APPENDIX A

DATA SHEETS FOR CHEMICALS WITH HAZARD-INDEX RANKING: HIGH

Chemical Name	Hazard Index: High
Common Name: Ammonia Empirical Formula: NH3	CAS Number: 7664-41-7

Sorptive Properties

Filter Performance Index: Poor

Physical Adsorption:	Weakly adsorbed on activated carbon due to high vapor pressure. Some retention under dry conditions followed by desorption. Water soluble, marginal increase in retention at high relative humidities and adsorbed water.
Chemisorption:	Weak chemisorption and retention by NBC filters under dry conditions. Initial retention is reversible with purge air dry and humid conditions. (Dinius, 1942; Emmet, 1943; Grue/Morrison 1990; Karwacki, unpublished data, 1999)

Physical Properties

Molecular Weight:	17.03 g/mole
Boiling Point:	-33.35 C
Vapor Pressure:	400 mmHg at -45.4C, 7600 mmHg at 25C, Antoine: T=164-239.5K, A=16.9481 B=2132.5 C=-32.98 (T in K, ln P in mm Hg, Prausnitz)
Volatility:	0.597 (air=1)
Critical Temperature:	132.4 C
Critical Pressure:	111.5 atm
Heat of Vaporization:	5.581 kcal/mol
Solubility in Water:	47% at 0C, 38% at 15C, 34% at 20C,31% at 25C, 28% at 30C
Liquid Density:	0.6175 g/mL (15 C, 7.188 atm), 0.6818 g/mL (-33.35 C, 1 atm)

Toxicity

ACGIH TLV-TWA: 17 mg/m3	NIOSH REL-TWA: 18 mg/m3	OSHA PEL: 35 mg/m3
ACGIH TLV-STEL: 24 mg/m3	NIOSH REL-STEL: 27 mg/m3	

References

1. NIST Chemistry WebBook
2. MSDS, Howard Hughes Medical Institute, Jul 94
3. The Merck Index, 11th Edition
4. Prausnitz
5. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Arsine Empirical Formula: AsH3	CAS Number: 7784-42-1

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed on activated carbon due to high vapor pressure.

Chemisorption: Effectively removed by NBC filters due to catalytic reaction with metal impregnants. (Hatcher, 1942; Hickey, 1942, D)

Physical Properties

Molecular Weight:	77.95 g/mole
Boiling Point:	-62.5 C
Vapor Pressure:	765.44 mmHg at -62.31C, 13600 mmHg at 25 C, Antoine: T = 130.5-211K A =3.4338 B = 606.597 C=-34.306 (T = K, log P = bar, NIST)
Volatility:	2.66 (air=1)
Critical Temperature:	99.9 C
Critical Pressure:	
Heat of Vaporization:	51.15 cal/g at -62.48 C
Solubility in Water:	0.20 v/v
Liquid Density:	3.42 g/L, 1.604 g/ml

Toxicity

ACGIH TLV-TWA: 0.16 mg/m3 NIOSH REL-TWA: 0.002 mg/m3 OSHA PEL: 0.2 mg/m3

ACGIH TLV-STEL: NIOSH REL-STEL:

References

1. MSDS, Radian Corporation, August 29, 1991
2. MSDS, Phoenix Research, December 1, 1987
3. Handbook of Chemistry and Physics
NIST Chemistry Webbook

Chemical Name	Hazard Index: High
Common Name: Boron Trichloride Empirical Formula: BCl3	CAS Number: 10294-34-5

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed on activated carbon due to high vapor pressure, decomposes in water.

