0.188	0.184	0.186	0.180	0.187	0.179	0.188	0.181	0.169	0.193	0.160	0.197
65	0.233	0.233	0.232	0.236	0.231	0.233	0.226	0.234	0.225	0.235	0.228	0.212	0.242	0.201	0.247
70	0.290	0.290	0.289	0.293	0.287	0.290	0.281	0.292	0.280	0.293	0.284	0.264	0.302	0.250	0.308
75	0.359	0.358	0.357	0.363	0.356	0.359	0.347	0.360	0.347	0.362	0.351	0.327	0.374	0.310	0.381
80	0.440	0.440	0.439	0.445	0.437	0.441	0.425	0.442	0.425	0.445	0.431	0.403	0.459	0.381	0.467
85	0.537	0.537	0.536	0.543	0.533	0.538	0.518	0.539	0.519	0.542	0.527	0.492	0.560	0.465	0.570
90	0.651	0.651	0.650	0.658	0.647	0.652	0.628	0.652	0.629	0.657	0.639	0.597	0.679	0.564	0.691
95	0.785	0.784	0.783	0.792	0.780	0.786	0.755	0.785	0.758	0.791	0.771	0.720	0.819	0.680	0.833
100	0.940	0.940	0.939	0.949	0.935	0.942	0.904	0.940	0.908	0.948	0.924	0.863	0.982	0.816	0.997
105	1.119	1.119	1.117	1.130	1.112	1.121	1.076	1.119	1.082	1.128	1.098	1.025	1.170	0.973	1.188
110	1.326	1.326	1.324	1.339	1.318	1.329	1.273	1.325	1.282	1.337	1.303	1.218	1.387	1.155	1.409
115	1.564	1.565	1.562	1.579	1.556	1.568	1.500	1.562	1.513	1.576	1.538	1.438	1.637	1.364	1.661
120	1.836	1.837	1.835	1.853	1.827	1.842	1.759	1.832	1.776	1.850	1.807	1.689	1.923	1.603	1.950

6.3 Comparison to a Simplified Correlation

The dominating factor that affects vapor pressure is the partial pressure of water such that a simple correlation may be adequate to estimate vapor pressure. Vapor pressure of water is directly proportional to the activity of the water. The activity of water decreases proportionally to the increase in electrolyte concentrations. The total electrolyte concentration for each waste group is proportional to sodium because sodium is the dominant cation. As such, the following correlation is implied:

$$P = m * [Na^+] + b$$

where m and b are liner regression constants for each composition and a function of temperature. b is the vapor pressure at no electrolytes, i.e., the vapor pressure of water. The following example is provided for the Ca Group composition.

Figure 6-4 shows linear regressions of OLI simulations of successive water dilutions of the Ca Group composition for several temperatures. The vapor pressure is nearly linear. The slopes can be approximated by an Arrhenius-type expression:

$$m = Ae^{\frac{-B}{T}}$$

where

A and B = constants,
T = is temperature (K).

For the Ca Group depicted in Figure 6-4, A = 30,588 and B = 5195.3. The dashed line shows that the correlation is a near perfect match to the linear regressions for each isotherm.

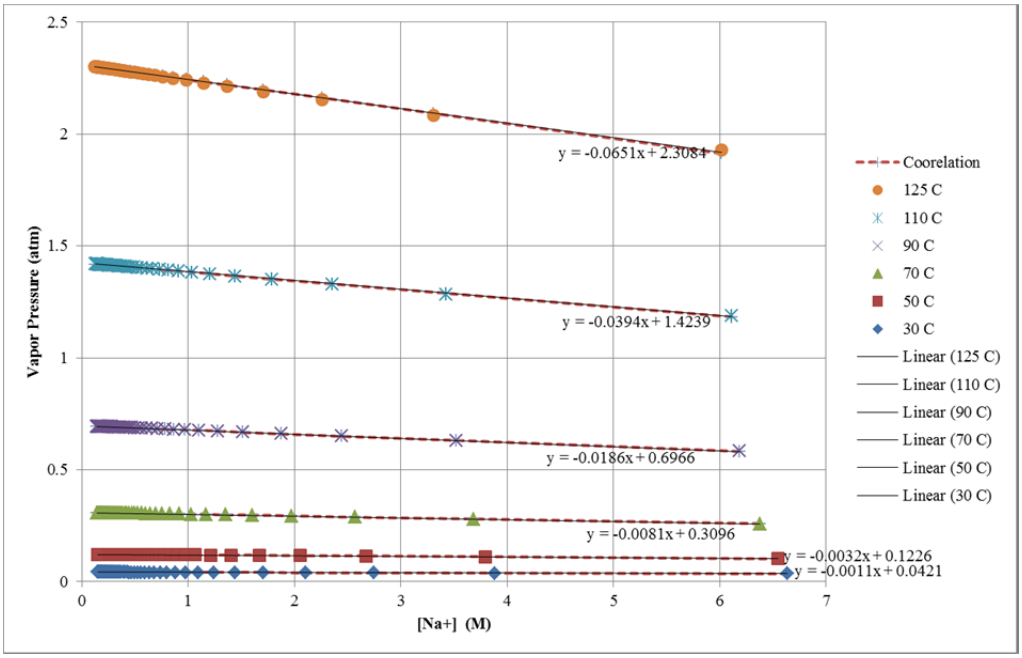

Figure 6-4: Vapor Pressure of Ca Group Slurry with Progressively Greater Dilution from 30°C to 125°C

7.0 Conclusions

The vapor pressure was estimated for each WTP waste group. The vapor pressure suppression caused by dissolved solids is much greater than the increase caused by organic components such that the vapor pressure for all of the waste group compositions is less than that of pure water. The vapor pressure for each group at 145°F ranges from 81% to 98% of the vapor pressure of water. If desired, the PJM could be operated at higher temperatures for waste groups with high dissolved solids that suppress vapor pressure. The SO4 group with the highest vapor pressure suppression could be operated up to 153°F before reaching the same vapor pressure of water at 145°F. However, most groups would reach equivalent vapor pressure at 147 to 148°F.

If any of these waste streams are diluted, the vapor pressure can exceed the vapor pressure of water at mass dilution ratios greater than 10, but the overall effect is less than 0.5%.

8.0 References

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6 "Vapor Pressure of Saturated Salt Solutions", CRC Handbook of Chemistry and Physics, 95th edition, CRC Press, 2014, p. 6-126

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Appendix A. Calculated Vapor Phase Composition for Each Waste Group

Al – LL Group Vapor Pressure and Composition and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.18E-02	3.16E-50	4.84E-112	1.78E-48	3.35E-17	3.94E-09	3.09E-13	1.47E-18	6.16E-13	7.66E-41	9.81E+01	7.21E-08	9.31E-12	1.71E+00	9.90E-25	4.78E-32	2.19E-02	5.52E-02	1.10E-01	9.00E-30	3.42E-05
25	2.95E-02	2.83E-49	2.71E-110	9.63E-48	6.17E-17	5.38E-09	4.86E-13	2.77E-18	9.88E-13	2.92E-40	9.81E+01	1.26E-07	1.47E-11	1.69E+00	2.67E-24	1.59E-31	2.62E-02	6.40E-02	1.24E-01	2.57E-29	4.58E-05
30	3.96E-02	2.29E-48	1.34E-108	4.91E-47	1.11E-16	7.24E-09	7.64E-13	5.14E-18	1.55E-12	1.06E-39	9.81E+01	2.16E-07	2.26E-11	1.67E+00	6.81E-24	5.07E-31	3.12E-02	7.38E-02	1.38E-01	7.28E-29	6.07E-05
35	5.24E-02	1.69E-47	5.82E-107	2.37E-46	1.98E-16	9.60E-09	1.20E-12	9.37E-18	2.39E-12	3.69E-39	9.81E+01	3.60E-07	3.40E-11	1.64E+00	1.65E-23	1.54E-30	3.69E-02	8.45E-02	1.54E-01	2.05E-28	7.94E-05
40	6.88E-02	1.14E-46	2.26E-105	1.10E-45	3.44E-16	1.26E-08	1.89E-12	1.68E-17	3.61E-12	1.24E-38	9.81E+01	5.88E-07	4.99E-11	1.61E+00	3.83E-23	4.46E-30	4.33E-02	9.64E-02	1.70E-01	5.74E-28	1.03E-04
45	8.93E-02	7.10E-46	7.80E-104	4.84E-45	5.89E-16	1.62E-08	2.96E-12	2.97E-17	5.37E-12	4.00E-38	9.81E+01	9.41E-07	7.19E-11	1.57E+00	8.50E-23	1.24E-29	5.05E-02	1.09E-01	1.88E-01	1.60E-27	1.31E-04
50	1.15E-01	4.08E-45	2.42E-102	2.06E-44	9.93E-16	2.08E-08	4.65E-12	5.16E-17	7.83E-12	1.26E-37	9.81E+01	1.48E-06	1.01E-10	1.53E+00	1.81E-22	3.32E-29	5.87E-02	1.23E-01	2.06E-01	4.40E-27	1.67E-04
55	1.47E-01	2.17E-44	6.76E-101	8.42E-44	1.65E-15	2.62E-08	7.28E-12	8.83E-17	1.12E-11	3.83E-37	9.81E+01	2.28E-06	1.40E-10	1.49E+00	3.71E-22	8.52E-29	6.78E-02	1.39E-01	2.26E-01	1.21E-26	2.09E-04
60	1.86E-01	1.08E-43	1.71E-99	3.34E-43	2.70E-15	3.27E-08	1.14E-11	1.49E-16	1.59E-11	1.14E-36	9.81E+01	3.45E-06	1.91E-10	1.44E+00	7.34E-22	2.11E-28	7.78E-02	1.55E-01	2.47E-01	3.28E-26	2.60E-04
65	2.33E-01	5.05E-43	3.94E-98	1.28E-42	4.36E-15	4.05E-08	1.78E-11	2.48E-16	2.21E-11	3.32E-36	9.81E+01	5.16E-06	2.56E-10	1.39E+00	1.41E-21	5.05E-28	8.90E-02	1.73E-01	2.68E-01	8.87E-26	3.20E-04
70	2.90E-01	2.23E-42	8.34E-97	4.79E-42	6.96E-15	4.97E-08	2.77E-11	4.08E-16	3.03E-11	9.47E-36	9.81E+01	7.62E-06	3.37E-10	1.34E+00	2.62E-21	1.17E-27	1.01E-01	1.92E-01	2.91E-01	2.38E-25	3.92E-04
75	3.59E-01	9.40E-42	1.63E-95	1.75E-41	1.10E-14	6.06E-08	4.33E-11	6.64E-16	4.11E-11	2.66E-35	9.81E+01	1.12E-05	4.39E-10	1.28E+00	4.77E-21	2.63E-27	1.15E-01	2.13E-01	3.15E-01	6.38E-25	4.76E-04
80	4.40E-01	3.81E-41	2.98E-94	6.30E-41	1.73E-14	7.36E-08	6.77E-11	1.07E-15	5.53E-11	7.41E-35	9.81E+01	1.63E-05	5.66E-10	1.23E+00	8.51E-21	5.79E-27	1.30E-01	2.35E-01	3.40E-01	1.71E-24	5.74E-04
85	5.37E-01	1.50E-40	5.13E-93	2.24E-40	2.69E-14	8.90E-08	1.06E-10	1.71E-15	7.37E-11	2.05E-34	9.80E+01	2.36E-05	7.23E-10	1.18E+00	1.50E-20	1.25E-26	1.46E-01	2.59E-01	3.67E-01	4.56E-24	6.88E-04
90	6.51E-01	5.80E-40	8.41E-92	7.86E-40	4.17E-14	1.08E-07	1.67E-10	2.73E-15	9.77E-11	5.64E-34	9.80E+01	3.44E-05	9.18E-10	1.12E+00	2.61E-20	2.64E-26	1.64E-01	2.84E-01	3.94E-01	1.23E-23	8.19E-04
95	7.85E-01	2.22E-39	1.33E-90	2.76E-39	6.46E-14	1.30E-07	2.63E-10	4.32E-15	1.29E-10	1.56E-33	9.80E+01	5.03E-05	1.16E-09	1.07E+00	4.52E-20	5.50E-26	1.83E-01	3.11E-01	4.23E-01	3.31E-23	9.71E-04
100	9.40E-01	8.49E-39	2.03E-89	9.65E-39	1.00E-13	1.57E-07	4.18E-10	6.83E-15	1.70E-10	4.34E-33	9.80E+01	7.40E-05	1.46E-09	1.02E+00	7.81E-20	1.14E-25	2.04E-01	3.40E-01	4.53E-01	9.04E-23	1.14E-03
105	1.12E+00	2.52E-39	2.34E-89	1.21E-38	9.41E-14	1.15E-07	4.02E-10	6.49E-15	1.35E-10	4.36E-33	9.79E+01	3.95E-05	1.11E-09	9.80E-01	4.91E-20	8.48E-26	2.27E-01	3.71E-01	4.85E-01	9.00E-23	1.36E-03
110	1.33E+00	6.39E-39	2.23E-88	3.59E-38	1.34E-13	1.29E-07	5.93E-10	9.40E-15	1.62E-10	1.04E-32	9.79E+01	5.00E-05	1.28E-09	9.31E-01	7.19E-20	1.46E-25	2.52E-01	4.04E-01	5.18E-01	2.11E-22	1.59E-03
115	1.56E+00	1.59E-38	2.03E-87	1.06E-37	1.91E-13	1.45E-07	8.76E-10	1.35E-14	1.95E-10	2.47E-32	9.78E+01	6.33E-05	1.48E-09	8.84E-01	1.05E-19	2.47E-25	2.79E-01	4.38E-01	5.52E-01	4.94E-22	1.85E-03
120	1.84E+00	3.92E-38	1.77E-86	3.10E-37	2.72E-13	1.62E-07	1.30E-09	1.94E-14	2.33E-10	5.89E-32	9.78E+01	8.05E-05	1.69E-09	8.39E-01	1.52E-19	4.13E-25	3.08E-01	4.75E-01	5.87E-01	1.16E-21	2.15E-03

