

POROUS POLYMERS

Since the development of porous polymers for use in gas chromatography by Hollis and Hayes in the mid 1960's, very little has been done to improve their performance. Commercial polymers such as Porapak® and Chromasorb® have been available since this time for chromatographic use. However these commercially available polymers have been plagued with problems such as batch-to-batch variations, incomplete or inadequate cleanup and shrinkage. These variations and inconsistencies in production and handling have led to poor performance and reproducibility.

HayeSep® analytical polymers and packed columns are now available to chromatographers at a reasonable cost. Hayes Separations, Inc. takes pride in providing the necessary technical assistance to support our users. We guarantee that our polymers are better than any other on the market and we are continuing to develop and test new packings for specific separation problems.

HayeSep® polymers are thoroughly cleaned and pre-conditioned for twelve hours under oxygen-free nitrogen before packaging. These handling techniques produce polymers which are consistently the same, with no shrinkage and minimum bleed. Columns packed with HayeSep® require minimum conditioning.

HayeSep® Polymer	Maximum Operating Temp.	Surface Area m ² /gram	Tapped Bulk Density gram/cc	Polymer Composition*	Polarity (1=lowest 9=highest)
A	165°C	526	0.356	DVB (high purity) EGDM (high purity)	7
B	190°C	608	0.330	DVB/PEI	8
C	250°C	442	0.322	DVB/ACN	6
D	290°C	795	0.3311	DVB (high purity)	1
N	165°C	405	0.355	DVB/EGDM	9
P	250°C	165	0.420	DVB/Styrene	3
Q	275°C	582	0.351	DVB	2
R	250°C	344	0.324	DVB/NV2P	5
S	250°C	583	0.334	DVB/4VP	4
T	165°C	250	0.381	EGDM	10

*DVB	Divinylbenzene	ACN	Acrylonitrile
EGDM	Ethyleneglycoldimethacrylate	NV2P	N-vinyl-2-pyrrolidinone
PEI	Polyethyleneimine	4VP	4-vinyl-pyridine

HayeSep® A This polymer separates permanent gases (hydrogen, nitrogen, oxygen, argon, carbon monoxide, and nitric oxide) at ambient temperatures. It also exhibits good separation characteristics for the C2's, hydrogen sulphide and water at higher temperatures.

Figure 1
PERMANENT GASES

Column: 36' x 1/8" packed
with HayeSep® A
80/100 mesh
Column Temp: 25°
Detector: P.E. 900 T.C. 225 ma
Att. x 2 180°C
Flow: He 23 cc/min
Sample: 25 microliters Air
plus Hydrogen and
Carbon Monoxide

1. Hydrogen 5%
2. Nitrogen 48.5%
3. Oxygen 13%
4. Argon 0.5%
5. Carbon Monoxide 33%

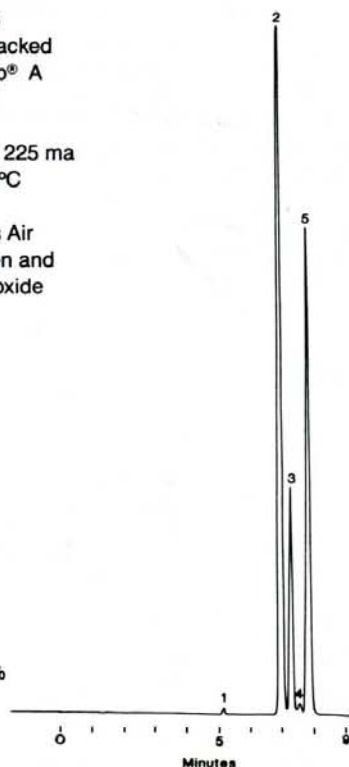
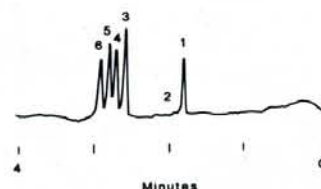


Figure 2
PERMANENT GAS
STANDARD 500 ppm

Column: 25' x 1mm packed
with HayeSep® A
170/200 mesh
Column Temp: 23°C
Flow: He 15 cc/min
Sample: 20 microliters

1. Neon
2. Hydrogen
3. Nitrogen
4. Oxygen
5. Argon
6. Carbon Monoxide



HayeSep® B Designed to separate the C1 and C2 amines as well as trace levels of ammonia and water, this polymer eliminates the need for caustic washing of material prior to packing.