Chemisorption: Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants. (Rogge, 1959)

Physical Properties

Molecular Weight:	117.17
Boiling Point:	12.5 C
Vapor Pressure:	400 mmHg at -3.6C, 760 mmHg at 12.7C, 1261 mmHg at 25C, Antoine: T=181.6-285.8 K, A=3.95145 B=973.995 C=-38.994 (T = K, log P = bar, NIST)
Volatility:	4.4 psig at 68F
Critical Temperature:	178.8 C
Critical Pressure:	38.2 atm
Heat of Vaporization:	38.2 cal/g
Solubility in Water:	decomposes at 20 C
Liquid Density:	1.35 g/mL at 12 C, 1.3728 g/mL at 0 C

Toxicity

ACGIH TLV-TWA:	NIOSH REL-TWA:	OSHA PEL:
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. NIST Chemistry WebBook
2. The Merck Index, 11th Edition
3. MSDS, University of Akron, Ohio
4. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Boron Trifluoride Empirical Formula: BF3	CAS Number: 7637-07-2

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed on activated carbon due to high vapor pressure, water soluble.

Chemisorption: Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants. (Karwacki, unpublished data, 1999, Emmett, 1943)

Physical Properties

Molecular Weight: 67.81

Boiling Point: -100 C

Vapor Pressure: 1 mmHg at -154.6C, 37392 mm Hg (critical pressure at -12.25 C), Antoine: T=118.5-172.4K A = 4.68215 B = 663.463 C = -30.795 (T = K, log P = bar, NIST)

Volatility: 2.4 (air=1)

Critical Temperature: -12.25 C

Critical Pressure: 49.2 atm

Heat of Vaporization: 68.1 cal/g

Solubility in Water: 369.4 g/100 g water

Liquid Density: 1.57 g/mL at -100.4 C

Toxicity

ACGIH TLV-TWA: 2.8	NIOSH REL-TWA: 2.8	OSHA PEL: 2.8
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. MSDS, Liquid Air Corporation, January 1, 1987
2. MSDS, Howard Hughes Medical Institute
3. MSDS, US Dept of Labor, OSHA, Jan 15, 93
4. The Merck Index, 11th Edition
5. Aldrich
6. OSHA & Siri web sites
7. Handbook of Chemistry and Physics
8. www.hhmi.org/science/labsafe
9. NIST Chemistry Webbook

Chemical Name	Hazard Index: High
Common Name: Carbon Disulfide Empirical Formula: CS2	CAS Number: 75-15-0

Sorptive Properties

Filter Performance Index: Poor

Physical Adsorption: Weak adsorption on activated carbon under dry conditions followed by desorption with increasing relative humidity, low solubility in water (Karwacki, unpublished data, 1999)

Chemisorption: negligible

Physical Properties

Molecular Weight:	76.14
Boiling Point:	46.5
Vapor Pressure:	200 mmHg at 10.4C, 367 mmHg at 25 C, 400 mmHg at 28C, Antoine: T=276.74 - 353.08K A = 4.06683 B = 1168.62 C = -31.616, (T = K, log P = bar, NIST)
Volatility:	2.64 (air =1)
Critical Temperature:	280 C
Critical Pressure:	72.9 atm
Heat of Vaporization:	84.1 cal/g at bp
Solubility in Water:	0.00294 g/g at 20 C
Liquid Density:	1.26 g/mL at 20 C

Toxicity

ACGIH TLV-TWA: 31 mg/m3	NIOSH REL-TWA: 3 mg/m3	OSHA PEL: 60 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL: 30 mg/m3	

References

1. NIST Chemistry WebBook
2. MSDS, Radian Corp, August 29, 1991
3. MSDS, Office of Pollution Prevention and Toxics, August 1994
4. MSDS, Howard Hughes Medical Institute
5. The Merck Index, 11th Edition
6. Prausnitz
7. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Chlorine Empirical Formula: Cl2	CAS Number: 7782-50-5

Sorptive Properties

Filter Performance Index:	Effective
Physical Adsorption:	Weakly adsorbed on activated carbon due to high vapor pressure, water soluble and reactive.
Chemisorption:	Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants and surface oxides of activated carbon. (Bohart, 1920; Rogge, 1959; Garrath, 1992; Karwacki, unpublished data, 1999)

