APPENDIX B

APPENDIX B

B.1 The Single-Parameter Wilson Equation

The original Wilson equation relates the activity coefficient to the composition of the mixture. For a binary mixture of components 1 and 2 having a composition of X_1 and X_2 respectively it is written as:

$$\ln \gamma_1 = -\ln(1 - A_{21}X_2) + X_2\left(\frac{X_2A_{12}}{1 - A_{12}X_1} - \frac{X_1A_{21}}{1 - A_{21}X_2}\right) \quad (B-1)$$

$$\ln \gamma_2 = -\ln(1 - A_{12}X_1) - X_1\left(\frac{X_2A_{12}}{1 - A_{12}X_1} - \frac{X_1A_{21}}{1 - A_{21}X_2}\right) \quad (B-2)$$

where

$$A_{21} = 1 - \frac{\overline{v}_2}{\overline{v}_1} \exp(-(g_{21} - g_{11})/RT) \quad (B-3)$$

$$A_{12} = 1 - \frac{\overline{v}_1}{\overline{v}_2} \exp(-(g_{12} - g_{22})/RT) \quad (B-4)$$

$$g_{12} = g_{21} \quad (B-5)$$

$\bar{V}_1$ and $\bar{V}_2$ are the molar volumes. The adjustable constants g_{11}, g_{22} and g_{12} are proportional to the interaction energies between either similar or dissimilar molecules. It is clear that in order to calculate activity coefficient at a composition g_{11}, g_{22} and g_{12} are the 3 basic parameters need to be known.

For g_{11} and g_{22} the energy of interaction between similar molecules, it has been proposed to be replaced by the opposite of the energy of vaporization of the pure components at the solution temperature and pressure.

$$g_{11} = -(\Delta H_{v1} - Z_1 RT) \qquad \text{(B-6)}$$

$$g_{22} = -(-\Delta H_{v2} - Z_2 RT) \qquad \text{(B-7)}$$

ΔH_{v1} and ΔH_{v2}, the heat of vaporization, can be related to vapor pressure by the Classius-Clapeyron equation:

$$\frac{d \ln P_1^s}{dT} = \frac{\Delta H_{v1}}{RT^2} \qquad \text{(B-8)}$$

$$\frac{d\ln P_2^S}{dT} = \frac{\Delta H_{v2}}{RT^2} \qquad \text{(B-9)}$$

substituting equation (B-8) and (B-9) into (B-6) and (B-7) results in:

$$g_{11} = -RT^2 \frac{d\ln P_1^S}{dT} + Z_1 RT \qquad \text{(B-10)}$$

$$g_{22} = -RT^2 \frac{d\ln P_1^S}{dT} + Z_2 RT \qquad \text{(B-11)}$$

The expression of vapor pressure in terms of temperature can simply be found by well-known Antonine equation:

$$\ln P^S = A + \frac{B}{T + C} \qquad \text{(B-12)}$$

where A, B and C are the equation constants and can be found in several publications.

The 3 parameters are now left with only g_{12} to be

solved. This parameter can be determined if one boundary condition is known, namely, the activity coefficient at infinite dilution.

At infinite dilution, $X_1 = 0$, equation (B-1) becomes

$$\ln \gamma_1^{\infty} = - \ln(1 - A_{21}) + A_{12} \qquad \text{(B-13)}$$

substituting equation (B-3) and (B-4) gives:

$$\ln \gamma_1^{\infty} = 1 - \ln(\frac{\bar{V}_2}{\bar{V}_1}) + \frac{\Delta G_1}{RT} - \frac{\bar{V}_1}{\bar{V}_2} \exp(\frac{\Delta G_2}{RT}) \qquad \text{(B-14)}$$

where

$$\Delta G_1 = g_{21} - g_{11} \qquad \text{(B-15)}$$

$$\Delta G_2 = g_{12} - g_{22} \qquad \text{(B-16)}$$

Therefore, once the γ^{∞} at one temperature is known, g_{12} can be solved implicitly form equation (B-14). The γ_1 and γ_2 at various composition can then be calculated and thus

vapor-liquid equilibrium data, such as vapor pressure of solute at the temperature of different concentration in liquid phase, can be obtained.

To solve g_{12} iterative techniques such as Newton's method can be employed. The objective function $F(g_{12})$ is defined as:

$$F(g_{12}) = 1.0 - \ln \frac{\bar{V}_2}{\bar{V}_1} + \frac{\Delta G_1}{RT} - \frac{\bar{V}_1}{\bar{V}_2} \exp\left(\frac{-\Delta G_2}{RT}\right) - \ln \gamma_1^{\infty} \quad \text{(B-17)}$$

The new value of g_{12} from Newton's method algorithm as iteration continues is:

$$F'(g_{12}) = \frac{dF(g_{12})}{dg_{12}} = \frac{1.0}{RT}\left(1.0 + \frac{\bar{V}_1}{\bar{V}_2} \exp\left(\frac{-\Delta G_2}{RT}\right)\right) \quad \text{(B-18)}$$

the derivertive of the function, $F'(g_{12})$, is:

$$g_{12n+1} = g_{12n} - \frac{F(g_{12})_n}{F'(g_{12})_n} \quad \text{(B-19)}$$

The criterion for the termination of iterative procedure is given by:

$$\left| \frac{g_{12n+1} - g_{12n}}{g_{12n+1}} \right| \leq \varepsilon \qquad \text{(B-20)}$$

where ε is a small positive numbe. The computer program that solves g_{12} implicitly and further calculate the vapor pressure of solute at its various compositon in liquid phase is presented in Appendix C.

APPENDIX C

APPENDIX C

C.1 Vapor-Liquid Equilibrium Data

This section includes an interactive program which solves for the Wilson parameter, g_{12} and vapor-liquid equilibrium of absorbed gases over the solvents.

In the experiment, when a mixture of absorbed and non-absorbed gases is inject, it is assumed that the non-absorbed gas appears only in vapor phase, that is, 2 components in liquid phase, 3 components in vapor phase.

The program first asks for the necessary data such as temperature and total pressure of the system, molar volume and Antonine constants for both of absorbed gas and solvent, and activity coefficient at infinite dilution. After implicitly calculating g_{12}, then use equation (B-1) and (B-2) to calculate activity coefficient at various composition.

$$\ln \gamma_1 = -\ln(1 - A_{21}X_2) + X_2\left(\frac{X_2A_{12}}{1 - A_{12}X_1} - \frac{X_1A_{21}}{1 - A_{21}X_2}\right) \quad \text{(B-1)}$$

$$\ln \gamma_2 = -\ln(1 - A_{12}X_1) - X_1\left(\frac{X_2A_{12}}{1 - A_{12}X_1} - \frac{X_1A_{21}}{1 - A_{21}X_2}\right) \quad \text{(B-2)}$$

where

$$X_2 = 1 - X_1$$

With each small increment of compositon of component 1 start from zero, by assuming the system is ideal gas, this program further calculate the partial pressure of component 1 and 2.

$$PP_1 = Y_1 \cdot P_t = \gamma_1 \cdot X_1 \cdot P_1^S \qquad (C-1)$$

$$PP_2 = Y_2 \cdot P_t = \gamma_2 \cdot X_2 \cdot P_2^S \qquad (C-2)$$

$$PP_3 = P_t - PP_1 - PP_2 \qquad (C-3)$$

where P_t = total pressure of system

PP = partial pressure

X = mole fraction in liquid phase

Y = mole fraction in vapor phase

P^S = vapor pressure at system temperature.