Figure 3

AMINES #1

Column: 5' x 1/8"
SS packed with
HayeSep® B
80/100 mesh
Column Temp: 140° up to
190°C at
16°C/min
Injector Temp: 150°C
Detector: P.E. 900 T.C.
175 ma
Att. x 8 180°C
Flow: He 30 cc/min
Sample: 0.2 microliters
with on-
column
injection

1. Air
2. Water
3. Methylamine
4. Dimethylamine
5. Trimethylamine
6. Ethylene diamine

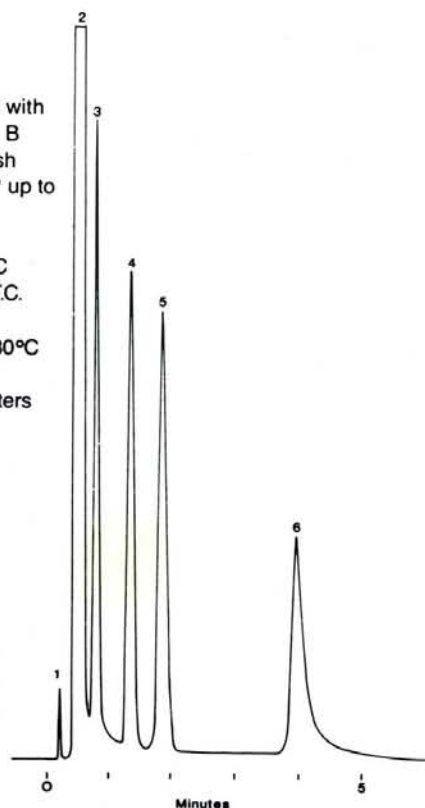
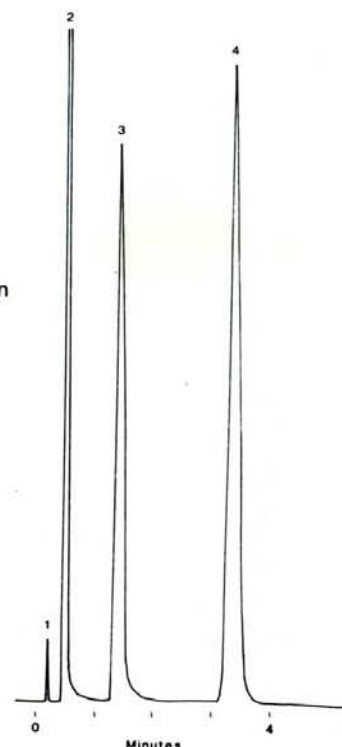


Figure 4

AMINES #2

Column: 5' x 1/8" packed
with HayeSep® B
80/100 mesh
Column Temp: 140°C up to
190°C at 16°C/min
Injector Temp: 150°C
Detector: P.E. 900 T.C.
175 ma
Att. x 8 180°C
Flow: He 30 cc/min
Sample: On-column injection

1. Air
2. Water
3. Ethylamine
4. Diethylamine



HayeSep® C This polymer is designed for polar hydrocarbons such as hydrogen cyanide, ammonia, hydrogen sulphide and water. HayeSep C® has similar separation characteristics to Chromosorb® 104.