Physical Properties

Molecular Weight:	70.91
Boiling Point:	-34.1 C
Vapor Pressure:	5771 mmHg at 25 C, 400 mmHg at -47.3C,Antoine: T=155-239.3K A=3.02130 B=530.591 C=-64.639, T=239.3-400.2K, A=4.28814 B= -969.992 C=-12.79, (T = K, log P = bar, NIST), T= 172-264, A=15.9610, B= 1978.32, C= -27.01 (T=K, LnP=mm Hg, Prausnitz)
Volatility:	2.4 (air=1)
Critical Temperature:	144C
Critical Pressure:	57836 mmHg, 76.1 atm
Heat of Vaporization:	288.1 kJ/kg
Solubility in Water:	7.3 g/L at 20C, 0.092 moles/L at 25C
Liquid Density:	1.5649 g/mL at -35 C at 0.9949 atm

Toxicity

ACGIH TLV-TWA: 1.45	NIOSH REL-TWA:	OSHA PEL: 2.9
ACGIH TLV-STEL: 2.9	NIOSH REL-STEL:	

References

1. Laboratory Chemical Safety Sheet, Howard Hughes Medical Institute, July 1994
2. MSDS, MedAccess, Office of Pollution Prevention and Toxics, USEPA, August 1994
3. NIST Chemistry WebBook
4. The Merck Index, 11th Edition
5. Prausnitz
6. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Diborane Empirical Formula: B2H6	CAS Number: 19287-45-7

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed on activated carbon due to high vapor pressure, hydrolyzes.

Chemisorption: Chemical is highly unstable in air and humidity. Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants (Karwacki, unpublished data, 1999)

Physical Properties

Molecular Weight:	27.67
Boiling Point:	-92.5 C
Vapor Pressure:	30020 mm Hg critical pressure at 16.7 C, 400 mmHg at -99.6 C, Antoine: T=118.2-180.8 K, A-3.78156, B=598.390, C=-22.175 (T=K, log P=bar, NIST)
Volatility:	<1.0
Critical Temperature:	16.7 C
Critical Pressure:	39.5 atm
Heat of Vaporization:	124.7 cal/g
Solubility in Water:	undergoes hydrolysis, produces H2 and H3BO3
Liquid Density:	0.210 g/mL at 15 C

Toxicity

ACGIH TLV-TWA: 0.11 mg/m3	NIOSH REL-TWA: 0.11 mg/m3	OSHA PEL: 0.11 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. MSDS, Liquid Air, January 1, 1987
2. The Merck Index, 11th Edition
3. NIST Chemistry WebBook
4. MSDS, Radian Corporation, August 29, 1991

Chemical Name	Hazard Index: High
Common Name: Ethylene Oxide Empirical Formula: C2H4O	CAS Number: 75-21-8

Sorptive Properties

Filter Performance Index: Poor

Physical Adsorption:	Moderate adsorption on activated carbon under dry conditions, followed by desorption with increasing relative humidity, miscible in water. (Karwacki, unpublished data, 1999, Goshorn, 1955)
Chemisorption:	Negligible

Physical Properties

Molecular Weight:	44.05
Boiling Point:	10.55 C
Vapor Pressure:	494 mmHg at 0 C, 1336 mmHg at 25 C, Antoine: T=182.59-283.59K, A=4.38578 B=1114.985 C=-29.03, T=273.4-304.9K A=5.84696 B=2022.83 C=62.656 (T=K, log P= bar, NIST), T=200-310 K, A=16.74 B=2567.61 C=-29.01 (T=K, ln P= mm Hg, Prausnitz)
Volatility:	1.52
Critical Temperature:	196C
Critical Pressure:	71 atm
Heat of Vaporization:	138.5 cal/g
Solubility in Water:	miscible
Liquid Density:	0.899 g/ml at 20C

Toxicity

ACGIH TLV-TWA: 1.8 mg/m3	NIOSH REL-TWA: 0.18	OSHA PEL: 1.8
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. NIST Chemistry WebBook
2. MSDS, Radian Corporation, August 29, 1991
3. Prausnitz

Chemical Name	Hazard Index: High
Common Name: Fluorine Empirical Formula: F2	CAS Number: 7782-41-4

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed due to high vapor pressure, reactive in water. (Dickinson, 1942; Dale, 1949; Rees, 1941; Miller, 1950)

Chemisorption: Effective removal by NBC filters due to hydrolysis and reaction with impregnants. Reacts vigorously with organic material. Decomposes in water producing hydrofluoric acid, HF, oxygen fluoride, OF2, hydrogen peroxide, oxygen and ozone.