Al - HL Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.18E-02	2.20E-50	2.64E-112	1.11E-48	2.56E-17	3.46E-09	2.76E-13	1.23E-18	5.20E-13	4.76E-41	9.83E+01	4.79E-08	8.17E-12	1.55E+00	7.61E-25	3.41E-32	2.26E-02	5.65E-02	1.14E-01	7.17E-30
25	2.95E-02	1.94E-49	1.46E-110	5.99E-48	4.70E-17	4.71E-09	4.33E-13	2.32E-18	8.32E-13	1.82E-40	9.82E+01	8.31E-08	1.28E-11	1.53E+00	2.04E-24	1.13E-31	2.71E-02	6.56E-02	1.28E-01	2.03E-29
30	3.95E-02	1.56E-48	7.12E-109	3.06E-47	8.47E-17	6.33E-09	6.79E-13	4.30E-18	1.31E-12	6.62E-40	9.82E+01	1.41E-07	1.97E-11	1.51E+00	5.18E-24	3.57E-31	3.22E-02	7.55E-02	1.43E-01	5.74E-29
35	5.23E-02	1.15E-47	3.09E-107	1.49E-46	1.50E-16	8.38E-09	1.07E-12	7.82E-18	2.01E-12	2.31E-39	9.82E+01	2.34E-07	2.96E-11	1.49E+00	1.25E-23	1.08E-30	3.81E-02	8.66E-02	1.59E-01	1.61E-28
40	6.87E-02	7.76E-47	1.20E-105	6.89E-46	2.61E-16	1.10E-08	1.68E-12	1.40E-17	3.04E-12	7.77E-39	9.82E+01	3.81E-07	4.35E-11	1.45E+00	2.91E-23	3.14E-30	4.48E-02	9.87E-02	1.76E-01	4.51E-28
45	8.92E-02	4.85E-46	4.15E-104	3.06E-45	4.48E-16	1.42E-08	2.63E-12	2.47E-17	4.51E-12	2.53E-38	9.82E+01	6.09E-07	6.27E-11	1.42E+00	6.45E-23	8.75E-30	5.22E-02	1.12E-01	1.94E-01	1.26E-27
50	1.15E-01	2.81E-45	1.30E-102	1.31E-44	7.56E-16	1.81E-08	4.13E-12	4.30E-17	6.58E-12	7.99E-38	9.82E+01	9.56E-07	8.85E-11	1.38E+00	1.38E-22	2.34E-29	6.06E-02	1.26E-01	2.13E-01	3.48E-27
55	1.46E-01	1.52E-44	3.66E-101	5.39E-44	1.26E-15	2.30E-08	6.48E-12	7.38E-17	9.47E-12	2.46E-37	9.82E+01	1.48E-06	1.23E-10	1.34E+00	2.84E-22	6.05E-29	7.00E-02	1.42E-01	2.33E-01	9.57E-27
60	1.85E-01	7.68E-44	9.38E-100	2.15E-43	2.06E-15	2.87E-08	1.02E-11	1.25E-16	1.34E-11	7.36E-37	9.82E+01	2.25E-06	1.68E-10	1.30E+00	5.64E-22	1.51E-28	8.04E-02	1.59E-01	2.55E-01	2.62E-26
65	2.33E-01	3.65E-43	2.19E-98	8.32E-43	3.34E-15	3.57E-08	1.59E-11	2.08E-16	1.87E-11	2.16E-36	9.82E+01	3.38E-06	2.25E-10	1.25E+00	1.09E-21	3.62E-28	9.19E-02	1.77E-01	2.77E-01	7.11E-26
70	2.90E-01	1.64E-42	4.71E-97	3.14E-42	5.36E-15	4.39E-08	2.49E-11	3.43E-16	2.58E-11	6.20E-36	9.82E+01	5.02E-06	2.98E-10	1.20E+00	2.04E-21	8.45E-28	1.05E-01	1.97E-01	3.01E-01	1.92E-25
75	3.58E-01	7.06E-42	9.35E-96	1.16E-41	8.49E-15	5.38E-08	3.91E-11	5.60E-16	3.51E-11	1.76E-35	9.82E+01	7.39E-06	3.89E-10	1.16E+00	3.74E-21	1.92E-27	1.19E-01	2.18E-01	3.26E-01	5.19E-25
80	4.40E-01	2.92E-41	1.73E-94	4.18E-41	1.34E-14	6.54E-08	6.12E-11	9.04E-16	4.74E-11	4.91E-35	9.82E+01	1.08E-05	5.03E-10	1.11E+00	6.73E-21	4.24E-27	1.34E-01	2.41E-01	3.51E-01	1.40E-24
85	5.37E-01	1.17E-40	3.02E-93	1.49E-40	2.09E-14	7.94E-08	9.62E-11	1.45E-15	6.33E-11	1.37E-34	9.81E+01	1.58E-05	6.45E-10	1.06E+00	1.19E-20	9.19E-27	1.51E-01	2.65E-01	3.79E-01	3.76E-24
90	6.51E-01	4.59E-40	5.00E-92	5.27E-40	3.25E-14	9.62E-08	1.52E-10	2.31E-15	8.42E-11	3.79E-34	9.81E+01	2.31E-05	8.21E-10	1.01E+00	2.09E-20	1.95E-26	1.69E-01	2.91E-01	4.07E-01	1.02E-23
95	7.84E-01	1.78E-39	7.95E-91	1.85E-39	5.04E-14	1.17E-07	2.40E-10	3.66E-15	1.11E-10	1.05E-33	9.81E+01	3.39E-05	1.04E-09	9.63E-01	3.63E-20	4.10E-26	1.89E-01	3.18E-01	4.36E-01	2.76E-23
100	9.40E-01	6.89E-39	1.22E-89	6.52E-39	7.80E-14	1.41E-07	3.82E-10	5.79E-15	1.47E-10	2.93E-33	9.81E+01	5.02E-05	1.31E-09	9.16E-01	6.30E-20	8.51E-26	2.11E-01	3.47E-01	4.67E-01	7.55E-23
105	1.12E+00	2.15E-39	1.48E-89	8.35E-39	7.42E-14	1.05E-07	3.71E-10	5.56E-15	1.18E-10	3.00E-33	9.80E+01	2.73E-05	1.01E-09	8.80E-01	4.04E-20	6.48E-26	2.34E-01	3.79E-01	5.00E-01	7.68E-23
110	1.33E+00	5.51E-39	1.41E-88	2.48E-38	1.06E-13	1.18E-07	5.49E-10	8.05E-15	1.42E-10	7.15E-33	9.80E+01	3.46E-05	1.17E-09	8.37E-01	5.95E-20	1.12E-25	2.60E-01	4.12E-01	5.33E-01	1.81E-22
115	1.56E+00	1.38E-38	1.28E-87	7.29E-38	1.51E-13	1.32E-07	8.12E-10	1.16E-14	1.71E-10	1.70E-32	9.79E+01	4.39E-05	1.35E-09	7.94E-01	8.70E-20	1.90E-25	2.88E-01	4.47E-01	5.68E-01	4.24E-22
120	1.84E+00	3.42E-38	1.11E-86	2.14E-37	2.15E-13	1.48E-07	1.20E-09	1.65E-14	2.04E-10	4.07E-32	9.78E+01	5.58E-05	1.54E-09	7.53E-01	1.27E-19	3.18E-25	3.18E-01	4.84E-01	6.04E-01	9.96E-22

Cr Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.17E-02	4.17E-51	5.25E-113	3.76E-49	1.30E-17	2.45E-09	1.82E-13	8.23E-19	1.97E-13	1.61E-41	9.83E+01	2.64E-08	3.09E-12	1.56E+00	1.08E-25	4.86E-33	2.10E-02	5.33E-02	1.05E-01	3.11E-30	6.74E-05
25	2.94E-02	3.75E-50	2.97E-111	2.09E-48	2.40E-17	3.34E-09	2.86E-13	1.55E-18	3.15E-13	6.32E-41	9.82E+01	4.55E-08	4.87E-12	1.55E+00	2.92E-25	1.62E-32	2.52E-02	6.18E-02	1.18E-01	8.86E-30	9.04E-05
30	3.94E-02	3.10E-49	1.50E-109	1.10E-47	4.34E-17	4.50E-09	4.51E-13	2.89E-18	4.96E-13	2.37E-40	9.82E+01	7.72E-08	7.50E-12	1.53E+00	7.47E-25	5.16E-32	3.00E-02	7.13E-02	1.32E-01	2.52E-29	1.20E-04
35	5.22E-02	2.36E-48	6.84E-108	5.54E-47	7.74E-17	5.99E-09	7.11E-13	5.31E-18	7.68E-13	8.59E-40	9.82E+01	1.29E-07	1.13E-11	1.50E+00	1.83E-24	1.58E-31	3.54E-02	8.17E-02	1.47E-01	7.15E-29	1.57E-04
40	6.85E-02	1.66E-47	2.79E-106	2.66E-46	1.36E-16	7.88E-09	1.12E-12	9.61E-18	1.17E-12	2.99E-39	9.82E+01	2.11E-07	1.67E-11	1.47E+00	4.29E-24	4.64E-31	4.16E-02	9.31E-02	1.62E-01	2.02E-28	2.03E-04
45	8.90E-02	1.09E-46	1.03E-104	1.22E-45	2.34E-16	1.03E-08	1.78E-12	1.72E-17	1.75E-12	1.01E-38	9.82E+01	3.40E-07	2.43E-11	1.43E+00	9.67E-24	1.31E-30	4.86E-02	1.06E-01	1.79E-01	5.72E-28	2.59E-04
50	1.15E-01	6.66E-46	3.48E-103	5.42E-45	3.99E-16	1.32E-08	2.81E-12	3.02E-17	2.58E-12	3.31E-38	9.82E+01	5.40E-07	3.46E-11	1.40E+00	2.10E-23	3.59E-30	5.64E-02	1.19E-01	1.97E-01	1.61E-27	3.29E-04
55	1.46E-01	3.82E-45	1.06E-101	2.32E-44	6.70E-16	1.69E-08	4.46E-12	5.26E-17	3.75E-12	1.05E-37	9.82E+01	8.46E-07	4.85E-11	1.35E+00	4.41E-23	9.45E-30	6.51E-02	1.34E-01	2.16E-01	4.52E-27	4.12E-04
60	1.85E-01	2.06E-44	2.98E-100	9.59E-44	1.11E-15	2.14E-08	7.07E-12	9.06E-17	5.37E-12	3.27E-37	9.82E+01	1.31E-06	6.69E-11	1.31E+00	8.98E-23	2.41E-29	7.48E-02	1.50E-01	2.35E-01	1.26E-26	5.13E-04
65	2.32E-01	1.05E-43	7.67E-99	3.84E-43	1.83E-15	2.69E-08	1.12E-11	1.54E-16	7.59E-12	9.94E-37	9.82E+01	2.00E-06	9.10E-11	1.26E+00	1.78E-22	5.94E-29	8.55E-02	1.67E-01	2.56E-01	3.51E-26	6.33E-04
70	2.89E-01	5.06E-43	1.82E-97	1.50E-42	2.96E-15	3.35E-08	1.78E-11	2.59E-16	1.06E-11	2.96E-36	9.82E+01	3.03E-06	1.22E-10	1.22E+00	3.42E-22	1.42E-28	9.74E-02	1.86E-01	2.78E-01	9.74E-26	7.75E-04
75	3.57E-01	2.33E-42	4.00E-96	5.70E-42	4.75E-15	4.14E-08	2.82E-11	4.31E-16	1.46E-11	8.64E-36	9.82E+01	4.56E-06	1.61E-10	1.17E+00	6.42E-22	3.31E-28	1.10E-01	2.06E-01	3.01E-01	2.69E-25	9.41E-04
80	4.39E-01	1.03E-41	8.18E-95	2.13E-41	7.57E-15	5.10E-08	4.47E-11	7.10E-16	2.00E-11	2.50E-35	9.82E+01	6.82E-06	2.11E-10	1.12E+00	1.18E-21	7.53E-28	1.25E-01	2.27E-01	3.25E-01	7.43E-25	1.14E-03
85	5.36E-01	4.42E-41	1.57E-93	7.89E-41	1.20E-14	6.25E-08	7.11E-11	1.16E-15	2.70E-11	7.22E-35	9.82E+01	1.02E-05	2.74E-10	1.07E+00	2.15E-21	1.67E-27	1.40E-01	2.50E-01	3.50E-01	2.05E-24	1.36E-03
90	6.50E-01	1.85E-40	2.85E-92	2.89E-40	1.88E-14	7.65E-08	1.13E-10	1.88E-15	3.63E-11	2.07E-34	9.82E+01	1.52E-05	3.53E-10	1.02E+00	3.84E-21	3.64E-27	1.58E-01	2.75E-01	3.77E-01	5.66E-24	1.62E-03
95	7.83E-01	7.57E-40	4.94E-91	1.05E-39	2.94E-14	9.34E-08	1.81E-10	3.04E-15	4.86E-11	5.93E-34	9.81E+01	2.27E-05	4.51E-10	9.69E-01	6.82E-21	7.79E-27	1.76E-01	3.01E-01	4.04E-01	1.57E-23	1.92E-03
100	9.39E-01	3.07E-39	8.22E-90	3.79E-39	4.58E-14	1.14E-07	2.90E-10	4.89E-15	6.46E-11	1.71E-33	9.81E+01	3.41E-05	5.75E-10	9.20E-01	1.20E-20	1.65E-26	1.96E-01	3.29E-01	4.33E-01	4.37E-23	2.26E-03
105	1.12E+00	1.10E-39	1.19E-89	5.16E-39	4.51E-14	8.69E-08	2.90E-10	4.88E-15	5.33E-11	1.85E-33	9.81E+01	1.94E-05	4.54E-10	8.90E-01	8.19E-21	1.33E-26	2.19E-01	3.58E-01	4.63E-01	4.70E-23	2.69E-03
110	1.32E+00	2.95E-39	1.24E-88	1.57E-38	6.48E-14	9.82E-08	4.33E-10	7.19E-15	6.50E-11	4.53E-33	9.80E+01	2.50E-05	5.31E-10	8.45E-01	1.23E-20	2.34E-26	2.42E-01	3.90E-01	4.94E-01	1.12E-22	3.15E-03
115	1.56E+00	7.66E-39	1.21E-87	4.74E-38	9.27E-14	1.11E-07	6.45E-10	1.05E-14	7.86E-11	1.11E-32	9.80E+01	3.20E-05	6.15E-10	8.01E-01	1.81E-20	4.03E-26	2.68E-01	4.23E-01	5.27E-01	2.67E-22	3.67E-03
120	1.83E+00	1.94E-38	1.11E-86	1.42E-37	1.32E-13	1.24E-07	9.59E-10	1.52E-14	9.44E-11	2.70E-32	9.79E+01	4.09E-05	7.08E-10	7.59E-01	2.66E-20	6.80E-26	2.96E-01	4.59E-01	5.60E-01	6.32E-22	4.26E-03