Figure 5

**AMMONIA IN
HYDROGEN SULPHIDE**

Column: 5' x 1/8" packed
with HayeSep® C
80/100 mesh
Column Temp: 70°C
Injector Temp: 200°C
Detector: P.E. 900 T.C.
225 ma
Att. x 2 180°C
Flow: He 30 cc/min
Sample: 100 microliters

1. Air
2. Carbon Dioxide
3. Ammonia
Trace 1: approx 15%
Trace 2: approx 1.5%
4. Hydrogen Sulphide
5. Unknown in
Hydrogen Sulphide
6. Unknown in
Hydrogen Sulphide
7. Water

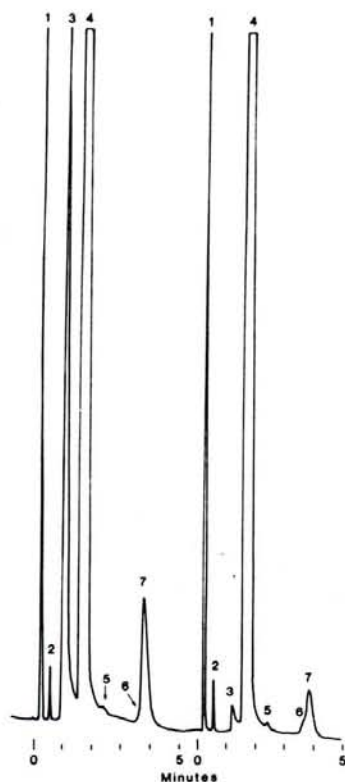


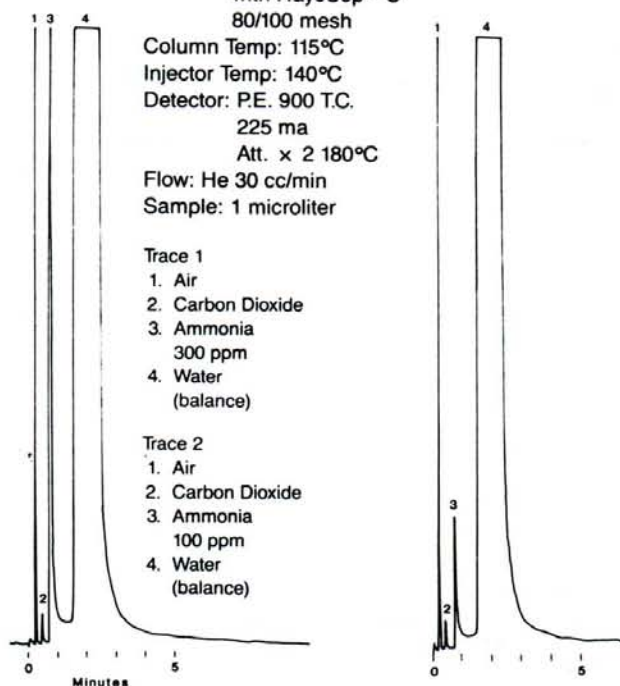
Figure 6

TRACE AMMONIA IN WATER

Column: 5' x 1/8" SS packed
with HayeSep® C
80/100 mesh
Column Temp: 115°C
Injector Temp: 140°C
Detector: P.E. 900 T.C.
225 ma
Att. x 2 180°C
Flow: He 30 cc/min
Sample: 1 microliter

- Trace 1
1. Air
 2. Carbon Dioxide
 3. Ammonia
300 ppm
 4. Water
(balance)

- Trace 2
1. Air
 2. Carbon Dioxide
 3. Ammonia
100 ppm
 4. Water
(balance)



POROUS POLYMER MICROPACKED COLUMNS

Hayes Separations, Inc. has been making porous polymers for ten years. We have occasionally made micropacked columns for various customers as well as supplied packings for this purpose. A few examples of these are listed on the following pages. Of interest is the elution time of acetylene relative to ethylene and ethane. Figure 43 shows acetylene between ethylene and ethane; Figure 47 shows acetylene behind ethylene and ethane; Figure 46 shows acetylene in front of ethylene and ethane; Figure 48 shows rapid elution of impurities in methane. References for the production of porous polymers are listed below.

- 1) Hollis, O.L., Analytical Chemistry 38:309-316 (1966).
- 2) Hollis, O.L. and Hayes, W.V., J. Gas Chrom. 4:235-239 (1966).
- 3) Hollis, O.L. and Hayes, W.V., Gas Chrom., A.B. Littlewood, editor, The Institute of Petroleum, Rome, 1966, p. 57-74.
- 4) U.S. Patent - 3,357,158 December 12, 1967.
- 5) U.S. Patent - 3,458,976 August 5, 1969.
- 6) 1966 IR 100 Award (R&D magazine).