Physical Properties

Molecular Weight:	37.98
Boiling Point:	-188 C
Vapor Pressure:	Antoine: T=50-85.2K A=4.62315 B=417.961 C=5.414, T=53.99-143.99K A=4.02355 B=322.067 C=-4.748 (T=K, log P=bar, NIST), T= 59-91 K, A=15.67 B=714.1 C=-6.0 (T=K, ln P=mm Hg, Pruasnitz)
Volatility:	1.31 (air=1)
Critical Temperature:	-129 C
Critical Pressure:	55 atm
Heat of Vaporization:	39.8 cal/g
Solubility in Water:	rapid decomposition
Liquid Density:	1.513 g/mL at-188C

Toxicity

ACGIH TLV-TWA: 1.6 mg/m3	NIOSH REL-TWA: 0.2 mg/m3	OSHA PEL: 0.2 mg/m3
ACGIH TLV-STEL: 3.1 mg/m3	NIOSH REL-STEL:	

References

1. MSDS, Allied-Signal, May 1, 1986
2. The Merck Index, 11th Edition
3. NIST Chemistry WebBook
4. Prausnitz
5. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Formaldehyde Empirical Formula: CH2O	CAS Number: 50-00-0

Sorptive Properties

Filter Performance Index: Poor

Physical Adsorption: Moderate to weak adsorption under dry conditions followed by desorption with increasing relative humidity, water soluble. (Karwacki, unpublished data, 1999, Goshorn, 1955; Henry, 1981)

Chemisorption: Negligible

Physical Properties

Molecular Weight: 30.03

Boiling Point: -19.1 C

Vapor Pressure: 3821 mm Hg at 25 C, 100 mmHg at -57.3C,Antoine: T=163.76-250-86K A=4.28176 B=959.43 C=-29.758 (T=-K, log P=bar, NIST), A=16.4775 B=2204.13 C=-30.15 (T=K, ln P=mm Hg, Prausnitz)

Volatility: 1.0 (air =1)

Critical Temperature:

Critical Pressure:

Heat of Vaporization:

Solubility in Water: ca. 0.4 g/g

Liquid Density: 0.815 g/mL at -20C

Toxicity

ACGIH TLV-TWA: 0.37	NIOSH REL-TWA: 0.02	OSHA PEL: 0.92
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. NIST Chemistry WebBook
2. MSDS, Radian Corporation, August 29, 1991
3. MSDS, Howard Hughes Medical Institute
4. Handbook of Chemistry and Physics
5. Prausnitz

Chemical Name	Hazard Index: High
Common Name: Hydrogen Bromide Empirical Formula: HBr	CAS Number: 10035-10-6

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed due to high vapor pressure, but highly reactive

Chemisorption: Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants under humid conditions. Sorption similar to HCl. (Karwacki, unpublished data, 1999)

Physical Properties

Molecular Weight:	80.91
Boiling Point:	-67C
Vapor Pressure:	13377 mmHg at 25C, 15200 mmHg at 16.8C, Antoine: T=134.3-206.6K, A=4.02419 B=695.466 C=-33.542, T=206.6-343.7K A=4.15585 B=754.969 C=-25.086 (T=K, Log P=bar, NIST), A=14.4687 B=1242.53 C=-47.86 (T=K, Ln=mm Hg, Prausnitz)
Volatility:	0.209 (air=1)
Critical Temperature:	89.8 C
Critical Pressure:	84.5 atm
Heat of Vaporization:	51.3 cal/g at bp
Solubility in Water:	1 vol H2O dissolves 600 vols HBr at 0C
Liquid Density:	2.16 g/mL at 216 K