Bi Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.21E-02	1.32E-46	5.78E-110	1.63E-47	7.67E-17	9.76E-09	1.36E-12	2.65E-18	3.32E-12	7.07E-40	9.77E+01	4.66E-07	5.10E-11	2.07E+00	3.01E-23	1.41E-30	2.18E-02	5.36E-02	1.14E-01	1.77E-28	2.45E-05
25	2.99E-02	1.18E-45	3.31E-108	8.77E-47	1.41E-16	1.34E-08	2.14E-12	5.05E-18	5.34E-12	2.69E-39	9.77E+01	8.31E-07	8.06E-11	2.05E+00	8.14E-23	4.73E-30	2.62E-02	6.21E-02	1.28E-01	5.06E-28	3.29E-05
30	4.01E-02	9.39E-45	1.64E-106	4.42E-46	2.54E-16	1.80E-08	3.37E-12	9.42E-18	8.38E-12	9.64E-39	9.77E+01	1.43E-06	1.24E-10	2.03E+00	2.07E-22	1.50E-29	3.12E-02	7.16E-02	1.44E-01	1.43E-27	4.36E-05
35	5.31E-02	6.67E-44	7.11E-105	2.10E-45	4.48E-16	2.38E-08	5.26E-12	1.72E-17	1.28E-11	3.29E-38	9.77E+01	2.38E-06	1.85E-10	2.00E+00	4.99E-22	4.49E-29	3.68E-02	8.21E-02	1.60E-01	3.99E-27	5.71E-05
40	6.97E-02	4.27E-43	2.70E-103	9.43E-45	7.72E-16	3.09E-08	8.20E-12	3.09E-17	1.93E-11	1.07E-37	9.77E+01	3.86E-06	2.70E-10	1.96E+00	1.14E-21	1.28E-28	4.33E-02	9.36E-02	1.77E-01	1.10E-26	7.40E-05
45	9.05E-02	2.47E-42	8.99E-102	4.04E-44	1.30E-15	3.95E-08	1.27E-11	5.43E-17	2.82E-11	3.37E-37	9.77E+01	6.09E-06	3.84E-10	1.92E+00	2.46E-21	3.48E-28	5.05E-02	1.06E-01	1.95E-01	2.98E-26	9.47E-05
50	1.16E-01	1.30E-41	2.64E-100	1.65E-43	2.16E-15	4.97E-08	1.96E-11	9.37E-17	4.05E-11	1.02E-36	9.77E+01	9.33E-06	5.34E-10	1.87E+00	5.08E-21	8.99E-28	5.87E-02	1.20E-01	2.15E-01	7.95E-26	1.20E-04
55	1.48E-01	6.21E-41	6.89E-99	6.44E-43	3.50E-15	6.16E-08	3.01E-11	1.59E-16	5.70E-11	2.96E-36	9.77E+01	1.39E-05	7.25E-10	1.82E+00	1.00E-20	2.22E-27	6.77E-02	1.35E-01	2.35E-01	2.09E-25	1.51E-04
60	1.88E-01	2.71E-40	1.60E-97	2.41E-42	5.58E-15	7.51E-08	4.60E-11	2.64E-16	7.85E-11	8.33E-36	9.78E+01	2.03E-05	9.63E-10	1.76E+00	1.89E-20	5.23E-27	7.78E-02	1.51E-01	2.57E-01	5.42E-25	1.88E-04
65	2.36E-01	1.09E-39	3.31E-96	8.70E-42	8.73E-15	9.05E-08	6.98E-11	4.33E-16	1.06E-10	2.27E-35	9.78E+01	2.88E-05	1.25E-09	1.70E+00	3.42E-20	1.18E-26	8.90E-02	1.68E-01	2.79E-01	1.38E-24	2.32E-04
70	2.93E-01	4.08E-39	6.24E-95	3.04E-41	1.35E-14	1.08E-07	1.06E-10	6.99E-16	1.41E-10	6.07E-35	9.78E+01	4.03E-05	1.60E-09	1.64E+00	5.99E-20	2.57E-26	1.01E-01	1.87E-01	3.03E-01	3.49E-24	2.84E-04
75	3.63E-01	1.45E-38	1.09E-93	1.04E-40	2.06E-14	1.27E-07	1.60E-10	1.12E-15	1.86E-10	1.59E-34	9.78E+01	5.56E-05	2.02E-09	1.58E+00	1.02E-19	5.42E-26	1.15E-01	2.07E-01	3.28E-01	8.76E-24	3.45E-04
80	4.45E-01	4.94E-38	1.76E-92	3.48E-40	3.11E-14	1.50E-07	2.41E-10	1.76E-15	2.41E-10	4.12E-34	9.78E+01	7.62E-05	2.52E-09	1.51E+00	1.71E-19	1.11E-25	1.30E-01	2.29E-01	3.55E-01	2.19E-23	4.17E-04
85	5.43E-01	1.63E-37	2.71E-91	1.15E-39	4.68E-14	1.75E-07	3.65E-10	2.77E-15	3.11E-10	1.06E-33	9.78E+01	1.04E-04	3.12E-09	1.45E+00	2.81E-19	2.24E-25	1.46E-01	2.52E-01	3.82E-01	5.49E-23	5.00E-04
90	6.58E-01	5.31E-37	3.98E-90	3.76E-39	7.01E-14	2.05E-07	5.56E-10	4.34E-15	3.99E-10	2.72E-33	9.78E+01	1.43E-04	3.83E-09	1.39E+00	4.59E-19	4.44E-25	1.64E-01	2.77E-01	4.11E-01	1.38E-22	5.97E-04
95	7.92E-01	1.72E-36	5.66E-89	1.23E-38	1.05E-13	2.40E-07	8.49E-10	6.76E-15	5.10E-10	7.01E-33	9.77E+01	1.96E-04	4.69E-09	1.32E+00	7.44E-19	8.68E-25	1.84E-01	3.03E-01	4.41E-01	3.49E-22	7.08E-04
100	9.49E-01	5.56E-36	7.85E-88	4.01E-38	1.57E-13	2.82E-07	1.31E-09	1.05E-14	6.50E-10	1.82E-32	9.77E+01	2.72E-04	5.73E-09	1.26E+00	1.21E-18	1.68E-24	2.05E-01	3.31E-01	4.73E-01	8.93E-22	8.36E-04
105	1.13E+00	2.00E-36	1.18E-87	5.41E-38	1.52E-13	2.14E-07	1.30E-09	1.06E-14	5.34E-10	1.96E-32	9.77E+01	1.58E-04	4.51E-09	1.21E+00	8.18E-19	1.35E-24	2.28E-01	3.61E-01	5.06E-01	9.59E-22	9.88E-04
110	1.34E+00	4.60E-36	1.10E-86	1.53E-37	2.13E-13	2.36E-07	1.89E-09	1.53E-14	6.33E-10	4.46E-32	9.77E+01	1.94E-04	5.13E-09	1.15E+00	1.16E-18	2.24E-24	2.53E-01	3.93E-01	5.40E-01	2.17E-21	1.16E-03
115	1.58E+00	1.05E-35	9.87E-86	4.33E-37	2.97E-13	2.60E-07	2.75E-09	2.21E-14	7.46E-10	1.02E-31	9.76E+01	2.39E-04	5.80E-09	1.09E+00	1.63E-18	3.66E-24	2.80E-01	4.27E-01	5.75E-01	4.90E-21	1.35E-03
120	1.85E+00	2.36E-35	8.59E-85	1.22E-36	4.14E-13	2.87E-07	4.00E-09	3.18E-14	8.76E-10	2.33E-31	9.76E+01	2.95E-04	6.54E-09	1.04E+00	2.29E-18	5.92E-24	3.09E-01	4.63E-01	6.13E-01	1.11E-20	1.57E-03

F Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.16E-02	3.84E-50	4.33E-114	2.65E-49	9.54E-18	1.18E-09	3.13E-13	4.35E-19	7.99E-14	1.13E-41	9.85E+01	1.88E-08	1.25E-12	1.27E+00	1.76E-26	7.96E-34	2.25E-02	5.66E-02	1.13E-01	9.13E-30	2.12E-05
25	2.92E-02	3.57E-49	2.60E-112	1.48E-48	1.77E-17	1.62E-09	4.94E-13	8.30E-19	1.29E-13	4.47E-41	9.85E+01	3.27E-08	1.98E-12	1.26E+00	4.78E-26	2.67E-33	2.70E-02	6.56E-02	1.27E-01	2.62E-29	2.84E-05
30	3.91E-02	3.05E-48	1.41E-110	7.89E-48	3.22E-17	2.19E-09	7.81E-13	1.57E-18	2.03E-13	1.69E-40	9.85E+01	5.59E-08	3.06E-12	1.24E+00	1.24E-25	8.60E-33	3.22E-02	7.56E-02	1.42E-01	7.51E-29	3.76E-05
35	5.19E-02	2.40E-47	6.89E-109	4.01E-47	5.77E-17	2.93E-09	1.24E-12	2.92E-18	3.16E-13	6.18E-40	9.85E+01	9.41E-08	4.64E-12	1.22E+00	3.05E-25	2.66E-32	3.80E-02	8.67E-02	1.58E-01	2.15E-28	4.92E-05
40	6.80E-02	1.75E-46	3.06E-107	1.94E-46	1.02E-16	3.88E-09	1.97E-12	5.37E-18	4.84E-13	2.18E-39	9.85E+01	1.56E-07	6.90E-12	1.19E+00	7.24E-25	7.90E-32	4.46E-02	9.88E-02	1.75E-01	6.15E-28	6.35E-05
45	8.84E-02	1.19E-45	1.25E-105	9.05E-46	1.77E-16	5.08E-09	3.13E-12	9.77E-18	7.28E-13	7.43E-39	9.85E+01	2.54E-07	1.01E-11	1.16E+00	1.65E-24	2.26E-31	5.21E-02	1.12E-01	1.93E-01	1.76E-27	8.12E-05
50	1.14E-01	7.60E-45	4.64E-104	4.05E-45	3.04E-16	6.58E-09	4.98E-12	1.76E-17	1.08E-12	2.46E-38	9.85E+01	4.10E-07	1.44E-11	1.13E+00	3.63E-24	6.25E-31	6.04E-02	1.26E-01	2.12E-01	5.01E-27	1.03E-04
55	1.45E-01	4.55E-44	1.59E-102	1.75E-44	5.15E-16	8.46E-09	7.94E-12	3.14E-17	1.58E-12	7.92E-38	9.85E+01	6.52E-07	2.04E-11	1.10E+00	7.73E-24	1.67E-30	6.98E-02	1.42E-01	2.32E-01	1.42E-26	1.29E-04
60	1.84E-01	2.56E-43	5.00E-101	7.31E-44	8.62E-16	1.08E-08	1.27E-11	5.53E-17	2.28E-12	2.49E-37	9.84E+01	1.02E-06	2.83E-11	1.06E+00	1.60E-23	4.31E-30	8.01E-02	1.59E-01	2.53E-01	4.03E-26	1.60E-04
65	2.31E-01	1.36E-42	1.45E-99	2.96E-43	1.43E-15	1.36E-08	2.02E-11	9.66E-17	3.24E-12	7.62E-37	9.84E+01	1.59E-06	3.87E-11	1.02E+00	3.20E-23	1.08E-29	9.16E-02	1.77E-01	2.76E-01	1.14E-25	1.97E-04
70	2.87E-01	6.83E-42	3.92E-98	1.16E-42	2.33E-15	1.71E-08	3.23E-11	1.67E-16	4.56E-12	2.28E-36	9.84E+01	2.45E-06	5.22E-11	9.82E-01	6.23E-23	2.62E-29	1.04E-01	1.97E-01	2.99E-01	3.20E-25	2.40E-04
75	3.56E-01	3.27E-41	9.83E-97	4.45E-42	3.77E-15	2.12E-08	5.15E-11	2.86E-16	6.33E-12	6.72E-36	9.84E+01	3.73E-06	6.95E-11	9.42E-01	1.19E-22	6.18E-29	1.18E-01	2.18E-01	3.23E-01	8.94E-25	2.91E-04
80	4.37E-01	1.49E-40	2.30E-95	1.66E-41	6.05E-15	2.63E-08	8.21E-11	4.87E-16	8.69E-12	1.94E-35	9.84E+01	5.65E-06	9.15E-11	9.01E-01	2.21E-22	1.42E-28	1.33E-01	2.40E-01	3.49E-01	2.49E-24	3.50E-04
85	5.33E-01	6.55E-40	5.07E-94	6.09E-41	9.61E-15	3.23E-08	1.31E-10	8.21E-16	1.18E-11	5.55E-35	9.83E+01	8.50E-06	1.19E-10	8.61E-01	4.04E-22	3.18E-28	1.50E-01	2.64E-01	3.76E-01	6.93E-24	4.19E-04
90	6.47E-01	2.79E-39	1.06E-92	2.20E-40	1.51E-14	3.96E-08	2.09E-10	1.38E-15	1.59E-11	1.57E-34	9.83E+01	1.28E-05	1.54E-10	8.20E-01	7.28E-22	6.97E-28	1.68E-01	2.90E-01	4.04E-01	1.92E-23	4.98E-04
95	7.80E-01	1.16E-38	2.10E-91	7.85E-40	2.38E-14	4.84E-08	3.35E-10	2.30E-15	2.14E-11	4.43E-34	9.83E+01	1.91E-05	1.97E-10	7.81E-01	1.30E-21	1.50E-27	1.88E-01	3.18E-01	4.33E-01	5.35E-23	5.89E-04
100	9.35E-01	3.73E-38	3.15E-90	2.54E-39	3.54E-14	5.64E-08	5.13E-10	3.64E-15	2.72E-11	1.14E-33	9.82E+01	2.62E-05	2.40E-10	7.43E-01	2.09E-21	2.90E-27	2.10E-01	3.47E-01	4.64E-01	1.36E-22	6.93E-04
105	1.11E+00	1.85E-38	7.26E-90	3.88E-39	3.74E-14	4.58E-08	5.47E-10	4.01E-15	2.39E-11	1.39E-33	9.82E+01	1.69E-05	2.02E-10	7.19E-01	1.62E-21	2.67E-27	2.33E-01	3.78E-01	4.96E-01	1.66E-22	8.28E-04
110	1.32E+00	5.06E-38	8.82E-89	1.17E-38	5.40E-14	5.19E-08	8.18E-10	6.13E-15	2.93E-11	3.37E-33	9.81E+01	2.20E-05	2.37E-10	6.83E-01	2.44E-21	4.72E-27	2.59E-01	4.11E-01	5.29E-01	3.99E-22	9.67E-04
115	1.56E+00	1.33E-37	1.01E-87	3.50E-38	7.74E-14	5.84E-08	1.22E-09	9.30E-15	3.55E-11	8.13E-33	9.81E+01	2.83E-05	2.75E-10	6.47E-01	3.62E-21	8.17E-27	2.86E-01	4.46E-01	5.64E-01	9.52E-22	1.13E-03
120	1.83E+00	3.39E-37	1.09E-86	1.03E-37	1.10E-13	6.55E-08	1.81E-09	1.40E-14	4.27E-11	1.96E-32	9.80E+01	3.63E-05	3.17E-10	6.12E-01	5.32E-21	1.38E-26	3.16E-01	4.83E-01	5.99E-01	2.25E-21	1.30E-03