Figure 43

SCOTT MIX 216 + MAPP GAS

Column: 10' x 1/16" x .04"
packed with HayeSep® S
100/120 mesh
Column Temp: 60°C 3min up to
90°C at 8°C/min
Detector: P.E. 990 T. C. D. 225 ma
Flow: He 14 cc/min
Chart Speed: 1 cm/min
Sample: 50 microliters

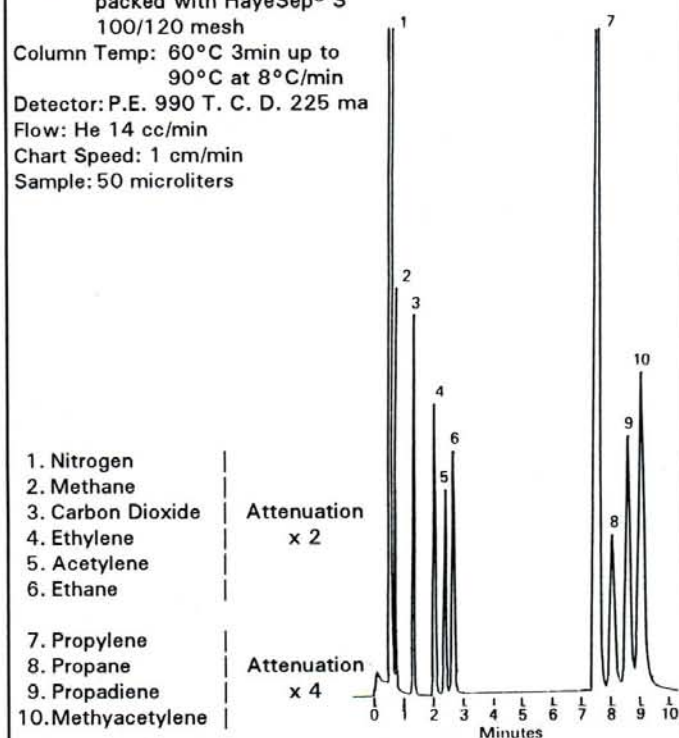


Figure 44

SCOTT MIX 234

Column: 20' x 1/16" x .04" SS
packed with HayeSep® D
100/120 mesh
Column Temp: 25°C
Detector: P.E. 900 T. C. D. 225 ma
140°C
Att. x 4
Flow: 13.3 cc/min He
Chart Speed: 1 cm/min
Sample Size: 25 microliters

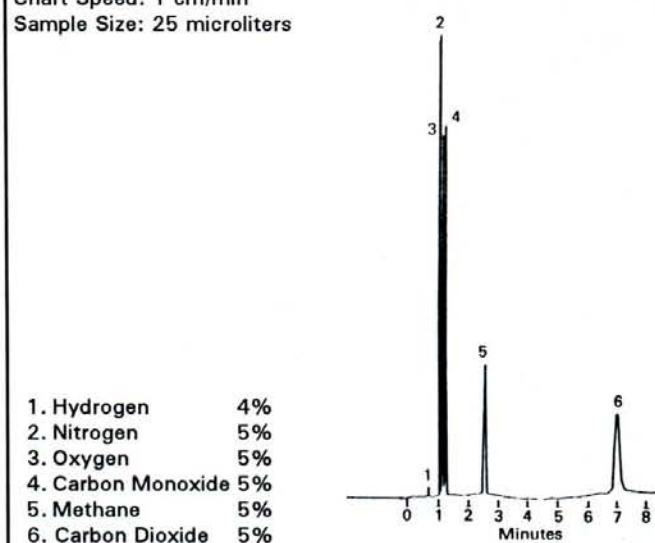


Figure 45

MIX 216 PROGRAMMED

Column: 20' x 1/16" x .04" SS
packed with HayeSep® D
100/120 mesh
Column Temp: 25°C 2min up to
110°C at 8°C/min
Detector: P.E. 900 T. C. D. at
225 ma 140°C
Att. x 4
Flow: 13.33 cc/min He
Chart Speed: 1 cm/min
Sample Size: 25 microliters