Toxicity

ACGIH TLV-TWA: 10 mg/m3	NIOSH REL-TWA: 10 mg/m3	OSHA PEL: 10 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. NIST Chemistry WebBook
2. Laboratory Chemical Safety Sheet, Howard Hughes Medical Institute
3. MSDS, Liquid Air Corporation, January 1, 1987
4. The Merck Index, 11th Edition
5. Prausnitz
6. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Hydrogen chloride Empirical Formula: HCl	CAS Number: 7647-01-0

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed due to high vapor pressure, water soluble and highly reactive

Chemisorption: Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants. (Pierce, 1942, Karwacki, unpublished data, 1999)

Physical Properties

Molecular Weight:	36.46 g/mole
Boiling Point:	-85C
Vapor Pressure:	30400 mmHg at -17.8C, 34000 mmHg at 25 C, Antoine: T=200-137 K, A=16.5040, B=1714.25 C=-14.45 (T=K, LnP=mm Hg, Prausnitz)
Volatility:	1.257 (air =1)
Critical Temperature:	324.6 K
Critical Pressure:	81.6 atm
Heat of Vaporization:	3860 cal/g-mole at -85C
Solubility in Water:	82.3 g/100 g at 0C, 67.3 g/100 g at 30C
Liquid Density:	1.193 g/L @ 188.1 K

Toxicity

ACGIH TLV-TWA: 7.5 mg/m3	NIOSH REL-TWA: 7 mg/m3	OSHA PEL: 7 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. MSDS, NTP Chemical Repository, Radian Corporation, 29 August 1991
2. MSDS, Liquid Air Corporation, 7 March 1986
3. The Merck Index, 11th Edition
4. NIST Chemistry WebBook
5. Handbook of Chemistry and Physics
6. Prausnitz

Chemical Name	Hazard Index: High
Common Name: Hydrogen cyanide Empirical Formula: HCN	CAS Number: 74-90-8

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Moderate to weak adsorption on activated carbon, water miscible.

Chemisorption: Effective removal by NBC filters due to reaction with metal impregnants. (Wigg, 1942; Wilkins, 1951; Barton, 198 ; Bailey, 1972; Deitz, 1975, 1990; Alves, 1986; Freeman, 1977)

Physical Properties

Molecular Weight:	27.03
Boiling Point:	26 C
Vapor Pressure:	400 mmHg at 10.2C, 735 mmHg at 25C, Antoine: T=256.73-319.38K A=4.67417 B=1340.791 C=-11.592 (T=K, Log P=bar, NIST), T= 330-234K, A=16.5138 B=2585.8 C=-37.15 (T=K, Ln P=mm Hg)
Volatility:	0.071 (air=1)
Critical Temperature:	183.5 C
Critical Pressure:	53.2 atm
Heat of Vaporization:	247 cal/g
Solubility in Water:	miscible
Liquid Density:	0.687 ar293 K

Toxicity

ACGIH TLV-TWA:	NIOSH REL-TWA: 5 mg/m3	OSHA PEL: 11 mg/m3
ACGIH TLV-STEL: 5 mg/m3	NIOSH REL-STEL:	

References

1. NIST Chemistry WebBook
2. MSDS, Howard Hughes Medical Institute
3. MSDS, Liquid Air, January 1, 1987
4. Prausnitz
5. Handbook of Chemistry and Physics
6. The Merck Index, 11th Edition

Chemical Name	Hazard Index: High
Common Name: Hydrogen Fluoride Empirical Formula: HF	CAS Number: 7664-39-3

Sorptive Properties

Filter Performance Index:	Effective
Physical Adsorption:	Weakly adsorbed on activated due to high vapor pressure, water soluble and highly reactive
Chemisorption:	Effective removal by NBC filters due to reaction with metal impregnants. (Otvos, 1943)