Extreme F and Oxalate Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.18E-02	2.33E-50	1.40E-113	3.77E-49	1.44E-17	1.66E-09	2.75E-13	5.80E-19	1.51E-13	1.63E-41	9.87E+01	4.50E-08	2.35E-12	1.12E+00	6.33E-26	2.86E-33	2.22E-02	5.58E-02	1.12E-01	7.09E-30	2.46E-05
25	2.95E-02	2.34E-49	8.83E-112	2.16E-48	2.71E-17	2.32E-09	4.40E-13	1.12E-18	2.47E-13	6.58E-41	9.87E+01	8.11E-08	3.79E-12	1.11E+00	1.77E-25	9.93E-33	2.66E-02	6.47E-02	1.26E-01	2.10E-29	3.31E-05
30	3.95E-02	2.11E-48	4.87E-110	1.17E-47	4.99E-17	3.17E-09	7.04E-13	2.11E-18	3.95E-13	2.54E-40	9.87E+01	1.42E-07	5.94E-12	1.10E+00	4.70E-25	3.28E-32	3.16E-02	7.45E-02	1.41E-01	6.18E-29	4.39E-05
35	5.24E-02	1.74E-47	2.37E-108	6.01E-47	9.02E-17	4.29E-09	1.13E-12	3.93E-18	6.20E-13	9.39E-40	9.86E+01	2.44E-07	9.10E-12	1.08E+00	1.18E-24	1.03E-31	3.74E-02	8.54E-02	1.56E-01	1.80E-28	5.74E-05
40	6.87E-02	1.30E-46	1.02E-106	2.94E-46	1.60E-16	5.71E-09	1.80E-12	7.17E-18	9.55E-13	3.33E-39	9.86E+01	4.09E-07	1.36E-11	1.06E+00	2.85E-24	3.11E-31	4.39E-02	9.73E-02	1.73E-01	5.23E-28	7.43E-05
45	8.93E-02	8.96E-46	3.95E-105	1.38E-45	2.79E-16	7.51E-09	2.88E-12	1.29E-17	1.44E-12	1.14E-38	9.86E+01	6.73E-07	2.00E-11	1.03E+00	6.55E-24	8.97E-31	5.12E-02	1.10E-01	1.91E-01	1.51E-27	9.51E-05
50	1.15E-01	5.70E-45	1.37E-103	6.18E-45	4.79E-16	9.75E-09	4.60E-12	2.29E-17	2.14E-12	3.79E-38	9.86E+01	1.08E-06	2.87E-11	1.01E+00	1.45E-23	2.49E-30	5.95E-02	1.25E-01	2.10E-01	4.31E-27	1.21E-04
55	1.47E-01	3.37E-44	4.26E-102	2.67E-44	8.11E-16	1.25E-08	7.33E-12	3.99E-17	3.13E-12	1.22E-37	9.86E+01	1.72E-06	4.04E-11	9.78E-01	3.07E-23	6.63E-30	6.86E-02	1.40E-01	2.30E-01	1.22E-26	1.51E-04
60	1.86E-01	1.85E-43	1.20E-100	1.11E-43	1.35E-15	1.59E-08	1.17E-11	6.87E-17	4.51E-12	3.82E-37	9.86E+01	2.68E-06	5.60E-11	9.48E-01	6.31E-23	1.71E-29	7.88E-02	1.57E-01	2.51E-01	3.45E-26	1.88E-04
65	2.33E-01	9.55E-43	3.08E-99	4.48E-43	2.22E-15	2.00E-08	1.85E-11	1.17E-16	6.39E-12	1.17E-36	9.85E+01	4.12E-06	7.63E-11	9.15E-01	1.25E-22	4.23E-29	9.01E-02	1.75E-01	2.73E-01	9.65E-26	2.32E-04
70	2.90E-01	4.63E-42	7.23E-98	1.75E-42	3.61E-15	2.50E-08	2.94E-11	1.96E-16	8.93E-12	3.48E-36	9.85E+01	6.24E-06	1.02E-10	8.82E-01	2.42E-22	1.02E-28	1.03E-01	1.94E-01	2.96E-01	2.68E-25	2.84E-04
75	3.59E-01	2.13E-41	1.56E-96	6.68E-42	5.80E-15	3.09E-08	4.66E-11	3.24E-16	1.23E-11	1.02E-35	9.85E+01	9.36E-06	1.36E-10	8.47E-01	4.55E-22	2.37E-28	1.16E-01	2.15E-01	3.21E-01	7.41E-25	3.45E-04
80	4.41E-01	9.34E-41	3.11E-95	2.49E-41	9.23E-15	3.80E-08	7.39E-11	5.31E-16	1.68E-11	2.94E-35	9.85E+01	1.39E-05	1.77E-10	8.13E-01	8.38E-22	5.36E-28	1.31E-01	2.37E-01	3.46E-01	2.04E-24	4.16E-04
85	5.38E-01	3.94E-40	5.81E-94	9.11E-41	1.46E-14	4.65E-08	1.17E-10	8.63E-16	2.27E-11	8.38E-35	9.84E+01	2.05E-05	2.30E-10	7.78E-01	1.51E-21	1.19E-27	1.48E-01	2.61E-01	3.73E-01	5.59E-24	4.99E-04
90	6.52E-01	1.62E-39	1.02E-92	3.29E-40	2.28E-14	5.67E-08	1.86E-10	1.39E-15	3.05E-11	2.37E-34	9.84E+01	3.03E-05	2.95E-10	7.43E-01	2.70E-21	2.57E-27	1.66E-01	2.86E-01	4.01E-01	1.53E-23	5.94E-04
95	7.86E-01	6.51E-39	1.71E-91	1.17E-39	3.56E-14	6.91E-08	2.96E-10	2.23E-15	4.06E-11	6.69E-34	9.84E+01	4.46E-05	3.76E-10	7.09E-01	4.76E-21	5.47E-27	1.85E-01	3.14E-01	4.30E-01	4.22E-23	7.04E-04
100	9.42E-01	2.60E-38	2.75E-90	4.18E-39	5.53E-14	8.42E-08	4.74E-10	3.56E-15	5.40E-11	1.89E-33	9.83E+01	6.60E-05	4.78E-10	6.75E-01	8.36E-21	1.15E-26	2.07E-01	3.42E-01	4.60E-01	1.17E-22	8.31E-04
105	1.12E+00	9.03E-39	3.73E-90	5.66E-39	5.40E-14	6.36E-08	4.71E-10	3.50E-15	4.42E-11	2.04E-33	9.83E+01	3.72E-05	3.75E-10	6.50E-01	5.61E-21	9.16E-27	2.30E-01	3.74E-01	4.92E-01	1.24E-22	9.87E-04
110	1.33E+00	2.38E-38	3.70E-89	1.72E-38	7.75E-14	7.16E-08	7.00E-10	5.10E-15	5.38E-11	4.99E-33	9.82E+01	4.74E-05	4.37E-10	6.18E-01	8.35E-21	1.60E-26	2.55E-01	4.06E-01	5.25E-01	2.95E-22	1.15E-03
115	1.57E+00	6.11E-38	3.45E-88	5.19E-38	1.11E-13	8.04E-08	1.04E-09	7.37E-15	6.49E-11	1.22E-32	9.81E+01	6.01E-05	5.06E-10	5.87E-01	1.23E-20	2.75E-26	2.82E-01	4.41E-01	5.60E-01	6.98E-22	1.35E-03
120	1.84E+00	1.54E-37	3.05E-87	1.56E-37	1.57E-13	9.01E-08	1.54E-09	1.06E-14	7.78E-11	2.97E-32	9.81E+01	7.61E-05	5.82E-10	5.56E-01	1.80E-20	4.64E-26	3.11E-01	4.78E-01	5.95E-01	1.64E-21	1.56E-03

Fe-Al Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.12E-02	1.93E-52	1.00E-114	2.43E-50	4.38E-18	2.05E-09	1.15E-13	4.16E-19	3.26E-13	9.66E-43	9.31E+01	2.21E-09	5.23E-12	6.76E+00	3.04E-25	1.30E-32	2.09E-02	5.26E-02	1.05E-01	1.21E-30	8.78E-05
25	2.87E-02	2.34E-51	6.29E-113	1.22E-49	8.26E-18	2.85E-09	1.91E-13	7.93E-19	5.31E-13	3.42E-42	9.31E+01	4.01E-09	8.39E-12	6.67E+00	8.46E-25	4.48E-32	2.51E-02	6.10E-02	1.18E-01	3.86E-30	1.17E-04
30	3.84E-02	2.84E-50	3.85E-111	6.13E-49	1.56E-17	3.98E-09	3.24E-13	1.51E-18	8.67E-13	1.22E-41	9.32E+01	7.36E-09	1.34E-11	6.56E+00	2.32E-24	1.54E-31	2.99E-02	7.04E-02	1.32E-01	1.27E-29	1.55E-04
35	5.09E-02	3.11E-49	2.07E-109	2.96E-48	2.89E-17	5.45E-09	5.49E-13	2.84E-18	1.39E-12	4.25E-41	9.33E+01	1.31E-08	2.09E-11	6.49E+00	6.08E-24	5.07E-31	3.53E-02	8.06E-02	1.47E-01	4.15E-29	2.04E-04
40	6.68E-02	3.04E-48	9.70E-108	1.37E-47	5.22E-17	7.32E-09	9.23E-13	5.21E-18	2.20E-12	1.43E-40	9.33E+01	2.26E-08	3.20E-11	6.44E+00	1.52E-23	1.61E-30	4.14E-02	9.16E-02	1.63E-01	1.33E-28	2.66E-04
45	8.69E-02	2.65E-47	3.96E-106	6.08E-47	9.25E-17	9.67E-09	1.54E-12	9.37E-18	3.41E-12	4.64E-40	9.33E+01	3.82E-08	4.77E-11	6.40E+00	3.64E-23	4.88E-30	4.82E-02	1.04E-01	1.79E-01	4.20E-28	3.45E-04
50	1.12E-01	2.22E-46	1.51E-104	2.66E-46	1.63E-16	1.28E-08	2.59E-12	1.67E-17	5.18E-12	1.50E-39	9.34E+01	6.47E-08	6.98E-11	6.24E+00	8.32E-23	1.41E-29	5.59E-02	1.17E-01	1.97E-01	1.33E-27	4.38E-04
55	1.42E-01	1.73E-45	5.18E-103	1.13E-45	2.84E-16	1.66E-08	4.36E-12	2.94E-17	7.75E-12	4.77E-39	9.35E+01	1.08E-07	1.00E-10	6.08E+00	1.84E-22	3.94E-29	6.46E-02	1.32E-01	2.16E-01	4.19E-27	5.51E-04
60	1.80E-01	1.14E-44	1.65E-101	4.85E-45	4.88E-16	2.15E-08	7.14E-12	5.14E-17	1.14E-11	1.54E-38	9.37E+01	1.77E-07	1.42E-10	5.89E+00	3.92E-22	1.06E-28	7.43E-02	1.48E-01	2.35E-01	1.25E-26	6.87E-04
65	2.26E-01	7.09E-44	4.90E-100	2.04E-44	8.29E-16	2.76E-08	1.17E-11	8.90E-17	1.66E-11	4.89E-38	9.38E+01	2.88E-07	1.97E-10	5.69E+00	8.14E-22	2.78E-28	8.50E-02	1.65E-01	2.56E-01	3.72E-26	8.48E-04
70	2.81E-01	4.22E-43	1.36E-98	8.43E-44	1.40E-15	3.51E-08	1.92E-11	1.53E-16	2.39E-11	1.54E-37	9.40E+01	4.63E-07	2.72E-10	5.47E+00	1.65E-21	7.06E-28	9.69E-02	1.83E-01	2.79E-01	1.10E-25	1.04E-03
75	3.47E-01	2.37E-42	3.50E-97	3.41E-43	2.32E-15	4.42E-08	3.15E-11	2.61E-16	3.39E-11	4.80E-37	9.41E+01	7.32E-07	3.68E-10	5.25E+00	3.24E-21	1.73E-27	1.10E-01	2.03E-01	3.02E-01	3.27E-25	1.26E-03
80	4.25E-01	8.24E-42	5.50E-96	1.13E-42	3.51E-15	5.11E-08	4.75E-11	4.07E-16	4.39E-11	1.23E-36	9.42E+01	9.70E-07	4.55E-10	5.07E+00	5.31E-21	3.53E-27	1.24E-01	2.24E-01	3.26E-01	8.14E-25	1.54E-03
85	5.18E-01	2.65E-41	7.94E-95	3.65E-42	5.25E-15	5.82E-08	7.13E-11	6.27E-16	5.59E-11	3.10E-36	9.44E+01	1.26E-06	5.52E-10	4.89E+00	8.41E-21	6.92E-27	1.40E-01	2.47E-01	3.51E-01	1.99E-24	1.85E-03
90	6.28E-01	7.97E-41	1.06E-93	1.14E-41	7.74E-15	6.55E-08	1.06E-10	9.57E-16	7.00E-11	7.62E-36	9.45E+01	1.59E-06	6.58E-10	4.71E+00	1.29E-20	1.30E-26	1.57E-01	2.71E-01	3.78E-01	4.81E-24	2.23E-03
95	7.55E-01	2.25E-40	1.32E-92	3.49E-41	1.12E-14	7.29E-08	1.57E-10	1.45E-15	8.63E-11	1.84E-35	9.46E+01	1.98E-06	7.73E-10	4.53E+00	1.93E-20	2.37E-26	1.76E-01	2.97E-01	4.06E-01	1.14E-23	2.66E-03
100	9.04E-01	5.97E-40	1.56E-91	1.04E-40	1.62E-14	8.01E-08	2.32E-10	2.18E-15	1.05E-10	4.35E-35	9.47E+01	2.41E-06	8.94E-10	4.35E+00	2.81E-20	4.17E-26	1.96E-01	3.25E-01	4.35E-01	2.67E-23	3.16E-03
105	1.08E+00	1.50E-39	1.75E-90	3.03E-40	2.30E-14	8.72E-08	3.39E-10	3.26E-15	1.26E-10	1.01E-34	9.48E+01	2.88E-06	1.02E-09	4.17E+00	3.99E-20	7.09E-26	2.18E-01	3.54E-01	4.65E-01	6.17E-23	3.73E-03
110	1.27E+00	3.60E-39	1.89E-89	8.67E-40	3.23E-14	9.41E-08	4.94E-10	4.88E-15	1.48E-10	2.33E-34	9.49E+01	3.40E-06	1.15E-09	3.99E+00	5.55E-20	1.17E-25	2.42E-01	3.85E-01	4.96E-01	1.41E-22	4.39E-03
115	1.50E+00	8.26E-39	2.00E-88	2.43E-39	4.50E-14	1.01E-07	7.17E-10	7.31E-15	1.73E-10	5.28E-34	9.50E+01	3.96E-06	1.28E-09	3.82E+00	7.58E-20	1.88E-25	2.68E-01	4.18E-01	5.29E-01	3.17E-22	5.15E-03
120	1.76E+00	1.82E-38	2.10E-87	6.73E-39	6.22E-14	1.07E-07	1.04E-09	1.10E-14	2.00E-10	1.19E-33	9.50E+01	4.55E-06	1.42E-09	3.65E+00	1.02E-19	2.93E-25	2.95E-01	4.53E-01	5.63E-01	7.07E-22	6.02E-03