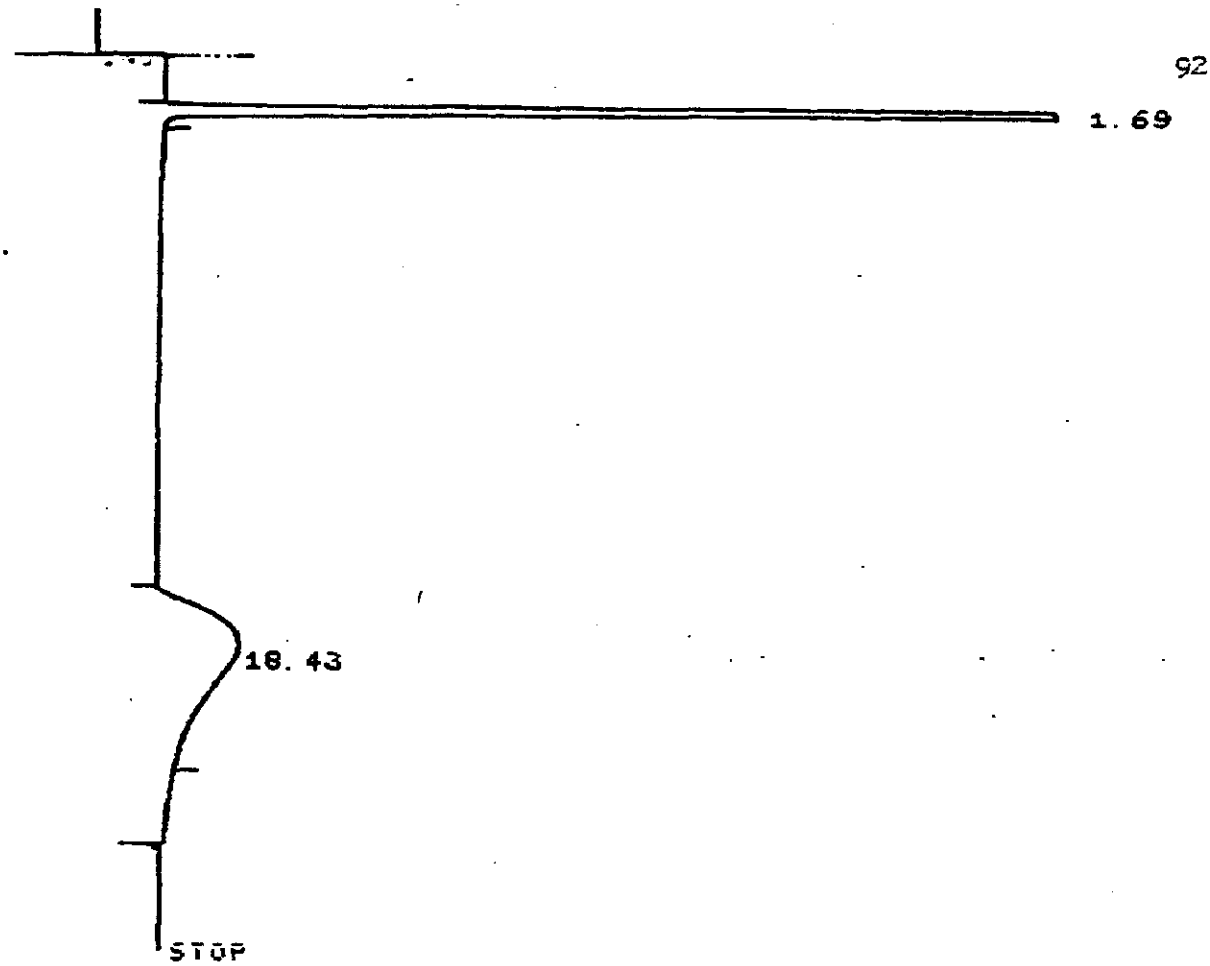
and the subscripts:

1 is component 1, the absorbed gas (NO, NO_2 or SO_2)

2 is component 2, the solvent

3 is component 3, the nonabsorbed gas (air or N_2)

APPENDIX D

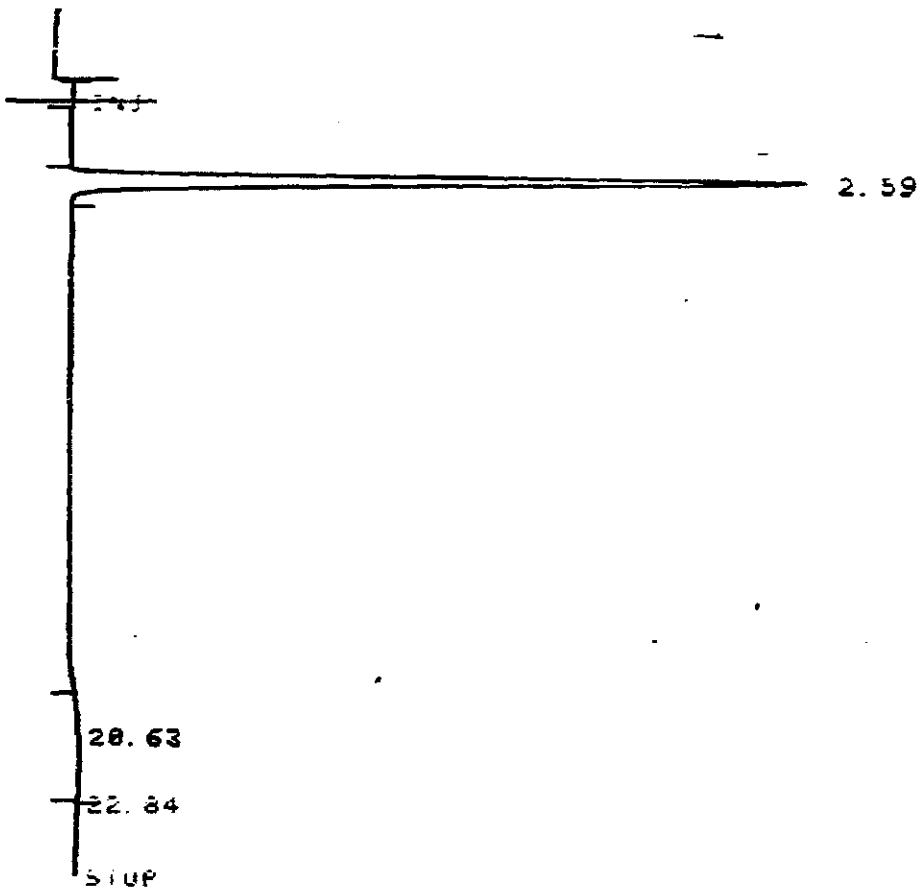


RT	TYPE	AREA	%
1.69		463973	68.72
18.43		211156	31.28

HP 3380H
DLY OFF STOP OFF REJECT OFF
MIN .30 MIN 16

Solvent Loading: 17.8%
Room Temp: 25 C
Column Temp: 100 C
Inlet Pressure: 11.8 psig
Gas Flow Rate: 27.03 cc/min
Rent. Time Diff.: 16.74 min
Henry's Constant: 2.40 atm
Act. Coefficient: 0.088