Physical Properties

Molecular Weight:	20.01
Boiling Point:	19.51 C
Vapor Pressure:	912 mmHg @ 25C, Antoine: T=273.17-303.09K A=4.9148 B=1556.559 C=24.199 (T=K, Log P= bar, NIST), T = 313-206 K, A=17.6958 B=3404.49 C=15.06 (T=K, Ln P=mm Hg, Prausnitz)
Volatility:	0.15 (air=1)
Critical Temperature:	188C
Critical Pressure:	64 atm
Heat of Vaporization:	80.45 cal/g
Solubility in Water:	very soluble
Liquid Density:	0.967 at 293 K

Toxicity

ACGIH TLV-TWA: 2.5 mg/m3	NIOSH REL-TWA: 2.5 mg/m3	OSHA PEL: 2.5 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. MSDS, Liquid Air Corporation, March 7, 1986
2. NIST Chemistry WebBook
3. The Merck Index, 11th Edition
4. Handbook of Chemistry and Physics
5. Prausnitz

Chemical Name	Hazard Index: High
Common Name: Hydrogen Sulfide Empirical Formula: H2S	CAS Number: 7783-06-4

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption:	Weakly adsorbed on activated carbon due to high vapor pressure, low water solubility.
Chemisorption:	Effective removal by NBC filters due to reaction with metal impregnants. (Benton, 1992)

Physical Properties

Molecular Weight:	34.08
Boiling Point:	-60.7 C
Vapor Pressure:	15200 at 25C, Antoine: T=138.8-212.7K A=4.43681 B=829.439 C=-25.412, T=212.7-349.4K A=4.52887 B=958.587 C=-0.539 (T=K, Log P=bar, NIST), T= 230-190 K, A=16.104 B=1768.69 C=-26.06 (T=K, Ln P=mm Hg, Prausnitz)
Volatility:	1.18 (air=1)
Critical Temperature:	373.6 K
Critical Pressure:	89.05 atm
Heat of Vaporization:	131 cal/g
Solubility in Water:	0.53% at 20C,
Liquid Density:	0.993 g/mL at 213.6 K

Toxicity

ACGIH TLV-TWA: 15 mg/m3	NIOSH REL-TWA: 15 mg/m3 ceiling OSHA PEL: 30 mg/m3 ceiling
ACGIH TLV-STEL: 21 mg/m3	NIOSH REL-STEL:

References

1. MSDS, New Jersey Dept of Health, May 1986
2. NIST Chemistry WebBook
3. Laboratory Chemical Safety Sheet, Howard Hughes Medical Institute
4. MSDS, Radian Corporation, August 29, 1991
5. Schupf Computational Chemistry Lab
6. MSDS, University of Akron, Ohio
7. The Merck Index, 11th Edition
8. Prausnitz
9. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Nitric Acid, Fuming Empirical Formula: HNO3	CAS Number: 7697-37-2

Sorptive Properties

Filter Performance Index: Poor

Physical Adsorption: Nitric acid (fuming) emits high vapor pressure NO2 gas which is weakly adsorbed.

Chemisorption: NO2 is not effectively removed by NBC filters due to complex reactions that are reversible. Nitric acid fraction is chemisorbed initially, but may produce NO and NO2 under certain conditions and desorb from the filter. (Karwacki, unpublished data, 1999, Lewis, 1943)

Physical Properties

Molecular Weight:	63
Boiling Point:	83 C
Vapor Pressure:	Nitric acid: 48 mm Hg at 20 C, NO2: 901 mm Hg at 25 C
Volatility:	2.2 (air=1)
Critical Temperature:	158.2 C NO2
Critical Pressure:	99.96 atm NO2
Heat of Vaporization:	
Solubility in Water:	infinite
Liquid Density:	1.5129 at 100%, 1.0036 at 1%

Toxicity

ACGIH TLV-TWA: 5 mg/m3	NIOSH REL-TWA: 5 mg/m3	OSHA PEL: 5 mg/m3
ACGIH TLV-STEL: 10 mg/m3	NIOSH REL-STEL:	