- | | |
|--------------------|----|
| 1. Nitrogen | 1% |
| 2. Carbon Monoxide | 1% |
| 3. Methane | 1% |
| 4. Carbon Dioxide | 1% |
| 5. Acetylene | 1% |
| 6. Ethylene | 1% |
| 7. Ethane | 1% |

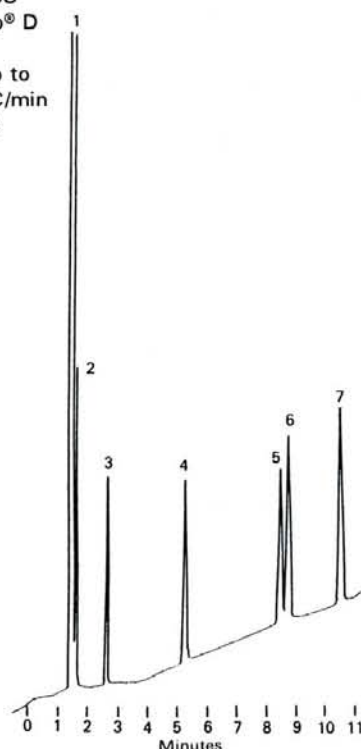


Figure 46

SCOTT MIX 216

Column: 20' x 1/16" x .04" SS
packed with HayeSep® D
100/120 mesh
Column Temp: 70° Isothermal
Detector: P.E. 900 T. C. D. at 225 ma
140°C
Att. x 4
Flow: 13.3 cc/min He
Chart Speed: 1 cm/min
Sample Size: 10 microliters

- | | |
|-------------------|-----------|
| 1. Nitrogen | (balance) |
| 2. Methane | 1% |
| 3. Carbon Dioxide | 1% |
| 4. Acetylene | 1% |
| 5. Ethylene | 1% |
| 6. Ethane | 1% |

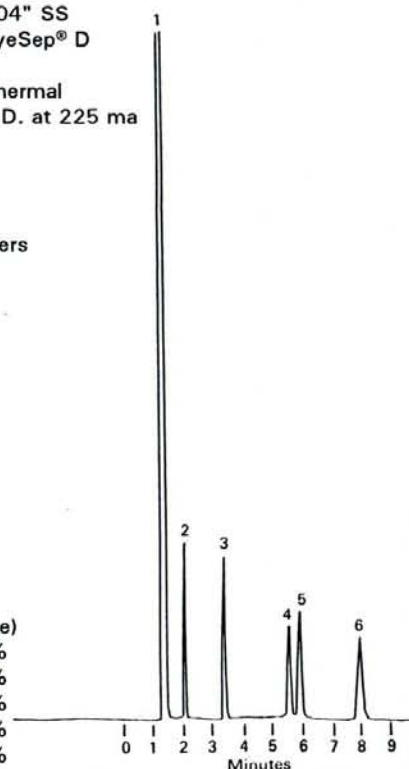


Figure 47

SCOTT MIX 216

Column: 15' x 1/16" x .03"
packed with HayeSep® A
120/140 mesh
Column Temp: 45°C
Detector: VICI micro T. C. D. 120°C
Att. x 8
Flow: He 8 cc/min
Chart Speed: 1 cm/min
Sample Size: 10 microliters

- | | |
|-------------------|-----------|
| 1. Nitrogen | (balance) |
| 2. Methane | 1% |
| 3. Carbon Dioxide | 1% |
| 4. Ethylene | 1% |
| 5. Ethane | 1% |
| 6. Acetylene | 1% |