Fig. D-1 SO_2 & CHP System

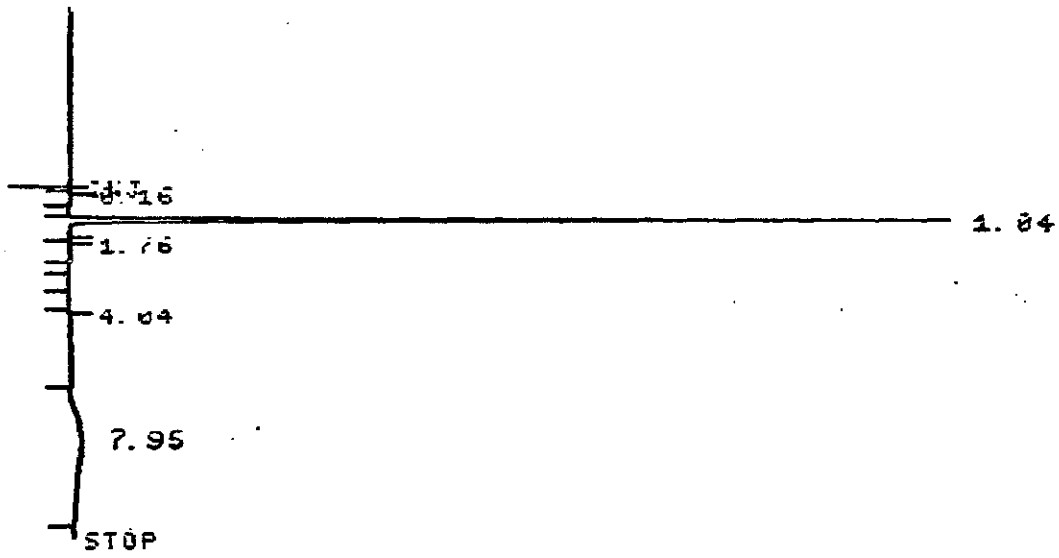


RT	TYPE	AREA	AREA %
2.59		424349	95.11
20.63		21802	4.887

HP 3380H
DLY OFF STOP OFF REJECT 1000
MV/M .10 MIN 32

Solvent Loading: 42.68%	**Room Temp: 28 C**
column Temp: 60 C	**Inlet Pressure: 6.5 psig**
Gas Flow Rate: 11.82 cc/min	**Rent. Time Diff.: 18.04 min**
Henry's Constant: 17.26 atm	**Act. Coefficient: 1.612**

Fig. D-2 SO_2 & DETA System

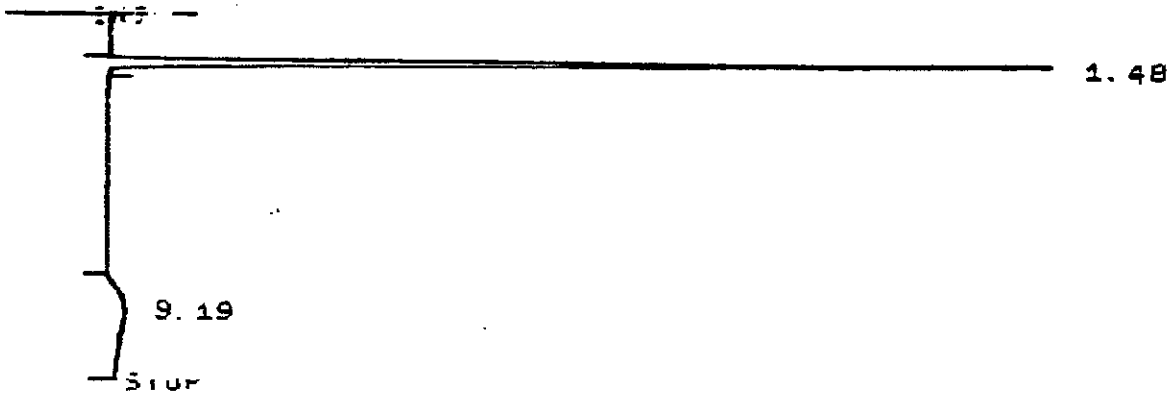


RT	TYPE	AREA	AREA %
1.04		127150	75.98
7.95		40106	24.02

[illegible]			
DLY OFF	STOP OFF	REJECT	1000
MV/M 10	ATTN 32		

Solvent Loading: 42.68%	**Room Temp: 28 C**
Column Temp: 60 C	**Inlet Pressure: 15.1 psig**
Gas Flow Rate: 39.37 cc/min	**Rent. Time Diff.: 6.91 min**
Henry's Constant: 17.23 atm	**Act. Coefficient: 1.59**

Fig. D-3 SO_2 & DETA System

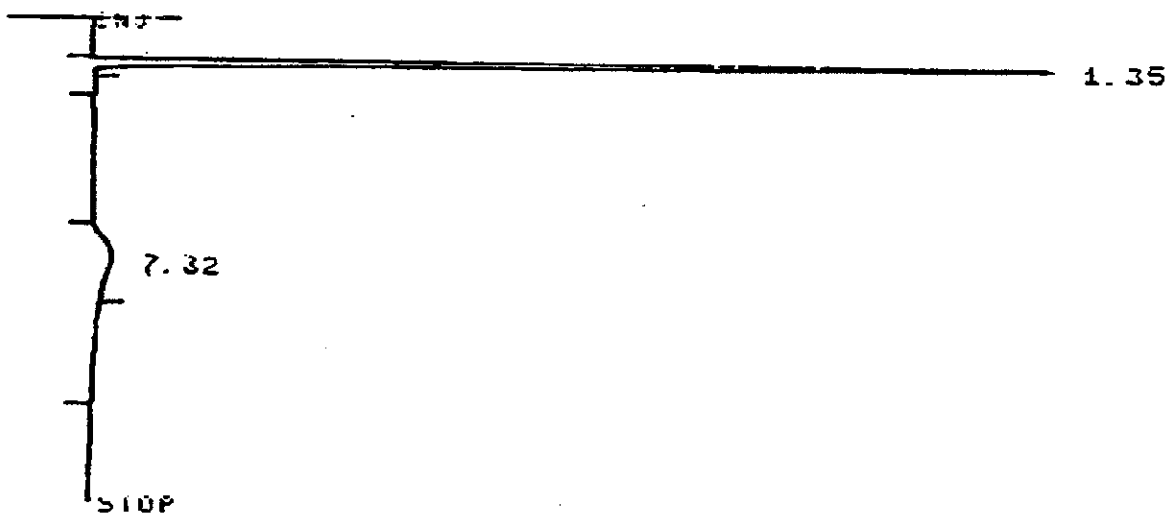


RT	TYPE	AREA	
1.48		227800	76.96
9.19	I	68206	23.04

HP 3390A
DLY OFF STOP OFF REJECT 1000
MW/N .10 ATTN ↑

Solvent Loading: 42.68%
Room Temp: 28 C
Column Temp: 70 C
Inlet Pressure: 11.0 psig
Gas Flow Rate: 24.14 cc/min
Rent. Time Diff.: 7.71 min
Henry's Constant: 22.56 atm
Act. Coefficient: 1.62

Fig. D-4 SO_2 & DETA System



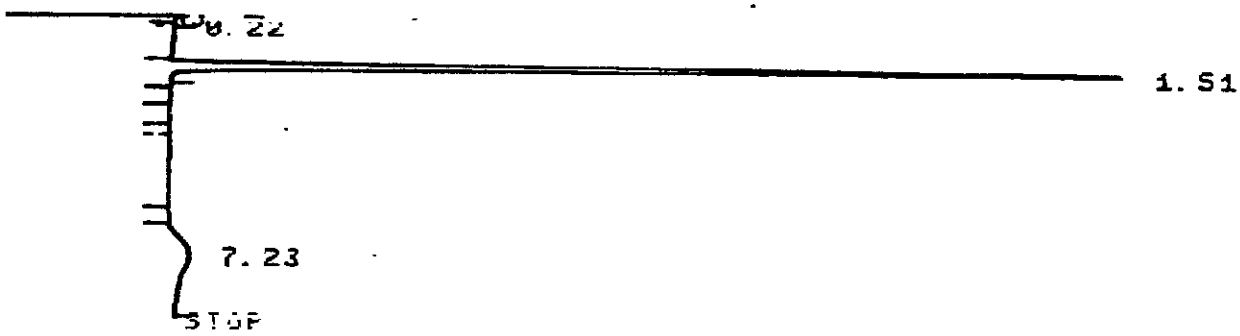
AREA %

RT	TYPE	AREA	
1.35		247809	86.6
7.32		38336	13.4

HP 3380A
DLY OFF STOP OFF REJECT 1000
MV/M .30 ATTN 32

Solvent Loading: 42.68%
Room Temp: 28 C
Column Temp: 80 C
Inlet Pressure: 12.0 psig
Gas Flow Rate: 26.13 cc/min
Rent. Time Diff.: 5.97 min
Henry's Constant: 27.67 atm
Act. Coefficient: 1.57