References

CRC Handbook of Chemistry and Physics
Registry of Toxic Effects of Chemical Substances

Chemical Name	Hazard Index: High
Common Name: Phosgene Empirical Formula: CCl2O	CAS Number: 75-44-5

Sorptive Properties

Filter Performance Index:	Effective
Physical Adsorption:	Weakly adsorbed due to high vapor pressure, water soluble and reactive.
Chemisorption:	Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants. (Nielsen, 1932, ASZM-T Purchase Description, EA-C-1704, 1992)

Physical Properties

Molecular Weight:	98.91
Boiling Point:	7.8 C
Vapor Pressure:	400 mm Hg at -7.6 C, 1180 mm Hg at 20 C, 1215 mm Hg at 20 C, Antoine: T=180.2-281.4K A=3.94888 B=945.332 C=-41.715, T=215.53-281K , A=4.05103 B=978.937 C=-38.717 (T=K, Log P=bar, NIST), T= 213-341 K, A=15.7565 B=2167.31 C=-43.15 (T=K,Ln P=mm Hg, Prausnitz)
Volatility:	3.4 (air =1)
Critical Temperature:	181.9 C
Critical Pressure:	56 atm
Heat of Vaporization:	58.96 cal/g
Solubility in Water:	6.83 g/Lat 25C, rapid hydrolosis in water
Liquid Density:	1.37 g/mL at 20 C

Toxicity

ACGIH TLV-TWA: 0.4 mg/m3	NIOSH REL-TWA: 0.4 mg/m3	OSHA PEL: 0.4 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. MSDS, Physical & Theoretical Chemistry Laboratory at Oxford, August 1, 1987
2. MSDS, Radian Corporation, August 29, 1991
3. The Merck Index, 11th Edition
4. NIST Chemistry WebBook
5. Prausnitz

Chemical Name	Hazard Index: High
Common Name: Phosphorus Trichloride Empirical Formula: Cl3P	CAS Number: 7719-12-2

Sorptive Properties

Filter Performance Index:	Effective
Physical Adsorption:	Moderate adsorption on activated carbon under dry conditions followed by desorption, decomposes in water.
Chemisorption:	Effective removal by NBC filters due to hydrolysis and reaction with metal impregnants. (Goshorn, 1957; Stosick, 1942 on PF3; Dickinson, 1942 on PF3)

Physical Properties

Molecular Weight:	137.33
Boiling Point:	76 C
Vapor Pressure:	118 mmHg at 25 C, 328 mmHg at 50C, 400 mmHg at 56.9 C, Antoine: T=221.5-347.3K A=4.19505 B=1304.4 C=-36.965 (T=K, Log P=bar, NIST)
Volatility:	4.75 (air=1)
Critical Temperature:	563 K
Critical Pressure:	56 atm
Heat of Vaporization:	51.4 cal/g
Solubility in Water:	decomposes in water
Liquid Density:	1.574 g/mL at 294 K

Toxicity

ACGIH TLV-TWA: 1.5 mg/m3	NIOSH REL-TWA: 1.5 mg/m3	OSHA PEL: 3 mg/m3
ACGIH TLV-STEL: 3 mg/m3	NIOSH REL-STEL: 3 mg/m3	

References

1. NIST Chemistry WebBook
2. MSDS, IUCLID, Oct 23, 1995

Chemical Name	Hazard Index: High
Common Name: Sulfur Dioxide Empirical Formula: SO2	CAS Number: 7446-09-5

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Weakly adsorbed on activated carbon due to high vapor pressure.