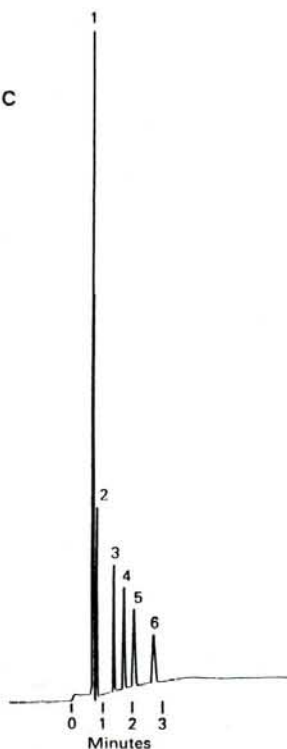


Figure 48

FAST ANALYSIS

Column: 48' x 1/16" x .04" ID SS
packed with HayeSep® DB
100/120 mesh
Column Temp: 70°C
Injector Temp: 70°C
Detector: P.E. 900 T. C. D.
225 ma 140°C
Flow: He 16 cc/min
Sample: 10 microliters
Valco valve

- | | |
|-------------------|-----------|
| 1. Nitrogen | 2.7% |
| 2. Methane | (balance) |
| 3. Carbon Dioxide | 3.0% |
| 4. Ethane | 3.5% |



Figure 21
TRACE ACETALDEHYDE
IN AIR 2500 ppm

Column: 3' x 1/8" SS
packed with
HayeSep® D
100/120 mesh
Column Temp: 100°C
Injector Temp: 140°C
Detector: P.E. 900 T.C.
225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve
100 microliters

1. Air
2. Water
3. Acetaldehyde
2500 ppm (vol.)



Figure 22
TEQUILA HEADSPACE

Column: 3' x 1/8" SS packed
with HayeSep® D
80/120 mesh
Column Temp: 100°
Injector Temp: 140°C
Detector: P.E. 900 T.C.
225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve
100 microliters

1. Air Att. x1
2. Carbon Dioxide Att. x1
3. Water Att. x1
4. Methanol Att. x1
5. Acetaldehyde Att. x1
6. Ethanol Att. x8

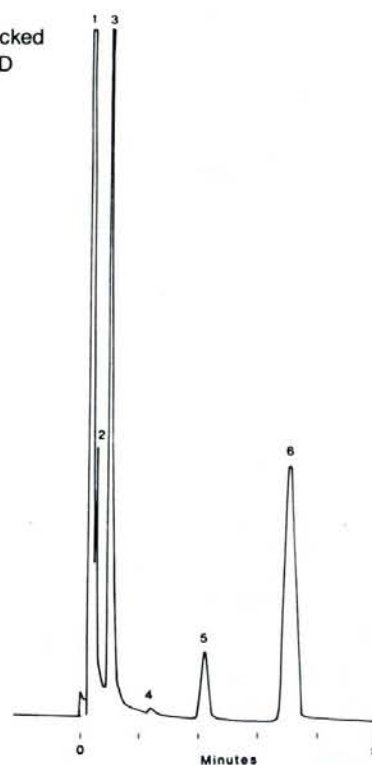


Figure 23
TRACE ALCOHOLS
IN WATER

Column: 10' x 1/8" packed
with HayeSep® D
80/100 mesh
Column Temp: 75°C up to
150°C at 16°C/min
Flow: He 33 cc/min
Injector Temp: 125°C
Detector: P.E. 900 T.C.
225 ma
Att. x 1 140°C
Sample: 3 microliters