PO4 Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.21E-02	6.21E-48	6.47E-113	4.33E-49	2.78E-17	2.93E-09	8.14E-13	6.23E-19	5.99E-13	1.85E-41	9.60E+01	3.80E-08	9.34E-12	3.83E+00	1.01E-24	4.58E-32	2.09E-02	5.28E-02	1.05E-01	6.31E-29	5.62E-05
25	2.99E-02	4.87E-47	3.68E-111	2.35E-48	5.22E-17	4.06E-09	1.23E-12	1.18E-18	9.65E-13	7.05E-41	9.60E+01	6.87E-08	1.48E-11	3.75E+00	2.75E-24	1.54E-31	2.51E-02	6.13E-02	1.18E-01	1.67E-28	7.48E-05
30	4.00E-02	3.80E-46	1.81E-109	1.18E-47	9.53E-17	5.51E-09	1.92E-12	2.18E-18	1.52E-12	2.53E-40	9.61E+01	1.19E-07	2.29E-11	3.69E+00	7.09E-24	4.93E-31	2.99E-02	7.07E-02	1.32E-01	4.63E-28	9.88E-05
35	5.30E-02	3.32E-45	7.67E-108	5.54E-47	1.69E-16	7.31E-09	3.14E-12	3.94E-18	2.35E-12	8.53E-40	9.61E+01	1.96E-07	3.45E-11	3.68E+00	1.73E-23	1.50E-30	3.54E-02	8.10E-02	1.47E-01	1.42E-27	1.31E-04
40	6.95E-02	2.46E-44	2.88E-106	2.48E-46	2.95E-16	9.58E-09	5.04E-12	7.01E-18	3.57E-12	2.77E-39	9.61E+01	3.18E-07	5.09E-11	3.63E+00	4.02E-23	4.39E-30	4.15E-02	9.23E-02	1.63E-01	4.14E-27	1.70E-04
45	9.02E-02	1.55E-43	9.58E-105	1.07E-45	5.09E-16	1.24E-08	7.94E-12	1.22E-17	5.31E-12	8.74E-39	9.61E+01	5.09E-07	7.35E-11	3.54E+00	8.96E-23	1.23E-29	4.85E-02	1.05E-01	1.80E-01	1.16E-26	2.18E-04
50	1.16E-01	9.01E-43	2.83E-103	4.41E-45	8.62E-16	1.59E-08	1.25E-11	2.10E-17	7.76E-12	2.66E-38	9.62E+01	7.98E-07	1.04E-10	3.45E+00	1.91E-22	3.29E-29	5.64E-02	1.18E-01	1.98E-01	3.20E-26	2.76E-04
55	1.48E-01	4.83E-42	7.41E-102	1.74E-44	1.44E-15	2.02E-08	1.95E-11	3.53E-17	1.11E-11	7.85E-38	9.62E+01	1.23E-06	1.44E-10	3.36E+00	3.92E-22	8.45E-29	6.51E-02	1.33E-01	2.16E-01	8.77E-26	3.47E-04
60	1.87E-01	2.40E-41	1.74E-100	6.66E-44	2.36E-15	2.52E-08	3.05E-11	5.85E-17	1.57E-11	2.25E-37	9.63E+01	1.85E-06	1.95E-10	3.25E+00	7.74E-22	2.09E-28	7.49E-02	1.49E-01	2.37E-01	2.38E-25	4.32E-04
65	2.34E-01	1.11E-40	3.65E-99	2.45E-43	3.82E-15	3.11E-08	4.76E-11	9.52E-17	2.18E-11	6.28E-37	9.64E+01	2.73E-06	2.61E-10	3.14E+00	1.48E-21	4.97E-28	8.57E-02	1.67E-01	2.58E-01	6.40E-25	5.33E-04
70	2.92E-01	4.83E-40	6.97E-98	8.79E-43	6.11E-15	3.81E-08	7.41E-11	1.53E-16	2.99E-11	1.72E-36	9.64E+01	3.98E-06	3.43E-10	3.02E+00	2.73E-21	1.15E-27	9.77E-02	1.85E-01	2.80E-01	1.71E-24	6.53E-04
75	3.60E-01	1.99E-39	1.21E-96	3.07E-42	9.65E-15	4.63E-08	1.15E-10	2.42E-16	4.04E-11	4.60E-36	9.65E+01	5.73E-06	4.45E-10	2.91E+00	4.92E-21	2.56E-27	1.11E-01	2.05E-01	3.03E-01	4.53E-24	7.94E-04
80	4.42E-01	7.85E-39	1.95E-95	1.05E-41	1.51E-14	5.59E-08	1.79E-10	3.78E-16	5.41E-11	1.22E-35	9.65E+01	8.17E-06	5.70E-10	2.79E+00	8.68E-21	5.56E-27	1.25E-01	2.27E-01	3.28E-01	1.20E-23	9.58E-04
85	5.39E-01	2.99E-38	2.92E-94	3.52E-41	2.35E-14	6.71E-08	2.78E-10	5.85E-16	7.17E-11	3.18E-35	9.66E+01	1.16E-05	7.24E-10	2.67E+00	1.50E-20	1.18E-26	1.41E-01	2.50E-01	3.54E-01	3.16E-23	1.15E-03
90	6.52E-01	1.11E-37	4.11E-93	1.17E-40	3.63E-14	8.04E-08	4.34E-10	8.97E-16	9.44E-11	8.30E-35	9.66E+01	1.64E-05	9.12E-10	2.54E+00	2.58E-20	2.46E-26	1.59E-01	2.75E-01	3.81E-01	8.35E-23	1.37E-03
95	7.85E-01	4.09E-37	5.51E-92	3.86E-40	5.59E-14	9.63E-08	6.80E-10	1.37E-15	1.24E-10	2.16E-34	9.67E+01	2.33E-05	1.14E-09	2.42E+00	4.38E-20	5.05E-26	1.78E-01	3.01E-01	4.09E-01	2.22E-22	1.62E-03
100	9.40E-01	1.49E-36	7.07E-91	1.27E-39	8.60E-14	1.15E-07	1.07E-09	2.07E-15	1.61E-10	5.65E-34	9.67E+01	3.33E-05	1.43E-09	2.31E+00	7.42E-20	1.03E-25	1.98E-01	3.29E-01	4.38E-01	5.92E-22	1.92E-03
105	1.12E+00	4.33E-37	7.04E-91	1.51E-39	8.08E-14	8.42E-08	1.02E-09	1.90E-15	1.27E-10	5.36E-34	9.67E+01	1.74E-05	1.08E-09	2.22E+00	4.62E-20	7.60E-26	2.21E-01	3.59E-01	4.69E-01	5.84E-22	2.28E-03
110	1.32E+00	1.07E-36	5.70E-90	4.23E-39	1.15E-13	9.37E-08	1.50E-09	2.65E-15	1.53E-10	1.21E-33	9.67E+01	2.15E-05	1.24E-09	2.11E+00	6.70E-20	1.30E-25	2.45E-01	3.91E-01	5.01E-01	1.35E-21	2.67E-03
115	1.56E+00	2.60E-36	4.39E-89	1.18E-38	1.64E-13	1.04E-07	2.21E-09	3.66E-15	1.83E-10	2.72E-33	9.68E+01	2.65E-05	1.42E-09	2.00E+00	9.66E-20	2.18E-25	2.71E-01	4.25E-01	5.34E-01	3.14E-21	3.11E-03
120	1.83E+00	6.31E-36	3.25E-88	3.28E-38	2.33E-13	1.16E-07	3.26E-09	5.03E-15	2.18E-10	6.14E-33	9.68E+01	3.29E-05	1.62E-09	1.90E+00	1.39E-19	3.62E-25	3.00E-01	4.61E-01	5.69E-01	7.29E-21	3.61E-03

Fe Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.10E-02	1.12E-52	1.54E-114	6.34E-50	4.89E-18	1.89E-09	9.07E-14	4.18E-19	1.50E-13	2.59E-42	9.67E+01	4.12E-09	2.40E-12	3.07E+00	6.33E-26	2.72E-33	2.34E-02	5.79E-02	1.13E-01	7.46E-31	2.14E-05
25	2.85E-02	1.13E-51	9.97E-113	3.55E-49	9.18E-18	2.61E-09	1.45E-13	8.07E-19	2.44E-13	1.02E-41	9.67E+01	7.23E-09	3.84E-12	3.05E+00	1.76E-25	9.40E-33	2.81E-02	6.71E-02	1.27E-01	2.19E-30	2.88E-05
30	3.81E-02	1.08E-50	6.05E-111	1.90E-48	1.71E-17	3.59E-09	2.32E-13	1.55E-18	3.93E-13	3.90E-41	9.67E+01	1.27E-08	6.04E-12	3.01E+00	4.69E-25	3.13E-32	3.34E-02	7.73E-02	1.42E-01	6.49E-30	3.80E-05
35	5.05E-02	9.48E-50	3.33E-109	9.67E-48	3.12E-17	4.88E-09	3.75E-13	2.94E-18	6.22E-13	1.43E-40	9.68E+01	2.20E-08	9.31E-12	2.95E+00	1.20E-24	1.00E-31	3.95E-02	8.86E-02	1.58E-01	1.92E-29	4.96E-05
40	6.63E-02	7.71E-49	1.67E-107	4.71E-47	5.63E-17	6.55E-09	6.04E-13	5.50E-18	9.67E-13	5.05E-40	9.68E+01	3.75E-08	1.41E-11	2.88E+00	2.93E-24	3.08E-31	4.63E-02	1.01E-01	1.75E-01	5.67E-29	6.41E-05
45	8.61E-02	5.81E-48	7.58E-106	2.19E-46	9.99E-17	8.70E-09	9.76E-13	1.02E-17	1.48E-12	1.72E-39	9.68E+01	6.29E-08	2.08E-11	2.81E+00	6.87E-24	9.11E-31	5.41E-02	1.14E-01	1.93E-01	1.67E-28	8.18E-05
50	1.11E-01	4.09E-47	3.15E-104	9.80E-46	1.75E-16	1.14E-08	1.58E-12	1.87E-17	2.23E-12	5.70E-39	9.69E+01	1.04E-07	3.02E-11	2.73E+00	1.55E-23	2.60E-30	6.28E-02	1.29E-01	2.12E-01	4.90E-28	1.03E-04
55	1.41E-01	2.69E-46	1.20E-102	4.22E-45	3.02E-16	1.49E-08	2.55E-12	3.39E-17	3.31E-12	1.83E-38	9.69E+01	1.70E-07	4.32E-11	2.65E+00	3.39E-23	7.15E-30	7.24E-02	1.45E-01	2.32E-01	1.43E-27	1.29E-04
60	1.79E-01	1.66E-45	4.19E-101	1.75E-44	5.16E-16	1.92E-08	4.12E-12	6.07E-17	4.85E-12	5.72E-38	9.69E+01	2.73E-07	6.08E-11	2.55E+00	7.17E-23	1.90E-29	8.32E-02	1.62E-01	2.53E-01	4.16E-27	1.61E-04
65	2.25E-01	9.63E-45	1.35E-99	7.05E-44	8.69E-16	2.45E-08	6.66E-12	1.08E-16	7.00E-12	1.74E-37	9.70E+01	4.35E-07	8.41E-11	2.46E+00	1.47E-22	4.91E-29	9.51E-02	1.81E-01	2.75E-01	1.20E-26	1.97E-04
70	2.80E-01	5.29E-44	4.00E-98	2.76E-43	1.45E-15	3.10E-08	1.08E-11	1.89E-16	9.98E-12	5.20E-37	9.70E+01	6.87E-07	1.15E-10	2.36E+00	2.94E-22	1.23E-28	1.08E-01	2.01E-01	2.98E-01	3.47E-26	2.40E-04
75	3.47E-01	2.60E-43	1.03E-96	1.02E-42	2.36E-15	3.85E-08	1.72E-11	3.25E-16	1.39E-11	1.49E-36	9.71E+01	1.05E-06	1.53E-10	2.26E+00	5.59E-22	2.91E-28	1.23E-01	2.23E-01	3.23E-01	9.73E-26	2.91E-04
80	4.25E-01	9.01E-43	1.85E-95	3.31E-42	3.61E-15	4.50E-08	2.59E-11	5.22E-16	1.81E-11	3.72E-36	9.71E+01	1.40E-06	1.90E-10	2.17E+00	9.29E-22	5.99E-28	1.38E-01	2.46E-01	3.49E-01	2.42E-25	3.52E-04
85	5.19E-01	2.89E-42	2.98E-94	1.03E-41	5.42E-15	5.18E-08	3.88E-11	8.27E-16	2.31E-11	9.05E-36	9.71E+01	1.84E-06	2.32E-10	2.09E+00	1.49E-21	1.19E-27	1.56E-01	2.70E-01	3.75E-01	5.91E-25	4.23E-04
90	6.29E-01	8.56E-42	4.34E-93	3.12E-41	8.02E-15	5.88E-08	5.75E-11	1.29E-15	2.91E-11	2.14E-35	9.71E+01	2.36E-06	2.79E-10	2.00E+00	2.32E-21	2.26E-27	1.75E-01	2.97E-01	4.03E-01	1.41E-24	5.06E-04
95	7.58E-01	2.36E-41	5.69E-92	9.09E-41	1.17E-14	6.60E-08	8.47E-11	1.97E-15	3.60E-11	4.93E-35	9.71E+01	2.97E-06	3.29E-10	1.92E+00	3.50E-21	4.14E-27	1.95E-01	3.25E-01	4.33E-01	3.32E-24	6.02E-04
100	9.08E-01	6.06E-41	6.77E-91	2.57E-40	1.69E-14	7.31E-08	1.24E-10	2.98E-15	4.38E-11	1.11E-34	9.71E+01	3.65E-06	3.81E-10	1.83E+00	5.13E-21	7.31E-27	2.18E-01	3.54E-01	4.63E-01	7.66E-24	7.12E-04
105	1.08E+00	1.46E-40	7.32E-90	7.07E-40	2.40E-14	8.01E-08	1.79E-10	4.42E-15	5.25E-11	2.43E-34	9.71E+01	4.41E-06	4.36E-10	1.75E+00	7.33E-21	1.25E-26	2.42E-01	3.86E-01	4.95E-01	1.73E-23	8.39E-04
110	1.28E+00	3.30E-40	7.20E-89	1.89E-39	3.38E-14	8.69E-08	2.58E-10	6.46E-15	6.20E-11	5.23E-34	9.71E+01	5.24E-06	4.92E-10	1.67E+00	1.02E-20	2.06E-26	2.68E-01	4.20E-01	5.28E-01	3.85E-23	9.85E-04
115	1.51E+00	7.06E-40	6.46E-88	4.94E-39	4.71E-14	9.33E-08	3.68E-10	9.29E-15	7.22E-11	1.10E-33	9.71E+01	6.12E-06	5.48E-10	1.59E+00	1.39E-20	3.29E-26	2.96E-01	4.55E-01	5.62E-01	8.41E-23	1.15E-03
120	1.78E+00	1.43E-39	5.31E-87	1.26E-38	6.50E-14	9.93E-08	5.21E-10	1.32E-14	8.30E-11	2.29E-33	9.71E+01	7.04E-06	6.02E-10	1.52E+00	1.86E-20	5.10E-26	3.27E-01	4.93E-01	5.98E-01	1.80E-22	1.34E-03