Fig. D-5 SO_2 & DETA System

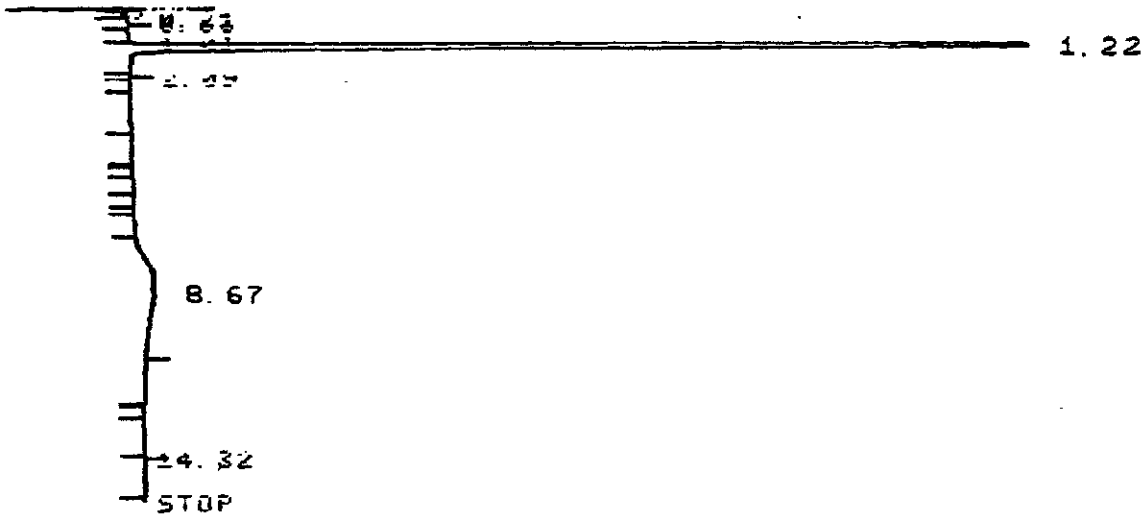


RT	TYPE	AREA	%
1.51		250598	84.23
7.23		46923	15.77

F 3380A
Y OFF STOP OFF REJECT 1000
/M ↑

Solvent Loading: 42.68%	**Room Temp.: 28°C**
Column Temperature: 90°C	**Inlet Pressure: 10.9 psig**
Gas Flow Rate: 22.08 cc/min	**Rent. Time Diff.: 5.72 min**
Henry's Constant: 33.15 atm	**Act. Coefficient: 1.503**

Fig. D-6. SO_2 and DETA System



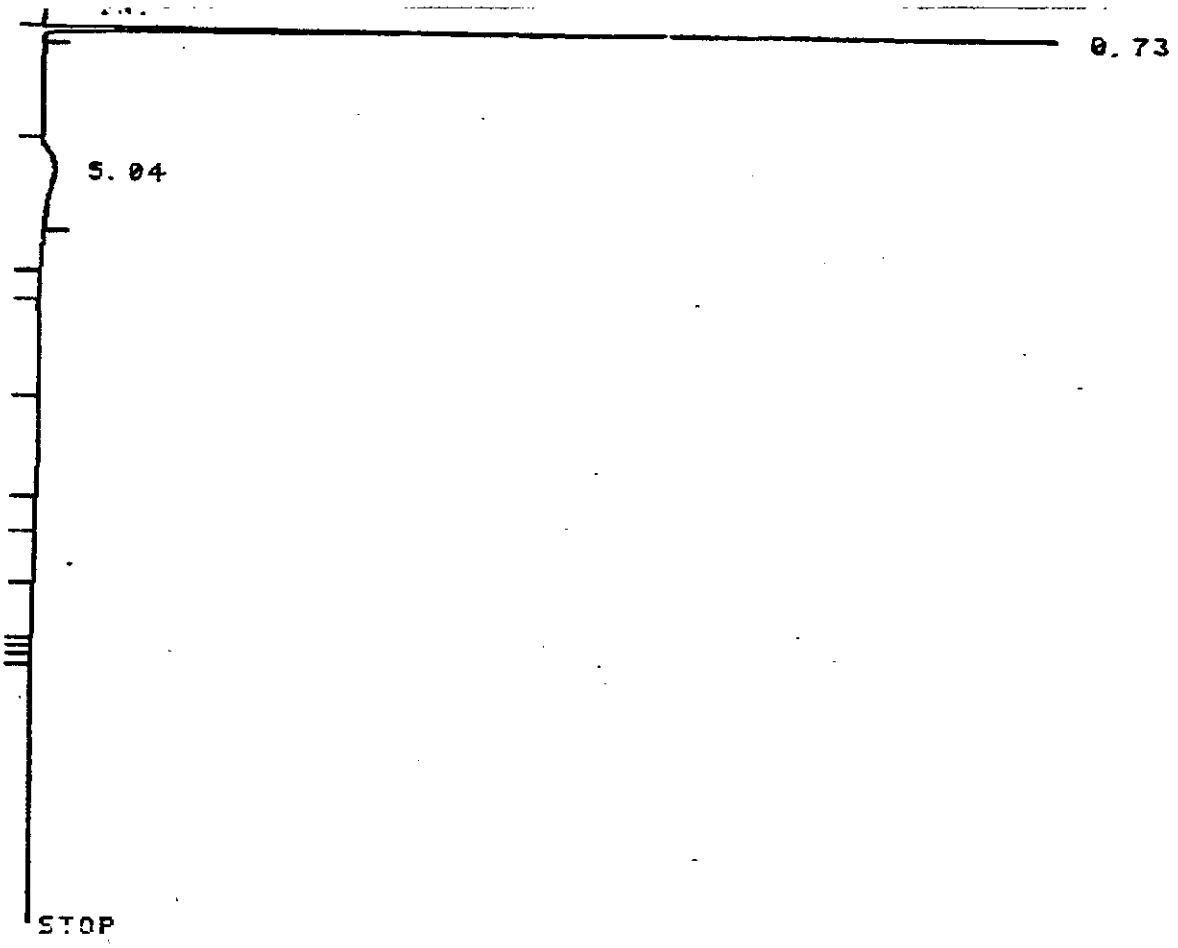
RT	TYPE	AREA	
1.22	M	189133	86.53
6.67		29435	13.47

HP 3380A
DLY OFF STOP 50 REJECT 1000
MKTM .10 MIN 16

Solvent Loading: 57.5%
Column Temp: 70 C
Gas Flow Rate: 26.62 cc/min
Henry's Constant: 20.26 atm

Room Temp: 23 C
Inlet Pressure: 12.2 psig
Rent. Time Diff.: 7.45 min
Act. Coefficient: 1.453