Chemisorption: Effective removal by NBC filters due to reaction with metal impregnants. (Goshorn, 1955; Leighton, 1942; Harrison, 1983)

Physical Properties

Molecular Weight:	64.06
Boiling Point:	-10 C
Vapor Pressure:	400 mmHg at -23C, 2553 mmHg at 20C, Antoine: T=177.6-263K A=3.48586 B=668.225 C=-72.252, T=263-414.8K A=4.37798 B=966.575 C=-42.071 (T=K, Log P=bar, NIST), T=195-280 K, A=16.768 B=2302.35 C=-35.97 (T=K, Ln P= mm Hg, Prausnitz)
Volatility:	2.26 (air=1)
Critical Temperature:	430 .8 K
Critical Pressure:	77.8 atm
Heat of Vaporization:	92.8 cal/g
Solubility in Water:	10g/100ml H2O at 20C
Liquid Density:	1.455 at 263 K

Toxicity

ACGIH TLV-TWA: 5 mg/m3	NIOSH REL-TWA: 5 mg/m3	OSHA PEL: 13 mg/m3
ACGIH TLV-STEL: 13 mg/m3	NIOSH REL-STEL: 13 mg/m3	

References

1. Laboratory Chemical Safety Sheet, Howard Hughes Medical Institute, July 1994
2. NIST Chemistry WebBook
3. The Merck Index, 11th Edition
4. Prausnitz
5. Handbook of Chemistry and Physics

Chemical Name	Hazard Index: High
Common Name: Sulfuric Acid Empirical Formula: H2SO4	CAS Number: 7664-93-9

Sorptive Properties

Filter Performance Index: Effective

Physical Adsorption: Moderate adsorption on activated carbon, water soluble and reactive. May contain up to three forms of SO3 which range in vapor pressure from 73 to 433 mm Hg at 25 C.

Chemisorption: Sulfur trioxide fraction is likely removed by NBC filters due to reaction with metal impregnants

Physical Properties

Molecular Weight: 98.08

Boiling Point: 290 C

Vapor Pressure: Sulfuric acid fraction, 1 mmHg at 145.8C, 10 mmHg at 194.2 C, 40 mmHg at 229.7C, 100 mmHg at 257C, 0.00117 mmHg at 298K. Sulfur trioxide fraction may contain three forms: alpha 73 mm Hg at 25 C, beta 344 mm Hg at 25 C, gamma 433 mm Hg at 25 C

Volatility:

Critical Temperature:

Critical Pressure:

Heat of Vaporization: 122.1 cal/g

Solubility in Water: infinite

Liquid Density: 1.84 g/mL

Toxicity

ACGIH TLV-TWA: 1 mg/m3	NIOSH REL-TWA: 1 mg/m3	OSHA PEL: 1 mg/m3
ACGIH TLV-STEL:	NIOSH REL-STEL:	

References

1. CRC Handbook of Chemistry and Physics
2. Registry of Toxic Effects of Chemical Substances

Chemical Name	Hazard Index: High
Common Name: Tungsten Hexafluoride Empirical Formula: WF6	CAS Number: 7783-82-6

Sorptive Properties

Filter Performance Index:	Poor
Physical Adsorption:	Weakly adsorbed due to high vapor pressure
Chemisorption:	Effectively removed by ASZM-TEDA adsorbent (Karwacki, unpublished data, 1999, and Olszwski on UF6, 1950)

Physical Properties

Molecular Weight:	297.86
Boiling Point:	17.5 C
Vapor Pressure:	1 mmHg at -71.4C, 10 mmHg at -49.2C, 40 mmHg at -33C, 100 mmHg at -20.3C, 400 mmHg at 1.2C, 760 mmHg at 17.3C, 1038 mm Hg at 25 C.
Volatility:	12.9 g/l
Critical Temperature:	
Critical Pressure:	
Heat of Vaporization:	
Solubility in Water:	
Liquid Density:	3.441 g/mL at 15 C

Toxicity

ACGIH TLV-TWA: 1 mg/m3	NIOSH REL-TWA: 1 mg/m3	OSHA PEL:
ACGIH TLV-STEL: 3 mg/m3	NIOSH REL-STEL: 3 mg/m3	

References

1. CRC Handbook of Chemistry and Physics
2. Registry of Toxic Effects of Chemical Substances