Zr-Al Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.21E-02	9.15E-48	9.20E-113	5.47E-49	2.48E-17	3.49E-09	8.96E-13	6.80E-19	6.74E-13	2.36E-41	9.71E+01	5.39E-08	1.05E-11	2.76E+00	1.28E-24	5.82E-32	2.06E-02	5.10E-02	1.11E-01	7.66E-29	6.03E-05
25	2.99E-02	8.36E-47	5.14E-111	2.96E-48	4.60E-17	4.80E-09	1.41E-12	1.28E-18	1.09E-12	9.01E-41	9.71E+01	9.49E-08	1.66E-11	2.73E+00	3.47E-24	1.95E-31	2.47E-02	5.91E-02	1.25E-01	2.20E-28	8.10E-05
30	4.01E-02	6.92E-46	2.51E-109	1.51E-47	8.36E-17	6.49E-09	2.23E-12	2.37E-18	1.71E-12	3.27E-40	9.71E+01	1.63E-07	2.57E-11	2.70E+00	8.94E-24	6.25E-31	2.94E-02	6.81E-02	1.40E-01	6.29E-28	1.07E-04
35	5.31E-02	5.21E-45	1.07E-107	7.28E-47	1.49E-16	8.66E-09	3.52E-12	4.29E-18	2.65E-12	1.13E-39	9.71E+01	2.73E-07	3.88E-11	2.66E+00	2.19E-23	1.91E-30	3.48E-02	7.81E-02	1.55E-01	1.78E-27	1.41E-04
40	6.97E-02	3.59E-44	4.04E-106	3.34E-46	2.61E-16	1.14E-08	5.55E-12	7.64E-18	4.02E-12	3.78E-39	9.71E+01	4.46E-07	5.73E-11	2.61E+00	5.11E-23	5.58E-30	4.08E-02	8.90E-02	1.72E-01	5.03E-27	1.82E-04
45	9.04E-02	2.27E-43	1.35E-104	1.46E-45	4.49E-16	1.48E-08	8.74E-12	1.33E-17	5.98E-12	1.21E-38	9.71E+01	7.13E-07	8.27E-11	2.55E+00	1.14E-22	1.56E-29	4.77E-02	1.01E-01	1.90E-01	1.41E-26	2.33E-04
50	1.16E-01	1.32E-42	3.98E-103	6.14E-45	7.60E-16	1.90E-08	1.37E-11	2.29E-17	8.74E-12	3.76E-38	9.71E+01	1.12E-06	1.17E-10	2.48E+00	2.44E-22	4.19E-29	5.54E-02	1.14E-01	2.09E-01	3.90E-26	2.96E-04
55	1.48E-01	7.09E-42	1.05E-101	2.48E-44	1.26E-15	2.40E-08	2.16E-11	3.86E-17	1.26E-11	1.13E-37	9.72E+01	1.72E-06	1.62E-10	2.41E+00	5.02E-22	1.08E-28	6.40E-02	1.28E-01	2.29E-01	1.07E-25	3.71E-04
60	1.88E-01	3.53E-41	2.47E-100	9.63E-44	2.07E-15	3.00E-08	3.37E-11	6.40E-17	1.77E-11	3.30E-37	9.72E+01	2.59E-06	2.21E-10	2.33E+00	9.94E-22	2.67E-28	7.36E-02	1.44E-01	2.50E-01	2.91E-25	4.62E-04
65	2.35E-01	1.65E-40	5.24E-99	3.62E-43	3.35E-15	3.72E-08	5.26E-11	1.04E-16	2.47E-11	9.39E-37	9.72E+01	3.83E-06	2.96E-10	2.25E+00	1.90E-21	6.38E-28	8.42E-02	1.60E-01	2.72E-01	7.86E-25	5.71E-04
70	2.93E-01	7.19E-40	1.00E-97	1.32E-42	5.33E-15	4.56E-08	8.20E-11	1.68E-16	3.38E-11	2.61E-36	9.73E+01	5.58E-06	3.89E-10	2.17E+00	3.53E-21	1.47E-27	9.59E-02	1.78E-01	2.95E-01	2.10E-24	6.99E-04
75	3.62E-01	2.97E-39	1.75E-96	4.69E-42	8.40E-15	5.55E-08	1.28E-10	2.66E-16	4.57E-11	7.13E-36	9.73E+01	8.04E-06	5.06E-10	2.09E+00	6.39E-21	3.29E-27	1.09E-01	1.98E-01	3.20E-01	5.59E-24	8.50E-04
80	4.45E-01	1.17E-38	2.82E-95	1.63E-41	1.31E-14	6.70E-08	1.98E-10	4.15E-16	6.12E-11	1.92E-35	9.73E+01	1.15E-05	6.48E-10	2.00E+00	1.13E-20	7.15E-27	1.23E-01	2.18E-01	3.46E-01	1.48E-23	1.03E-03
85	5.42E-01	4.45E-38	4.20E-94	5.57E-41	2.03E-14	8.05E-08	3.08E-10	6.43E-16	8.10E-11	5.11E-35	9.73E+01	1.63E-05	8.23E-10	1.91E+00	1.96E-20	1.52E-26	1.39E-01	2.40E-01	3.73E-01	3.90E-23	1.23E-03
90	6.57E-01	1.65E-37	5.87E-93	1.88E-40	3.11E-14	9.65E-08	4.81E-10	9.85E-16	1.06E-10	1.35E-34	9.74E+01	2.30E-05	1.04E-09	1.83E+00	3.35E-20	3.15E-26	1.55E-01	2.64E-01	4.01E-01	1.03E-22	1.47E-03
95	7.91E-01	5.98E-37	7.77E-92	6.28E-40	4.76E-14	1.15E-07	7.51E-10	1.50E-15	1.39E-10	3.57E-34	9.74E+01	3.25E-05	1.30E-09	1.74E+00	5.69E-20	6.45E-26	1.74E-01	2.89E-01	4.30E-01	2.73E-22	1.74E-03
100	9.48E-01	2.15E-36	9.81E-91	2.09E-39	7.27E-14	1.38E-07	1.18E-09	2.27E-15	1.81E-10	9.44E-34	9.74E+01	4.62E-05	1.62E-09	1.66E+00	9.60E-20	1.30E-25	1.94E-01	3.16E-01	4.61E-01	7.26E-22	2.06E-03
105	1.13E+00	7.31E-37	1.14E-90	2.70E-39	7.04E-14	1.04E-07	1.17E-09	2.15E-15	1.47E-10	9.71E-34	9.73E+01	2.57E-05	1.26E-09	1.60E+00	6.38E-20	1.03E-25	2.16E-01	3.45E-01	4.93E-01	7.64E-22	2.44E-03
110	1.34E+00	1.80E-36	9.20E-90	7.68E-39	9.98E-14	1.16E-07	1.71E-09	2.98E-15	1.77E-10	2.22E-33	9.73E+01	3.17E-05	1.45E-09	1.52E+00	9.25E-20	1.75E-25	2.40E-01	3.75E-01	5.27E-01	1.77E-21	2.86E-03
115	1.58E+00	4.33E-36	6.99E-89	2.17E-38	1.41E-13	1.29E-07	2.51E-09	4.11E-15	2.11E-10	5.07E-33	9.73E+01	3.91E-05	1.66E-09	1.44E+00	1.33E-19	2.92E-25	2.65E-01	4.08E-01	5.62E-01	4.09E-21	3.33E-03
120	1.85E+00	1.03E-35	5.06E-88	6.10E-38	1.98E-13	1.43E-07	3.70E-09	5.63E-15	2.50E-10	1.16E-32	9.73E+01	4.83E-05	1.89E-09	1.37E+00	1.91E-19	4.82E-25	2.93E-01	4.42E-01	5.98E-01	9.46E-21	3.88E-03