Fig. D-7 SO_2 & TETA System

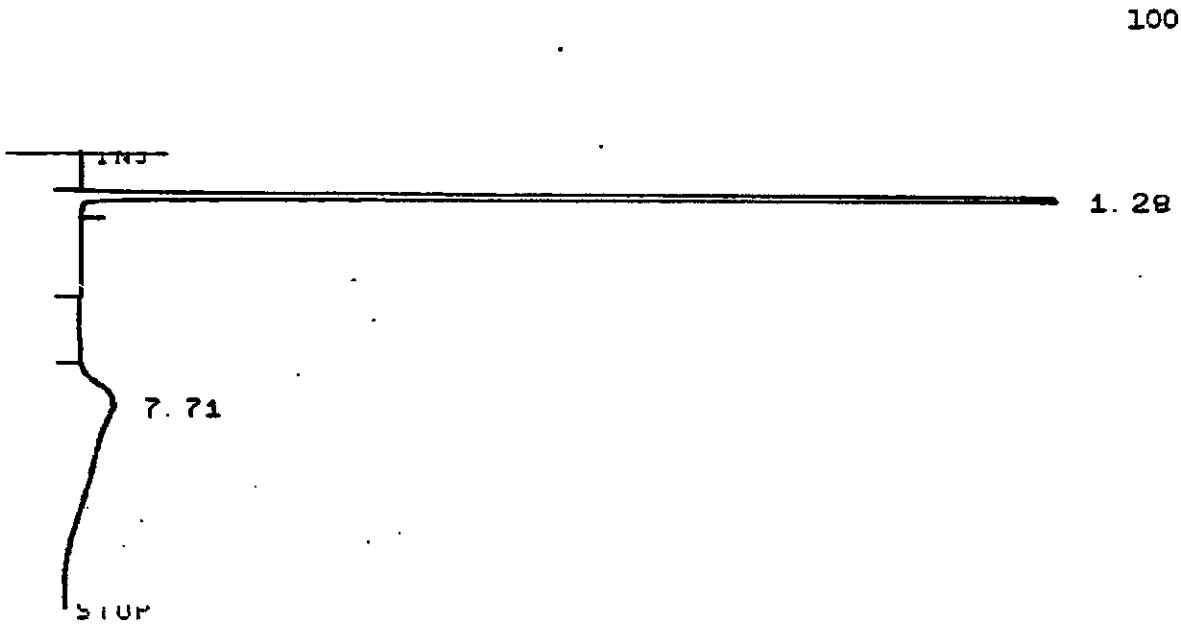


RT	TYPE	AREA	AREA %
.73		94155	85.87
5.04		15491	14.13

P 3380M
LY OFF
ATT .10
STOP 30
ATTN 16
REJECT 1000

Solvent Loading: 57.5%	Room Temp: 23 C
Column Temp: 70 C	Inlet Pressure: 20.5 psig
Gas Flow Rate: 57.47 cc/min	Rent. Time Diff.: 4.31 min
Henry's Constant: 19.98 atm	Act. Coefficient: 1.433

Fig. D-8 SO_2 & TETA System



Solvent Loading: 57.5%

Room Temp: 28 C

Column Temp: 80 C

Inlet Pressure: 11.5 psig

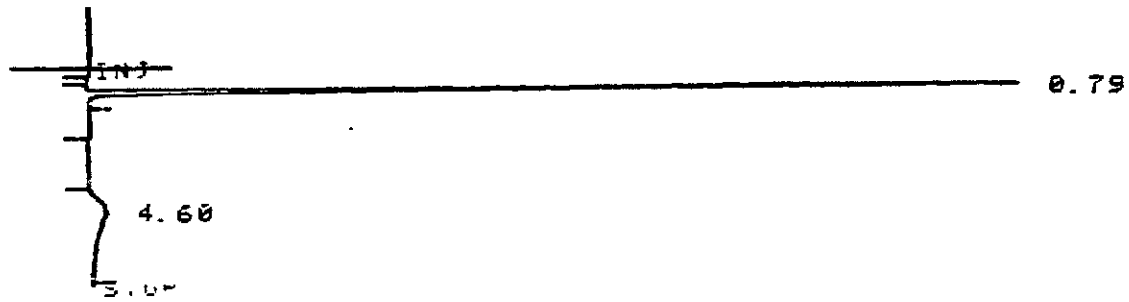
Gas Flow Rate: 24.96 cc/min

Rent. Time Diff.: 6.43 min

Henry's Constant: 25.27 atm

Act. Coefficient: 1.43

Fig. D-9 SO_2 & TETA System



RT	TYPE	AREA	AREA %
.79		115490	84.78
4.60		20726	15.22

Solvent Loading: 57.5%

Column Temp: 80 C

Gas Flow Rate: 50.93 cc/min

Henry's Constant: 25.17 atm

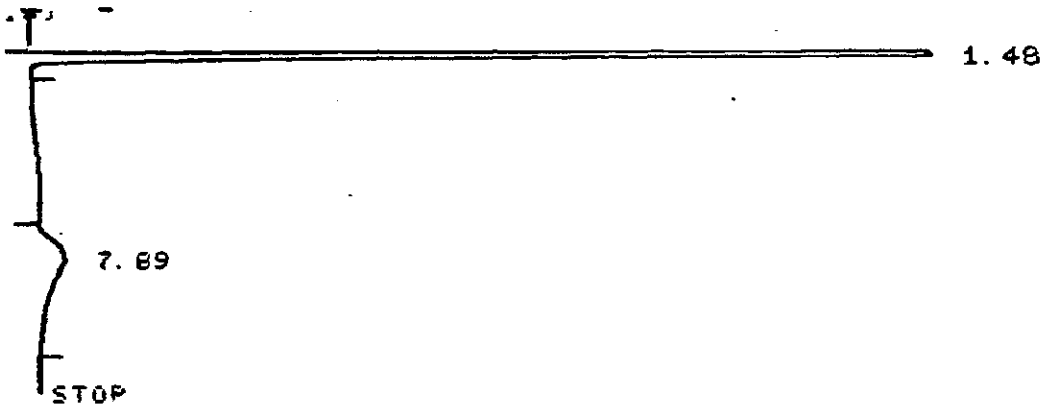
Room Temp: 28 C

Inlet Pressure: 18.8 psig

Rent. Time Diff.: 3.81 min

Act. Coefficient: 1.43

Fig. D-10 SO_2 & TETA System



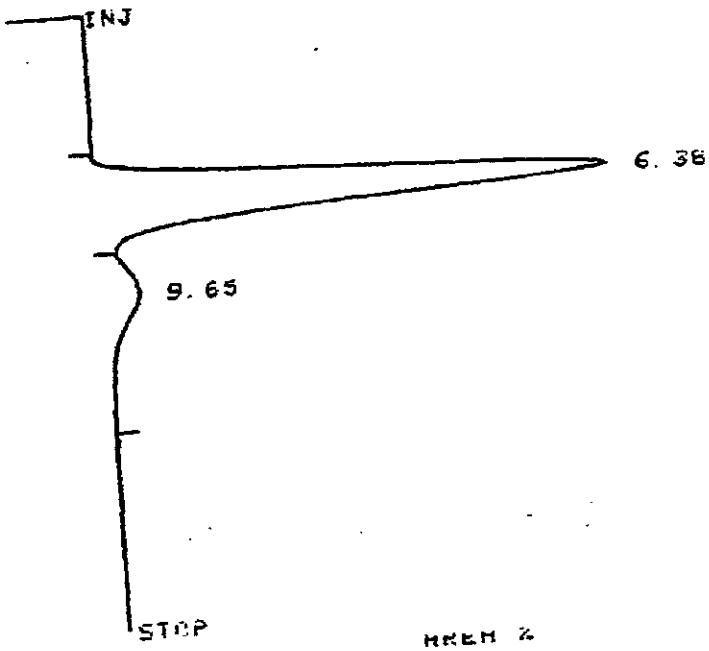
AREA %

RT	TYPE	AREA	
48		287580	86.38
89		45345	13.62

olvent Loading: 57.5%
olumn Temp: 90 C
as Flow Rate: 20.46 cc/min
enry's Constant: 29.82 atm