1. Methanol
500 ppm
2. Ethanol
200 ppm

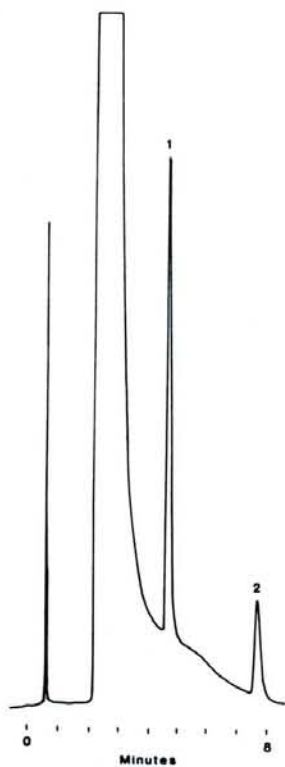
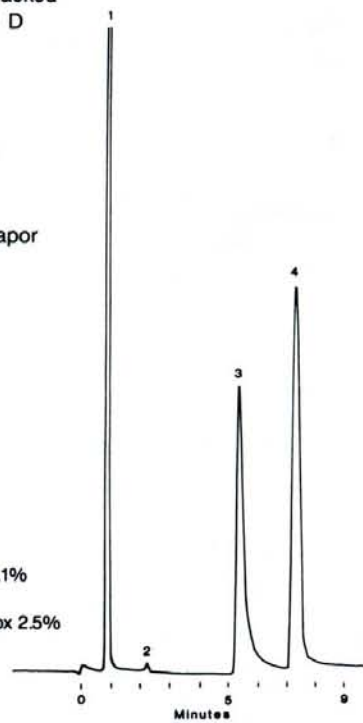


Figure 24
HYDROGEN SULPHIDE

Column: 10' x 1/8" Ni packed
with HayeSep® D
100/120 mesh
Column Temp: 60°C
Injector Temp: 100°C
Detector: P.E. 900 T.C.
225 ma 140°C
Flow: He 30 cc/min
Sample: Valco valve
50 microliters vapor
(ambient)

1. Air (balance)
2. Carbon Dioxide approx 0.1%
3. Water approx 2.5%
4. Hydrogen Sulphide approx 2.5%



COMPARISON OF "D" FORMULATIONS

Retention Time in Minutes

	AIR	CH ₄	CO ₂	C ₂ H ₂	C ₂ H ₄	C ₂ H ₆	H ₂ O
Dip	0.9	1.7	3.1	5.4	5.8	8.3	9.0
D*	0.9	1.7	3.1	5.8	6.1	8.4	8.6
DB	0.9	1.6	3.1	6.1	6.6	8.7	8.1

*This is our standard D.

Column: 10' x 1/8" SS
80/100 mesh
Column Temp: 45°C
Detector: 175 ma Att. x 2 150°
Flow: He 30 cc/min
Sample: 50 microliters
Valco valve

Figure 25 TRACE ETHYLENE OXIDE IN NITROGEN

Column: 10' x 1/8" SS packed
with HayeSep® D
80/100 mesh
Column Temp: 130°C
Injector Temp: 100°C
Detector: Varian 1400 F.I.D.
Att. 10⁻¹² x 2 140°C
Flow: He 30 cc/min
Sample: 250 microliters
Valco valve

1. Ethylene Oxide 23 ppm

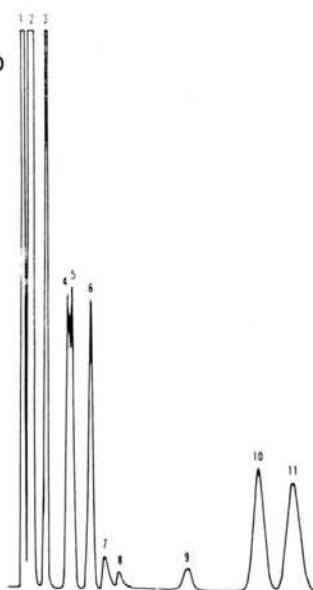


Courtesy of John Booker Co.

Figure 26 HYDROCARBONS/SULFUR GASES

Column: 9' x 1/8" HayeSep® Dip
100/120 mesh
Column Temp: 100°C
Detector: P.E. Sigma 300 TCD
Low current
Att. x 1
Flow: He 30 cc/min
Sample: 0.5 cc
Valco valve

PEAK	RET. TIME	AREA %	CPD
1.	0.71	31.59	Air
2.	0.86	48.88	Methane
3.	1.23	5.48	Carbon Dioxide
4.	1.71	2.17	Acetylene
5.	1.79	2.72	Ethylene
6.	2.19	3.09	Ethane
7.	2.52	0.45	Water
8.	2.83	0.19	Hydrogen Sulfide
9.	4.30	0.44	Carbonyl Sulfide
10.	5.82	3.36	Propylene
11.	6.57	3.59	Propane



Courtesy of John Booker Co.