Na Group Vapor Pressure and Composition

Temp	Pressure	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.12E-02	5.99E-50	5.47E-18	2.23E-09	8.03E-14	9.79E-19	1.22E-13	2.51E-42	9.79E+01	8.05E-09	1.94E-12	1.89E+00	4.17E-26	1.83E-33	2.18E-02	5.49E-02	1.10E-01	5.91E-31	5.67E-05
25	2.88E-02	3.46E-49	1.03E-17	3.09E-09	1.28E-13	1.88E-18	1.99E-13	1.02E-41	9.79E+01	1.43E-08	3.11E-12	1.87E+00	1.16E-25	6.33E-33	2.62E-02	6.37E-02	1.24E-01	1.74E-30	7.59E-05
30	3.86E-02	1.91E-48	1.90E-17	4.23E-09	2.06E-13	3.55E-18	3.20E-13	4.01E-41	9.79E+01	2.49E-08	4.88E-12	1.84E+00	3.09E-25	2.10E-32	3.11E-02	7.33E-02	1.38E-01	5.15E-30	1.00E-04
35	5.11E-02	1.00E-47	3.47E-17	5.73E-09	3.32E-13	6.63E-18	5.06E-13	1.52E-40	9.79E+01	4.28E-08	7.51E-12	1.81E+00	7.87E-25	6.71E-32	3.68E-02	8.40E-02	1.54E-01	1.52E-29	1.31E-04
40	6.71E-02	5.07E-47	6.23E-17	7.69E-09	5.35E-13	1.22E-17	7.86E-13	5.57E-40	9.79E+01	7.24E-08	1.13E-11	1.77E+00	1.92E-24	2.06E-31	4.32E-02	9.57E-02	1.70E-01	4.49E-29	1.69E-04
45	8.72E-02	2.46E-46	1.10E-16	1.02E-08	8.64E-13	2.22E-17	1.20E-12	1.98E-39	9.79E+01	1.21E-07	1.68E-11	1.72E+00	4.52E-24	6.10E-31	5.04E-02	1.09E-01	1.88E-01	1.32E-28	2.16E-04
50	1.12E-01	1.15E-45	1.93E-16	1.34E-08	1.40E-12	4.00E-17	1.82E-12	6.86E-39	9.79E+01	1.99E-07	2.44E-11	1.67E+00	1.03E-23	1.74E-30	5.85E-02	1.23E-01	2.06E-01	3.89E-28	2.73E-04
55	1.43E-01	5.20E-45	3.32E-16	1.75E-08	2.26E-12	7.11E-17	2.70E-12	2.31E-38	9.79E+01	3.24E-07	3.50E-11	1.62E+00	2.25E-23	4.81E-30	6.76E-02	1.38E-01	2.26E-01	1.14E-27	3.42E-04
60	1.81E-01	2.27E-44	5.65E-16	2.25E-08	3.67E-12	1.25E-16	3.96E-12	7.58E-38	9.80E+01	5.21E-07	4.93E-11	1.56E+00	4.78E-23	1.28E-29	7.76E-02	1.54E-01	2.47E-01	3.33E-27	4.25E-04
65	2.28E-01	9.61E-44	9.50E-16	2.88E-08	5.94E-12	2.17E-16	5.72E-12	2.43E-37	9.80E+01	8.27E-07	6.84E-11	1.51E+00	9.85E-23	3.32E-29	8.87E-02	1.72E-01	2.68E-01	9.68E-27	5.23E-04
70	2.84E-01	3.95E-43	1.58E-15	3.65E-08	9.61E-12	3.72E-16	8.17E-12	7.62E-37	9.80E+01	1.30E-06	9.36E-11	1.45E+00	1.97E-22	8.31E-29	1.01E-01	1.91E-01	2.91E-01	2.80E-26	6.39E-04
75	3.51E-01	1.58E-42	2.59E-15	4.59E-08	1.55E-11	6.30E-16	1.15E-11	2.34E-36	9.80E+01	2.02E-06	1.26E-10	1.39E+00	3.86E-22	2.02E-28	1.14E-01	2.11E-01	3.15E-01	8.04E-26	7.75E-04
80	4.31E-01	6.16E-42	4.21E-15	5.73E-08	2.51E-11	1.06E-15	1.60E-11	7.08E-36	9.80E+01	3.11E-06	1.68E-10	1.33E+00	7.36E-22	4.77E-28	1.29E-01	2.33E-01	3.40E-01	2.30E-25	9.34E-04
85	5.27E-01	2.36E-41	6.77E-15	7.10E-08	4.05E-11	1.75E-15	2.21E-11	2.11E-35	9.80E+01	4.76E-06	2.21E-10	1.26E+00	1.38E-21	1.10E-27	1.45E-01	2.56E-01	3.66E-01	6.53E-25	1.12E-03
90	6.39E-01	8.87E-41	1.08E-14	8.77E-08	6.54E-11	2.89E-15	3.02E-11	6.24E-35	9.80E+01	7.25E-06	2.89E-10	1.20E+00	2.54E-21	2.46E-27	1.63E-01	2.81E-01	3.93E-01	1.85E-24	1.33E-03
95	7.71E-01	3.31E-40	1.71E-14	1.08E-07	1.06E-10	4.72E-15	4.09E-11	1.84E-34	9.79E+01	1.10E-05	3.74E-10	1.14E+00	4.62E-21	5.44E-27	1.82E-01	3.08E-01	4.22E-01	5.27E-24	1.57E-03
100	9.24E-01	1.24E-39	2.70E-14	1.33E-07	1.72E-10	7.66E-15	5.52E-11	5.48E-34	9.79E+01	1.69E-05	4.83E-10	1.08E+00	8.37E-21	1.18E-26	2.03E-01	3.36E-01	4.51E-01	1.51E-23	1.85E-03
105	1.10E+00	1.80E-39	2.76E-14	1.03E-07	1.76E-10	7.83E-15	4.68E-11	6.33E-34	9.79E+01	9.88E-06	3.91E-10	1.06E+00	5.98E-21	1.01E-26	2.26E-01	3.67E-01	4.83E-01	1.69E-23	2.21E-03
110	1.30E+00	5.65E-39	4.02E-14	1.17E-07	2.65E-10	1.16E-14	5.78E-11	1.60E-33	9.78E+01	1.29E-05	4.62E-10	1.00E+00	9.14E-21	1.82E-26	2.50E-01	3.99E-01	5.15E-01	4.13E-23	2.59E-03
115	1.54E+00	1.75E-38	5.79E-14	1.32E-07	3.97E-10	1.70E-14	7.06E-11	4.01E-33	9.78E+01	1.67E-05	5.40E-10	9.51E-01	1.37E-20	3.19E-26	2.77E-01	4.32E-01	5.49E-01	9.97E-23	3.01E-03
120	1.81E+00	5.38E-38	8.29E-14	1.48E-07	5.94E-10	2.47E-14	8.54E-11	1.00E-32	9.77E+01	2.14E-05	6.25E-10	9.00E-01	2.04E-20	5.48E-26	3.05E-01	4.68E-01	5.83E-01	2.39E-22	3.49E-03

Ca Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	1.97E-02	2.71E-55	1.07E-114	9.73E-51	3.42E-18	1.33E-09	3.16E-14	6.00E-19	9.97E-14	3.71E-43	9.59E+01	7.04E-10	1.63E-12	3.88E+00	2.74E-26	1.14E-33	2.40E-02	6.02E-02	1.21E-01	8.50E-32	4.38E-05
25	2.68E-02	3.16E-54	7.63E-113	5.68E-50	6.59E-18	1.87E-09	5.15E-14	1.17E-18	1.67E-13	1.53E-42	9.59E+01	1.31E-09	2.67E-12	3.83E+00	7.98E-26	4.11E-33	2.87E-02	6.98E-02	1.35E-01	2.61E-31	5.86E-05
30	3.59E-02	3.36E-53	4.85E-111	3.14E-49	1.25E-17	2.61E-09	8.42E-14	2.25E-18	2.73E-13	6.02E-42	9.60E+01	2.40E-09	4.27E-12	3.77E+00	2.21E-25	1.43E-32	3.41E-02	8.04E-02	1.51E-01	8.01E-31	7.75E-05
35	4.75E-02	3.29E-52	2.77E-109	1.65E-48	2.33E-17	3.59E-09	1.38E-13	4.25E-18	4.41E-13	2.28E-41	9.60E+01	4.32E-09	6.69E-12	3.70E+00	5.82E-25	4.74E-32	4.03E-02	9.21E-02	1.68E-01	2.45E-30	1.01E-04
40	6.24E-02	2.97E-51	1.42E-107	8.28E-48	4.27E-17	4.87E-09	2.26E-13	7.93E-18	6.98E-13	8.30E-41	9.60E+01	7.66E-09	1.03E-11	3.62E+00	1.47E-24	1.51E-31	4.73E-02	1.05E-01	1.86E-01	7.45E-30	1.31E-04
45	8.11E-02	2.48E-50	6.56E-106	3.98E-47	7.72E-17	6.54E-09	3.70E-13	1.46E-17	1.09E-12	2.92E-40	9.61E+01	1.34E-08	1.54E-11	3.52E+00	3.55E-24	4.64E-31	5.52E-02	1.19E-01	2.05E-01	2.26E-29	1.67E-04
50	1.04E-01	1.93E-49	2.75E-104	1.84E-46	1.38E-16	8.68E-09	6.07E-13	2.65E-17	1.67E-12	1.00E-39	9.62E+01	2.31E-08	2.27E-11	3.42E+00	8.27E-24	1.37E-30	6.41E-02	1.34E-01	2.25E-01	6.82E-29	2.10E-04
55	1.33E-01	1.40E-48	1.05E-102	8.21E-46	2.42E-16	1.14E-08	9.94E-13	4.75E-17	2.52E-12	3.33E-39	9.62E+01	3.94E-08	3.30E-11	3.30E+00	1.86E-23	3.91E-30	7.39E-02	1.51E-01	2.47E-01	2.05E-28	2.63E-04
60	1.69E-01	9.51E-48	3.63E-101	3.55E-45	4.22E-16	1.48E-08	1.63E-12	8.41E-17	3.76E-12	1.08E-38	9.63E+01	6.63E-08	4.70E-11	3.18E+00	4.05E-23	1.08E-29	8.48E-02	1.68E-01	2.69E-01	6.13E-28	3.26E-04
65	2.12E-01	6.11E-47	1.16E-99	1.50E-44	7.25E-16	1.91E-08	2.67E-12	1.47E-16	5.53E-12	3.47E-38	9.64E+01	1.10E-07	6.60E-11	3.06E+00	8.55E-23	2.88E-29	9.69E-02	1.88E-01	2.92E-01	1.83E-27	4.00E-04
70	2.64E-01	3.73E-46	3.39E-98	6.17E-44	1.23E-15	2.44E-08	4.38E-12	2.55E-16	8.02E-12	1.09E-37	9.64E+01	1.81E-07	9.15E-11	2.92E+00	1.76E-22	7.48E-29	1.10E-01	2.08E-01	3.17E-01	5.43E-27	4.86E-04
75	3.27E-01	2.17E-45	9.19E-97	2.49E-43	2.08E-15	3.10E-08	7.20E-12	4.36E-16	1.15E-11	3.39E-37	9.65E+01	2.95E-07	1.25E-10	2.78E+00	3.54E-22	1.89E-28	1.25E-01	2.30E-01	3.42E-01	1.61E-26	5.85E-04
80	4.03E-01	1.21E-44	2.32E-95	9.89E-43	3.48E-15	3.91E-08	1.18E-11	7.40E-16	1.64E-11	1.05E-36	9.66E+01	4.76E-07	1.69E-10	2.64E+00	6.98E-22	4.64E-28	1.41E-01	2.54E-01	3.69E-01	4.77E-26	6.99E-04
85	4.92E-01	6.58E-44	5.49E-94	3.88E-42	5.77E-15	4.91E-08	1.95E-11	1.25E-15	2.31E-11	3.21E-36	9.67E+01	7.64E-07	2.27E-10	2.50E+00	1.35E-21	1.12E-27	1.58E-01	2.79E-01	3.97E-01	1.42E-25	8.29E-04
90	5.97E-01	2.31E-43	8.28E-93	1.29E-41	8.82E-15	5.70E-08	2.98E-11	1.93E-15	2.99E-11	8.34E-36	9.67E+01	1.04E-06	2.80E-10	2.38E+00	2.24E-21	2.27E-27	1.77E-01	3.05E-01	4.26E-01	3.59E-25	9.87E-04
95	7.20E-01	6.32E-43	9.54E-92	3.86E-41	1.29E-14	6.33E-08	4.36E-11	2.86E-15	3.70E-11	1.98E-35	9.67E+01	1.30E-06	3.30E-10	2.29E+00	3.36E-21	4.17E-27	1.98E-01	3.34E-01	4.57E-01	8.37E-25	1.18E-03
100	8.63E-01	1.62E-42	1.00E-90	1.13E-40	1.86E-14	6.96E-08	6.35E-11	4.17E-15	4.52E-11	4.60E-35	9.67E+01	1.60E-06	3.83E-10	2.19E+00	4.92E-21	7.40E-27	2.20E-01	3.65E-01	4.88E-01	1.92E-24	1.39E-03
105	1.03E+00	2.33E-42	6.00E-90	2.68E-40	2.41E-14	6.89E-08	8.29E-11	5.48E-15	4.96E-11	8.67E-35	9.67E+01	1.60E-06	4.00E-10	2.16E+00	5.84E-21	1.06E-26	2.45E-01	3.97E-01	5.23E-01	3.52E-24	1.68E-03
110	1.22E+00	7.40E-42	7.14E-89	8.52E-40	3.61E-14	7.86E-08	1.27E-10	8.21E-15	6.23E-11	2.22E-34	9.67E+01	2.14E-06	4.79E-10	2.03E+00	9.19E-21	1.98E-26	2.71E-01	4.31E-01	5.56E-01	8.87E-24	1.95E-03
115	1.44E+00	1.92E-41	6.76E-88	2.50E-39	5.20E-14	8.66E-08	1.87E-10	1.18E-14	7.53E-11	5.29E-34	9.67E+01	2.66E-06	5.51E-10	1.92E+00	1.34E-20	3.40E-26	2.99E-01	4.67E-01	5.92E-01	2.08E-23	2.27E-03
120	1.69E+00	4.05E-41	5.10E-87	6.78E-39	7.23E-14	9.19E-08	2.67E-10	1.63E-14	8.74E-11	1.16E-33	9.67E+01	3.08E-06	6.10E-10	1.83E+00	1.82E-20	5.38E-26	3.29E-01	5.06E-01	6.29E-01	4.50E-23	2.64E-03