Room Temp: 28 C
Inlet Pressure: 10.4 psig
Rent. Time Diff.: 6.41 min
Act. Coefficient: 1.35

Fig. D-11 SO_2 & TETA System



AREA %

RT	TYPE	AREA	
6.38		1299501	87.41
9.65	M	187106	12.59

P 3380Å
LT OFF
WDTH .10

STOP TO
MIN 32

REJECT 1000

Solvent Loading: 53.2%

Column Temp: 49 C

Gas Flow Rate: 3.37 cc/min

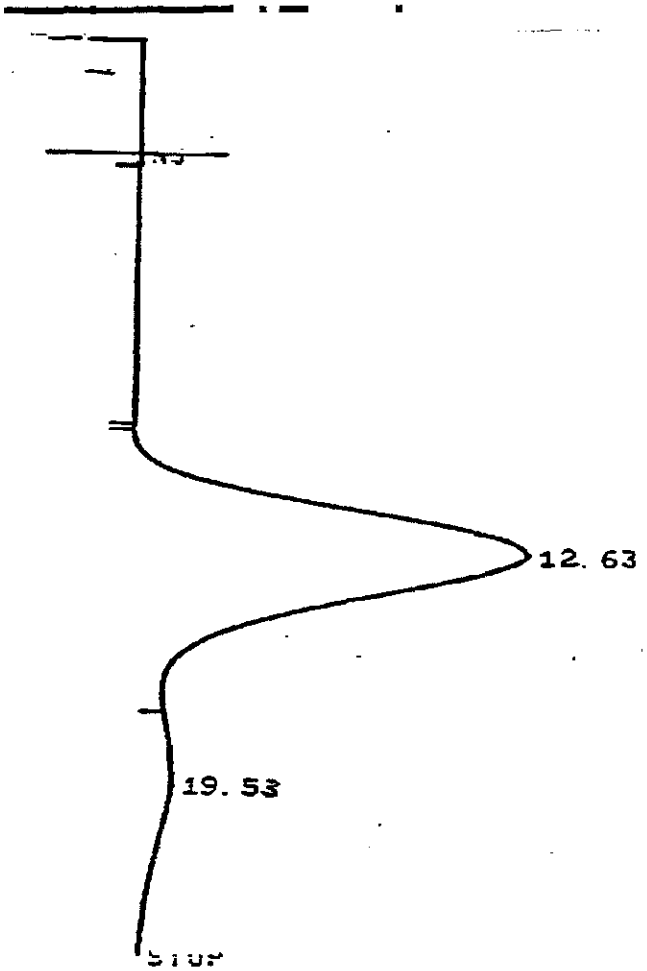
Henry's Constant: 245.89 atm

Room Temp: 25 C

Inlet Pressure: 2.2 psig

Rent. Time Diff.: 3.27 min

Fig. D-12 NO & TETA System



104

RT	TYPE	AREA	
53		2540577	84.87
53	IM	452756	15.13

Solvent Loading: 53.2%

Column Temp: 49 C

Gas Flow Rate: 1.62 cc/min

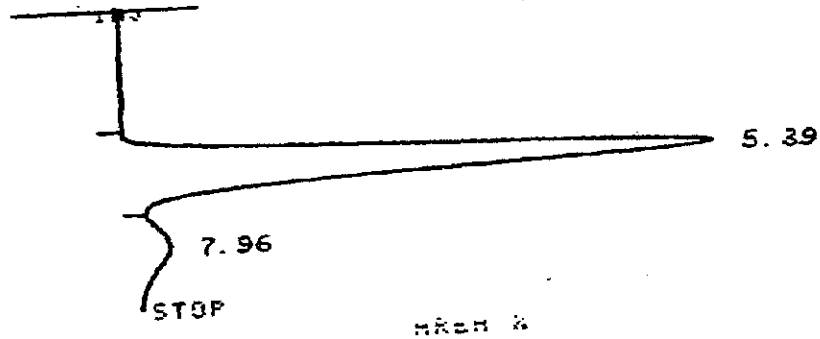
Henry's Constant: 255.58 atm

Room Temp: 25 C

Inlet Pressure: 0.7 psig

Rent. Time Diff.: 6.90 min

Fig. D-13 NO & TETA System



RT	TYPE	AREA	
5.39		1135140	86.06
7.96	IM	183879	13.94

Solvent Loading: 53.2%

Column Temp: 59 C

Gas Flow Rate: 4.46 cc/min

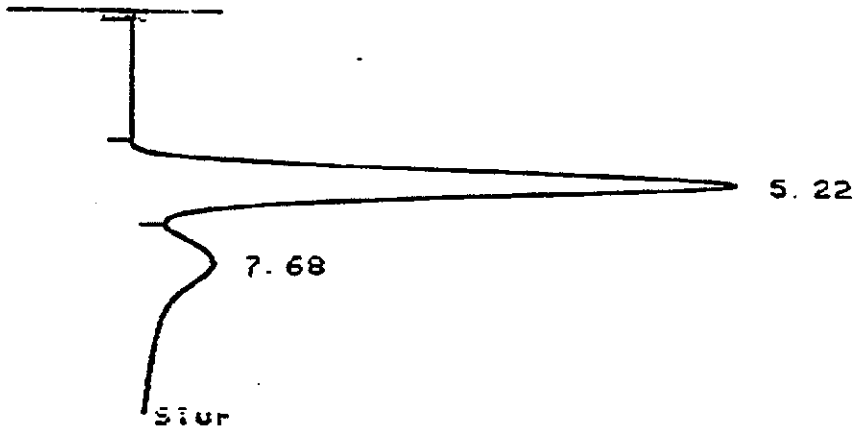
Henry's Constant: 275.55 atm

Room Temp: 25 C

Inlet Pressure: 2.8 psig

Rent. Time Diff.: 2.57 min

Fig. D-14 NO & TETA System



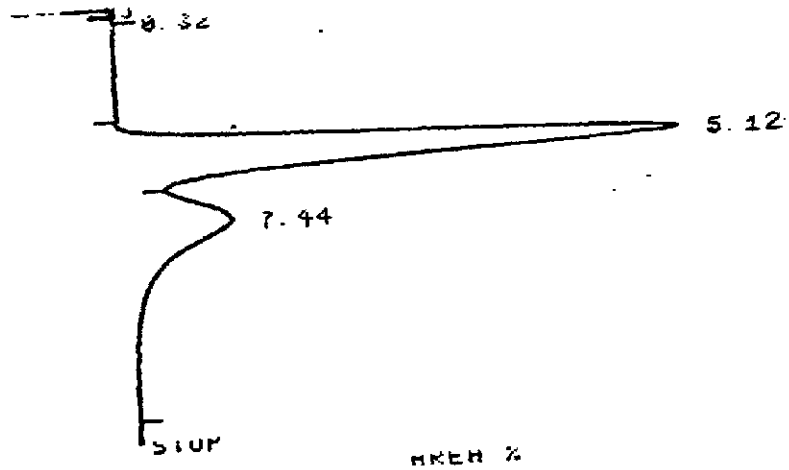
RT	TYPE	AREA	AREA %
22		1027846	71.38
68	IM	412106	28.62

OFF STOP 90 REJECT 1000
1 .10 ATTN 32

olvent Loading: 53.2%
olumn Temp: 70 C
as Flow Rate: 4.46 cc/min
enry's Constant: 297.41 atm

Room Temp: 25 C
Inlet Pressure: 2.8 psig
Rent. Time Diff.: 2.46 min

Fig. D-15 NO & TETA System



AREA %

RT	TYPE	AREA	
5.12		1059021	68.2
7.44	M	493768	31.8

3380M
Y OFF
M .10

STOP OFF
ATTN 32

REJECT 1000

Solvent Loading: 53.2%

Column Temp: 80 C

Gas Flow Rate: 4.46 cc/min

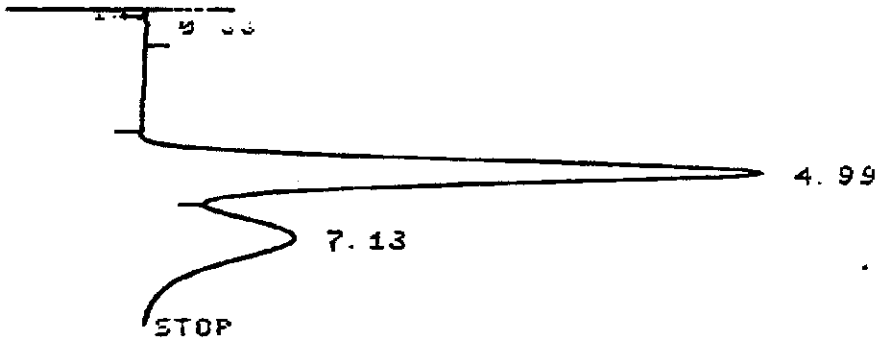
Henry's Constant: 324.55 atm

Room Temp: 25 C

Inlet Pressure: 2.8 psig

Rent. Time Diff.: 2.32 min

Fig. D-16 NO & TETA System



RT	Type	Area	
4.99		1036918	67.72
7.13	IM	494183	32.28

HP 3380A
DLY OFF STOP 30 REJECT 1000
MKR .10 ATTN 32

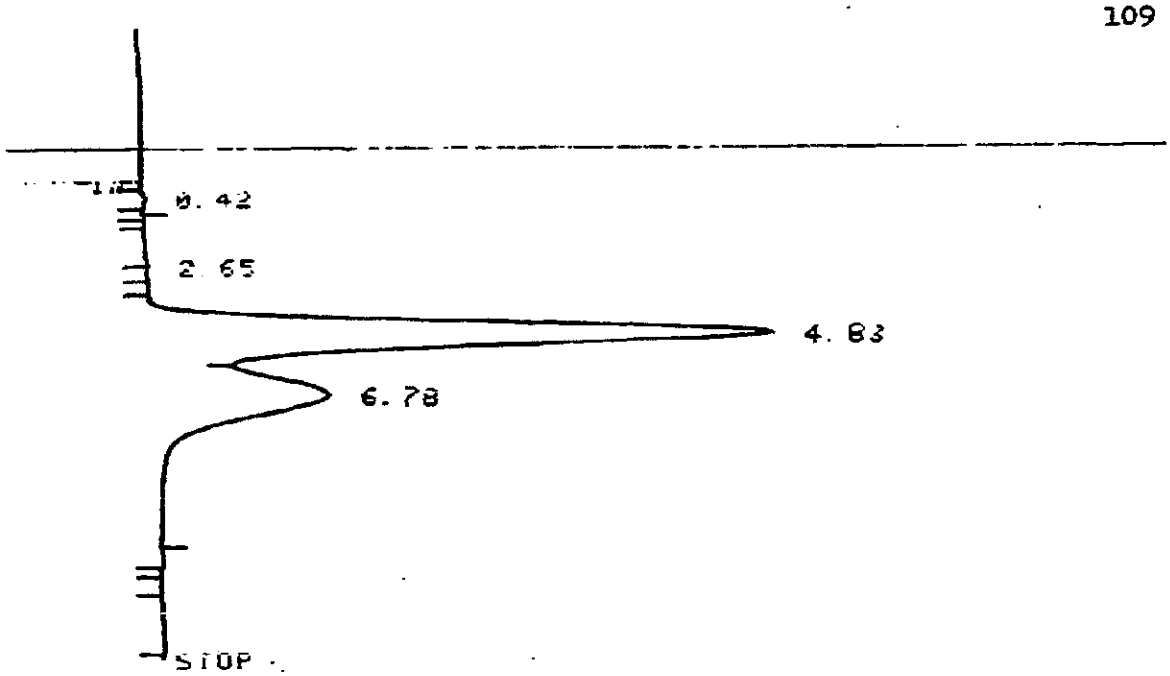
Solvent Loading: 53.2% **Room Temp: 25 C**

Column Temp: 90 C **Inlet Pressure: 2.8 psig**

Gas Flow Rate: 4.46 cc/min **Rent. Time Diff.: 2.14 min**

Henry's constant: 361.81 atm

Fig. D-17 NO & TETA System



AREA %

RT	TYPE	AREA	
.42		1167	.075 99
4.83		1018117	66.29
6.78	M	516503	33.63

3200A
Y OFF STOP 30 REJECT 1000
ZM .10 MIN 32

Solvent Loading: 53.2%

Column Temp: 90 C

Gas Flow Rate: 4.46 cc/min

Henry's Constant: 408.01 atm

Room Temp: 25 C

Inlet Pressure: 2.8 psig

Rent. Time Diff.: 1.95 min

Fig. D-18 NO & TETA System

APPENDIX E

TABLE E-1

Antoine Equation's Constants

$$\ln P^S = A + \frac{B}{T+C}$$

[P] = mmHg [K] = Kelvin

Solvent	A	B	C	Ref.
SO_2	16.77	-2302.35	-35.97	21
CHP	21.4	-7850.9	-1.0	22
TETA	39.3	-29647.2	408.6	23
DETA	10.3	-1319.4	-182.1	23

Biblography

1. Considine,D.M., ed.,Energy Technology Handbook, "Wet Scrubbing Process ---- SO_2 and NOx Removal Chemistry by R. G. Neville," (New York: McGraw-Hill, 1977), Chapter 9, p.312.

2. Sax, N.I.,Dangerous Properties of Industrial Material, 4th Ed., (New York: Van Nostrand Reinhold Company), p.1195.

3. Considine, D.M., op. cit., p.313.

4. Hudson, J. L. and Rochelle, G. T., eds,Advances in Chemistry Serier No. 188, "Kinetics of Reactions in a Wet Flue Gas Simultaneous Desulfurization and Denitrification System by S. G. Chang, D. Littlejohn and N. H. Lin," (Wash. D.C.: American Chemical Society, 1982), Chapter 7, pp. 127-152.

5. Johnstone, H.F., "Recovery of Sulfur Dioxide from Waste Gases: Equilibrium Partial Vapor Pressures Over Solutions of the Ammonia-Sulfur Dioxide-Water System," Industrial and Engineering Chemistry, Vol. 27, No. 5 (May, 1935), pp. 587-592.

6. Johnstone, H.F., Read, H.J. and Blankmeyer, H.C., "Recovery of Sulfur Dioxide from Waste Gases: Equilibrium Vapor Pressures over Sulfite-Bisulfite Solution," Industrial and Engineering Chemistry, Vol. 30, No. 1 (January 1938), pp. 101-9.

7. Hikita, H., Asai, S., Ishikawa. H, Hirano, S., "Kinetics of Absorption of Nitric Oxide in Aqueous Acidic Solotions of Ferrous Sulfate," Journal of Chemical Engineering of Japan, Vol. 10 (1977), pp. 120-4.

8. Uchida, S., Kobayashi, T. and Kageyama, S., "Absorption of Nitrogen Monoxide into Aqueous $KMnO_4$/NaOH and $Na_2SO_3/FeSO_4$ Solutions," Industrial Engineering Chemical Process Design and Development, Vol. 22 (1983), pp. 323-9.