U Group Vapor Pressure and Composition

Temp	Pressure	SiF4	SiCl4	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	2.27E-02	4.79E-48	4.13E-111	1.32E-47	3.75E-17	5.03E-09	5.45E-13	1.26E-18	1.43E-12	5.99E-40	9.93E+01	5.24E-07	2.18E-11	5.10E-01	5.63E-24	2.68E-31	2.11E-02	5.28E-02	1.06E-01	2.90E-29	3.37E-05
25	3.07E-02	3.76E-47	2.01E-109	7.04E-47	6.76E-17	6.73E-09	8.36E-13	2.31E-18	2.24E-12	2.25E-39	9.93E+01	8.83E-07	3.36E-11	5.06E-01	1.45E-23	8.54E-31	2.53E-02	6.12E-02	1.19E-01	7.90E-29	4.53E-05
30	4.11E-02	2.69E-46	8.56E-108	3.55E-46	1.19E-16	8.90E-09	1.29E-12	4.18E-18	3.45E-12	8.06E-39	9.93E+01	1.45E-06	5.07E-11	4.99E-01	3.57E-23	2.60E-30	3.01E-02	7.05E-02	1.33E-01	2.14E-28	6.00E-05
35	5.45E-02	1.76E-45	3.23E-106	1.70E-45	2.07E-16	1.16E-08	1.98E-12	7.41E-18	5.21E-12	2.78E-38	9.92E+01	2.34E-06	7.49E-11	4.91E-01	8.36E-23	7.58E-30	3.55E-02	8.08E-02	1.48E-01	5.78E-28	7.85E-05
40	7.15E-02	1.06E-44	1.08E-104	7.75E-45	3.52E-16	1.50E-08	3.05E-12	1.29E-17	7.72E-12	9.20E-38	9.92E+01	3.70E-06	1.08E-10	4.81E-01	1.87E-22	2.12E-29	4.17E-02	9.21E-02	1.64E-01	1.56E-27	1.02E-04
45	9.29E-02	5.90E-44	3.21E-103	3.38E-44	5.90E-16	1.91E-08	4.69E-12	2.22E-17	1.12E-11	2.94E-37	9.92E+01	5.74E-06	1.53E-10	4.71E-01	4.02E-22	5.67E-29	4.87E-02	1.05E-01	1.81E-01	4.16E-27	1.30E-04
50	1.20E-01	3.04E-43	8.54E-102	1.41E-43	9.70E-16	2.40E-08	7.22E-12	3.74E-17	1.61E-11	9.09E-37	9.92E+01	8.73E-06	2.13E-10	4.58E-01	8.32E-22	1.46E-28	5.66E-02	1.18E-01	1.99E-01	1.11E-26	1.65E-04
55	1.53E-01	1.46E-42	2.04E-100	5.68E-43	1.57E-15	2.99E-08	1.11E-11	6.20E-17	2.27E-11	2.72E-36	9.91E+01	1.30E-05	2.91E-10	4.45E-01	1.66E-21	3.61E-28	6.53E-02	1.33E-01	2.18E-01	2.92E-26	2.07E-04
60	1.93E-01	6.49E-42	4.36E-99	2.20E-42	2.50E-15	3.69E-08	1.71E-11	1.01E-16	3.14E-11	7.92E-36	9.91E+01	1.92E-05	3.90E-10	4.32E-01	3.19E-21	8.61E-28	7.50E-02	1.48E-01	2.38E-01	7.67E-26	2.58E-04
65	2.42E-01	2.69E-41	8.38E-98	8.21E-42	3.93E-15	4.50E-08	2.61E-11	1.63E-16	4.28E-11	2.24E-35	9.91E+01	2.77E-05	5.14E-10	4.17E-01	5.92E-21	1.98E-27	8.58E-02	1.66E-01	2.59E-01	1.99E-25	3.18E-04
70	3.02E-01	1.05E-40	1.46E-96	2.97E-41	6.07E-15	5.45E-08	3.99E-11	2.58E-16	5.75E-11	6.17E-35	9.90E+01	3.94E-05	6.67E-10	4.02E-01	1.07E-20	4.39E-27	9.77E-02	1.84E-01	2.81E-01	5.14E-25	3.90E-04
75	3.74E-01	3.90E-40	2.33E-95	1.05E-40	9.27E-15	6.55E-08	6.10E-11	4.03E-16	7.63E-11	1.67E-34	9.90E+01	5.54E-05	8.54E-10	3.87E-01	1.88E-20	9.45E-27	1.11E-01	2.04E-01	3.04E-01	1.32E-24	4.74E-04
80	4.59E-01	1.38E-39	3.43E-94	3.60E-40	1.40E-14	7.82E-08	9.32E-11	6.22E-16	1.00E-10	4.45E-34	9.89E+01	7.74E-05	1.08E-09	3.72E-01	3.24E-20	1.98E-26	1.25E-01	2.25E-01	3.29E-01	3.38E-24	5.73E-04
85	5.60E-01	4.72E-39	4.68E-93	1.22E-39	2.10E-14	9.31E-08	1.43E-10	9.51E-16	1.30E-10	1.17E-33	9.89E+01	1.07E-04	1.35E-09	3.56E-01	5.48E-20	4.05E-26	1.41E-01	2.47E-01	3.54E-01	8.62E-24	6.88E-04
90	6.79E-01	1.57E-38	5.98E-92	4.04E-39	3.11E-14	1.10E-07	2.18E-10	1.44E-15	1.68E-10	3.05E-33	9.88E+01	1.49E-04	1.68E-09	3.41E-01	9.15E-20	8.11E-26	1.58E-01	2.72E-01	3.80E-01	2.20E-23	8.21E-04
95	8.19E-01	5.08E-38	7.21E-91	1.33E-38	4.59E-14	1.31E-07	3.35E-10	2.16E-15	2.15E-10	7.91E-33	9.88E+01	2.06E-04	2.08E-09	3.26E-01	1.51E-19	1.60E-25	1.77E-01	2.97E-01	4.08E-01	5.63E-23	9.75E-04
100	9.82E-01	1.62E-37	8.26E-90	4.31E-38	6.75E-14	1.55E-07	5.17E-10	3.23E-15	2.74E-10	2.04E-32	9.87E+01	2.85E-04	2.55E-09	3.10E-01	2.48E-19	3.09E-25	1.97E-01	3.25E-01	4.37E-01	1.44E-22	1.15E-03
105	1.17E+00	9.56E-38	1.69E-89	7.15E-38	7.13E-14	1.32E-07	5.72E-10	3.43E-15	2.49E-10	2.71E-32	9.87E+01	2.03E-04	2.24E-09	2.97E-01	2.08E-19	3.02E-25	2.19E-01	3.54E-01	4.67E-01	1.91E-22	1.36E-03
110	1.39E+00	2.25E-37	1.32E-88	2.05E-37	9.84E-14	1.47E-07	8.37E-10	4.78E-15	2.96E-10	6.23E-32	9.86E+01	2.53E-04	2.57E-09	2.83E-01	3.02E-19	5.09E-25	2.43E-01	3.85E-01	4.99E-01	4.39E-22	1.60E-03
115	1.64E+00	5.14E-37	9.74E-88	5.77E-37	1.35E-13	1.65E-07	1.22E-09	6.59E-15	3.51E-10	1.42E-31	9.85E+01	3.12E-04	2.94E-09	2.69E-01	4.33E-19	8.37E-25	2.69E-01	4.18E-01	5.31E-01	1.01E-21	1.87E-03
120	1.92E+00	1.15E-36	6.75E-87	1.61E-36	1.84E-13	1.84E-07	1.78E-09	8.99E-15	4.11E-10	3.22E-31	9.84E+01	3.85E-04	3.33E-09	2.56E-01	6.17E-19	1.35E-24	2.97E-01	4.53E-01	5.65E-01	2.29E-21	2.17E-03

SO4 Group Vapor Pressure and Composition

Temp	Pressure	SO3	HNO3	HNO2	HF	HCl	HCOOH	H2SO4	H2O	CO2	CH3COOH	CH3COCH3	C4H8O4	C2H4O4	C14H30	C13H28	C12H26	(HF)2	(C4H9)3PO4
°C	atm	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %	mole %
20	1.84E-02	1.23E-52	6.99E-19	5.33E-10	6.97E-15	3.55E-19	6.24E-14	3.96E-45	8.72E+01	3.75E-11	1.05E-12	1.26E+01	1.07E-26	4.15E-34	2.55E-02	6.40E-02	1.28E-01	3.87E-33	4.85E-05
25	2.50E-02	7.23E-52	1.38E-18	7.64E-10	1.17E-14	6.95E-19	1.09E-13	1.65E-44	8.72E+01	8.37E-11	1.79E-12	1.26E+01	3.34E-26	1.64E-33	3.05E-02	7.40E-02	1.44E-01	1.26E-32	6.57E-05
30	3.36E-02	4.27E-51	2.73E-18	1.10E-09	1.99E-14	1.36E-18	1.88E-13	6.96E-44	8.72E+01	1.81E-10	3.00E-12	1.25E+01	1.02E-25	6.31E-33	3.61E-02	8.49E-02	1.60E-01	4.17E-32	8.72E-05
35	4.47E-02	2.51E-50	5.34E-18	1.57E-09	3.38E-14	2.62E-18	3.21E-13	2.96E-43	8.74E+01	3.77E-10	4.95E-12	1.22E+01	2.99E-25	2.36E-32	4.25E-02	9.69E-02	1.77E-01	1.38E-31	1.14E-04
40	5.88E-02	1.46E-49	1.04E-17	2.23E-09	5.76E-14	4.99E-18	5.40E-13	1.26E-42	8.77E+01	7.58E-10	8.02E-12	1.19E+01	8.44E-25	8.52E-32	4.98E-02	1.10E-01	1.95E-01	4.57E-31	1.46E-04
45	7.65E-02	8.32E-49	1.99E-17	3.13E-09	9.87E-14	9.38E-18	8.95E-13	5.29E-42	8.81E+01	1.48E-09	1.27E-11	1.15E+01	2.29E-24	2.96E-31	5.79E-02	1.24E-01	2.15E-01	1.52E-30	1.85E-04
50	9.88E-02	4.64E-48	3.78E-17	4.38E-09	1.70E-13	1.74E-17	1.46E-12	2.20E-41	8.85E+01	2.82E-09	1.99E-11	1.10E+01	6.00E-24	9.91E-31	6.70E-02	1.40E-01	2.35E-01	5.04E-30	2.31E-04
55	1.26E-01	2.43E-47	6.98E-17	5.97E-09	2.87E-13	3.12E-17	2.31E-12	8.63E-41	8.89E+01	5.11E-09	3.01E-11	1.06E+01	1.47E-23	3.11E-30	7.72E-02	1.57E-01	2.57E-01	1.62E-29	2.88E-04
60	1.60E-01	1.13E-46	1.23E-16	7.80E-09	4.68E-13	5.36E-17	3.50E-12	3.04E-40	8.92E+01	8.49E-09	4.35E-11	1.03E+01	3.29E-23	8.88E-30	8.85E-02	1.75E-01	2.80E-01	4.80E-29	3.58E-04
65	2.01E-01	5.14E-46	2.12E-16	1.01E-08	7.63E-13	9.03E-17	5.21E-12	1.05E-39	8.95E+01	1.38E-08	6.17E-11	9.94E+00	7.07E-23	2.43E-29	1.01E-01	1.95E-01	3.04E-01	1.41E-28	4.43E-04
70	2.50E-01	2.26E-45	3.63E-16	1.29E-08	1.24E-12	1.50E-16	7.64E-12	3.53E-39	8.97E+01	2.20E-08	8.59E-11	9.60E+00	1.47E-22	6.43E-29	1.15E-01	2.16E-01	3.29E-01	4.12E-28	5.43E-04
75	3.10E-01	9.71E-45	6.13E-16	1.63E-08	2.02E-12	2.44E-16	1.10E-11	1.17E-38	9.00E+01	3.44E-08	1.18E-10	9.25E+00	2.97E-22	1.64E-28	1.30E-01	2.39E-01	3.56E-01	1.20E-27	6.61E-04
80	3.81E-01	4.07E-44	1.02E-15	2.04E-08	3.28E-12	3.93E-16	1.57E-11	3.80E-38	9.03E+01	5.30E-08	1.59E-10	8.90E+00	5.84E-22	4.05E-28	1.46E-01	2.63E-01	3.83E-01	3.46E-27	7.99E-04
85	4.65E-01	1.66E-43	1.69E-15	2.53E-08	5.31E-12	6.22E-16	2.21E-11	1.22E-37	9.06E+01	8.07E-08	2.12E-10	8.54E+00	1.12E-21	9.70E-28	1.64E-01	2.89E-01	4.12E-01	9.95E-27	9.60E-04
90	5.64E-01	6.67E-43	2.77E-15	3.10E-08	8.61E-12	9.70E-16	3.07E-11	3.84E-37	9.09E+01	1.21E-07	2.80E-10	8.19E+00	2.10E-21	2.25E-27	1.84E-01	3.17E-01	4.42E-01	2.84E-26	1.15E-03
95	6.80E-01	2.62E-42	4.49E-15	3.78E-08	1.39E-11	1.49E-15	4.21E-11	1.19E-36	9.11E+01	1.80E-07	3.64E-10	7.84E+00	3.86E-21	5.08E-27	2.05E-01	3.46E-01	4.73E-01	8.09E-26	1.36E-03
100	8.16E-01	1.01E-41	7.21E-15	4.57E-08	2.26E-11	2.27E-15	5.70E-11	3.67E-36	9.14E+01	2.64E-07	4.68E-10	7.49E+00	6.96E-21	1.11E-26	2.28E-01	3.77E-01	5.06E-01	2.29E-25	1.61E-03
105	9.73E-01	3.79E-41	1.15E-14	5.47E-08	3.63E-11	3.39E-15	7.63E-11	1.10E-35	9.16E+01	3.81E-07	5.95E-10	7.16E+00	1.23E-20	2.37E-26	2.53E-01	4.10E-01	5.39E-01	6.41E-25	1.90E-03
110	1.16E+00	1.41E-40	1.81E-14	6.51E-08	5.86E-11	5.02E-15	1.01E-10	3.31E-35	9.19E+01	5.47E-07	7.50E-10	6.82E+00	2.14E-20	4.94E-26	2.79E-01	4.45E-01	5.74E-01	1.80E-24	2.22E-03
115	1.36E+00	4.60E-40	2.85E-14	7.70E-08	1.07E-10	7.32E-15	1.33E-10	8.77E-35	9.21E+01	7.70E-07	9.36E-10	6.48E+00	3.68E-20	1.00E-25	3.08E-01	4.81E-01	6.10E-01	6.39E-24	2.59E-03
120	1.60E+00	1.46E-39	4.44E-14	9.04E-08	1.95E-10	1.05E-14	1.72E-10	2.28E-34	9.23E+01	1.07E-06	1.16E-09	6.14E+00	6.23E-20	1.98E-25	3.39E-01	5.20E-01	6.47E-01	2.30E-23	3.01E-03

Posted by
Jeff Pike
Entered on
02/09/2015

SRNL-STI-2014-00555 Rev 0 Approval Routing

Tracking Number
GenAppr-2015-00001
Status: Approved

Title Estimated Vapor Pressure for WTP Process Streams

Attachments

SRNL-STI-2014-00555 Rev. 0 - Estimated Vapor Pressure for WTP Process Streams.docx

Please send any comments directly to the authors.

Typos were corrected with this last revision and one statement in the QA sections was revised to be more precise.

Approval Routing: Approved on 02/22/2015

Approvers	Title	Assigned	Received	Status Changed	Status
Frank Pennebaker	Manager	02/17/2015 11:29:28 AM	02/17/2015 12:29:07 PM	02/18/2015 12:41:56 PM	Approved
Michael Poirier	Author	02/17/2015 11:29:28 AM	02/17/2015 12:16:57 PM	02/17/2015 12:34:03 PM	Approved
James Laurinat	Technical Reviewer	02/17/2015 11:29:28 AM	02/17/2015 12:05:19 PM	02/17/2015 12:07:13 PM	Approved
Samuel Fink	Program Manager	02/17/2015 11:29:28 AM	02/17/2015 03:06:30 PM	02/18/2015 08:37:39 AM	Approved
Sharon Marra		02/17/2015 11:29:28 AM	02/17/2015 12:37:01 PM	02/22/2015 01:27:47 PM	Approved

Previous Process - Approval Routing: Denied on 02/17/2015

Approvers	Title	Assigned	Received	Status Changed	Status
Frank Pennebaker	Manager	02/09/2015 09:59:27 AM	02/09/2015 10:18:28 AM	-	-
Michael Poirier	Author	02/09/2015 09:59:27 AM	02/10/2015 10:30:33 AM	02/10/2015 11:06:01 AM	Approved
James Laurinat	Technical Reviewer	02/09/2015 09:59:27 AM	02/09/2015 12:47:11 PM	02/09/2015 01:41:16 PM	Approved
Samuel Fink	Program Manager	02/09/2015 09:59:27 AM	02/16/2015 01:03:29 PM	02/17/2015 07:24:31 AM	Denied
Sharon Marra		02/09/2015 09:59:27 AM	02/09/2015 02:07:38 PM	-	-

Approver Comments

Previous Comments - Approval Routing: Denied on 02/17/2015
On Feb 17, Samuel Fink denied this document and wrote:
Denied for corrections requested by M. Poirier. Replace with updated version and restart approval cycle.