9. Sada, E. and Kumazawa H., "Individual and Simultaneous Absorption of Dilute NO and SO_2 in Aqueous Slurries of $MgSO_3$ with Fe^{II}-EDTA," Industrial Engineering Chemical Process Design and Development, Vol. 19 (1980), pp. 377-382.

10. Jimeson, R. M., and Spirint, R. S., eds., Advances in Chemistry Series 127, "Adueous Scrubbing of Nitrogen Oxides from Stack Gases by G. A. Chappell," (Wash. D.C.:American Chemical Society, 1973), Chapter 18, pp.206-217.

11. Sartori, G. and Savage, D.W. (July 18, 1978) U.S. Patent 4 101 633.

12. James, A.T. and Martin, A.J.P., "Gas-Liquid Partition chromatography: The Separation and Micro-Estimation of Volatile Fatty Acids from Formic Acid to Dodecanoic Acid," Biochemical Journal, Vol. 50 (1952), pp. 679-690.

13. Stock, R. and Rice, C.B.F., Chromatographic Methods, 3rd ed., "Gas Chromagraphy," (New York: John Wiley & Sons, 1974), Chapter 4, p.225.

14. Sheets, M.R. and Marchello, J.M., "Rate Extractive Distillation Solvents," Hydrocarbon Processing and Petroleum Refiner, Vol. 42, No. 12 (December, 1963), pp. 99-103.

15. Personal Communication with Technical Service Representative, Supelco, Inc.

16. Parcher, J.F., Weiner, P.H., Hussey, C.L. and Westlake T.N., "Specific Retention Volumes and Limiting Activity Coefficients of C_4 - C_8 Alkane Solutes in C_{22} - C_{36} n-alkane Solvents," Journal of Chemical and Engineering Data, Vol. 20, No. 2 (1975), pp. 145-151.

17. Conder, J.R. and Young, C.L., Physicochemical Measurement by Gas Chromatography, (New York: John wiley & Sons, 1979), Chapter 5, p. 213.

18. Ng, C., Harris, H.G. and Prausnitz, J.M., "Henry's constants for Methane, Ethane, Ethylene, Propane and Propylene in Octadecane, Eicosane and Docosane", Journal of Chemical and Engineering Data, Vol. 14, No. 4 (October 1969) pp. 432-433.

19. Littlewood, A. B., Phillips, C. S. and Price, D. T., "The Chromatography of Gases and Vapors; Part V: Partition Analysis with Columns of Silicone 702 and of Tritolyl Phosphate," Journal of Chemical Society, 1955, pp. 1480-1485.

20. Martire, D.E., "Application of the Theory of Solutions to the Choice of Solvent for Gas-Liquid Chromatography," Analytical Chemistry, Vol. 33, No. 9 (August, 1961) pp. 1143-7.

21. Reid, C. R., Prausnitz, M. J. and Sherwood, T. K., The Properties of Gases and Liquid, "Property Data Bank," 3rd Ed. (New York: McGraw-Hill Book Company, 1977), Appendix A, p.632.

22. Data From Dr. R. J. Walker.

23. Wilson, A. L., "New Aliphatic Amines," Industrial and Engineering Chemistry, Vol. 8, No. 27 (August, 1935), pp.867-871.

24. Way, J.D., Noble, R.D., Flynn, T.M. and Sloan, E.D., "Liquid Membrane Transport: A Survey," Journal of Membrane Science, Vol. 12 (1982), pp. 239-259.

25. Cussler, E. L., Multicomponent Diffusion, "Carrier-Containing Membranes," (New York: Elsevier Scientific Publishing Company), 1976, Chapter 8, p.112.

26. Ward, W.J., "Analytical and Experimental Studies of Facilitated Transport," AIChE Journal, Vol. 16, No. 3 (May, 1970), pp. 405-410.

27. Li, N.N., "Encapsulation and Separation by Liquid Surfactant Membranes," The Chemical Engineer, (July 1981), pp. 325-327.

28. Schultz, J. S., Goddard, J. D. and Suchdeo, S. R., "Facilitated Transport via Carrier-Mediated Diffusion in Membranes, Part I.," AIChE Journal, Vol. 20 (1974), pp. 417-444.

29. Schultz, J. S., Goddard, J. D. and Suchdeo, S. R., "Facilitated Transport via Carrier-Mediated Diffusion in Membranes, Part II.," AIChE Journal, Vol. 20 (1974), pp. 625-645.

30. Smith, D.R., Lander, R.J. and Quinn, J.A., "Carrier-Mediated Transport in Synthetic Membranes," in Li, N.N. (Ed.), Recent Developments in Separation Science, Vol. 3, CRC Press, Cleveland, Ohio, (1977).

31. Kimura, S.G., Matson, S.L. and Ward, W.J., "Industrial Applications of Facilitated Transport by Li, N. N.," Recent Developments in Separation Science, Vol. 5, CRC Press, Cleveland, Chio (1979).

32. Goddard, J.D., "Further Application of Carrier-Mediated Transport Theory - A Survey," Chemical Engineering Science, Vol. 32 (1977), pp. 795-809.

33. Cussler, E. L., op. cit., pp.138-9.

34. Personal Communication with T. Snyder, Research & Development Department in Westing House.

35. Tassios, D., "A Single-Parameter Equation for Isothermal Vapor-Liquid Equilibrium Correlations," AIChE Journal, Vol. 17, No. 6 (November, 1971), pp. 1367-71.

36. Ambrose, D., Keulemans A.I.M. and Purnell, J.H., "Presentation of Gas-Liquid Chromatographic Retention Data," Analytical Chemistry, Vol. 30, No. 10 (October 1958), pp. 1582-6.

37. Wicarova, O., Novak, J. and Janak, J. "A Study on the Reliability of the Excess Enthalpies Calculated from Gas-Liquid Chromatographic Retention Data," Journal of Chromatography, Vol. 65 (1972), pp. 241-8.

NOMENCLATURE

A	First Antonie equation constant
A	Wilson's equation constant
B	Second Antonie equation constant
C	Third Antonie equation constant
D	Molar conc. in gas phase
F	Gas flow rate (cc/min)
g	Binary energy interaction paramter (cal/g-mole)
H_v	Heat of vaporization
H	Henry's law constant (atm)
J	Pressure correct factor
K	Partition coefficient
M	Molecule weight (solvent)
n	Number of moles
P_i	Inlet pressure (psi or mmHg)
P_o	Outlet pressure (psi or mmHg)
p^s	Vapor pressure (psi or mmHg)
P_t	Total pressure of a system (psi or mmHg)

P_w	Vapor pressure of water (psi or mmHg)
Q	Molar conc. in liquid phase
R	Gas constant
S	Retention ratio
T	Temperature (K)
T_c	Column temperature (K)
T_r	Room temperature (K)
t	Retention time difference (min)
t_m	Time for non-absorbed gas to pass the column
t_r	Time for absorbed gas to pass the column
V	Volume
V_s	Specific retention volume (cc/g)
V_m	Gas hold up volume
V_n	Net retention volume (cc)
V_r	Retention volume
$\bar{V}$	Molar volume (cc/g-mole)
W	Weight of solvent (g)
X	Mole fraction in liquid phase
Y	Mole fraction in gas phase
Z	Gas compressibility factor

Greek Letters

ϕ	Fugacity coefficient
γ	Activity coefficient
Ω	Uncertanity range

Superscript

$^{\circ}$	Corrected paramter
$^{\infty}$	Infinite dilution

Subscript

1	Component 1, or solute
2	Component 2, or solvnet
3	Component 3, or inert gas
i	The solute in Henry's law constant
j	the solvent in Henry's law constant
$_{\ell}$	Liquid phase
g	Gas phase