Figure 27 NITROGEN IN OXYGEN

Column: 30' x 1/8" SS packed
with HayeSep® DB
Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma
Att. x 2 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen 0.4%
2. Oxygen - balance



Figure 28
SCOTT MIX 234

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh

Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma 140°C

Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Hydrogen 4% Att. x 01
2. Nitrogen 5% Att. x 32
3. Carbon
Monoxide 5% Att. x 32
4. Methane 4% Att. x 32
5. Carbon
Dioxide 5% Att. x 08

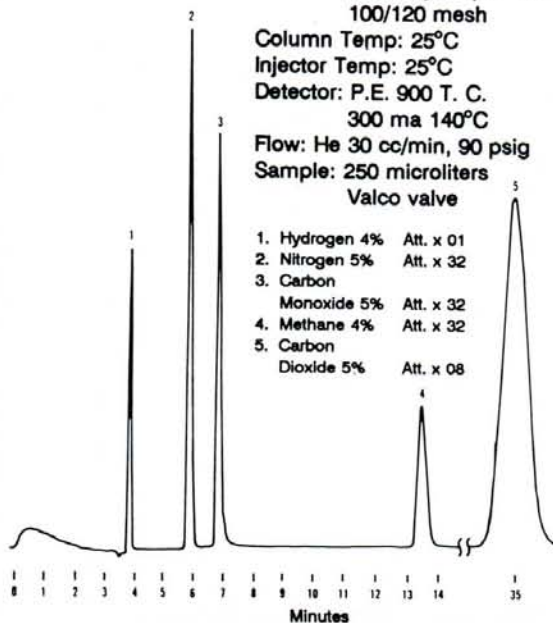


Figure 29
AIR

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh

Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma

Att. x 32 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen 78%
2. Oxygen 21%
3. Argon 0.94%

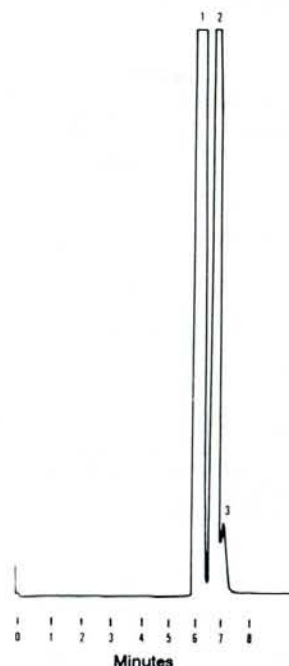


Figure 30
NITROGEN IN ARGON

Column: 30' x 1/8" SS packed
with HayeSep® D
100/120 mesh

Column Temp: 25°C
Injector Temp: 25°C
Detector: P.E. 900 T. C.
300 ma

Att. x 1 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen 373 ppm
2. Argon - balance

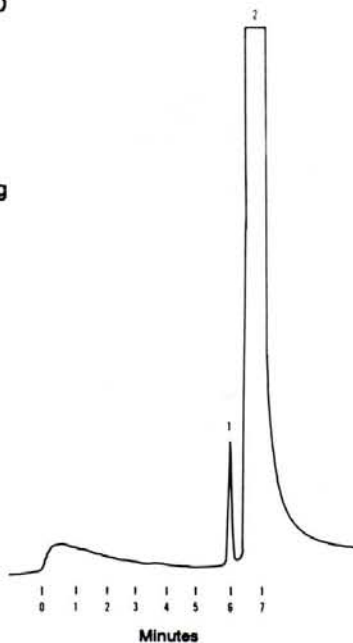


Figure 31
ETHYLENE AND SCOTT MIX 216

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh

Column Temp: 120°C
Injector Temp: 120°C
Detector: P.E. 900 T. C.
300 ma

Att. x 1 140°C
Flow: He 30 cc/min, 90 psig
Sample: 250 microliters
Valco valve

1. Nitrogen
2. Carbon
Monoxide
3. Methane
4. Carbon
Dioxide
5. Acetylene 924 ppm
6. Ethylene
7. Water
8. Ethane

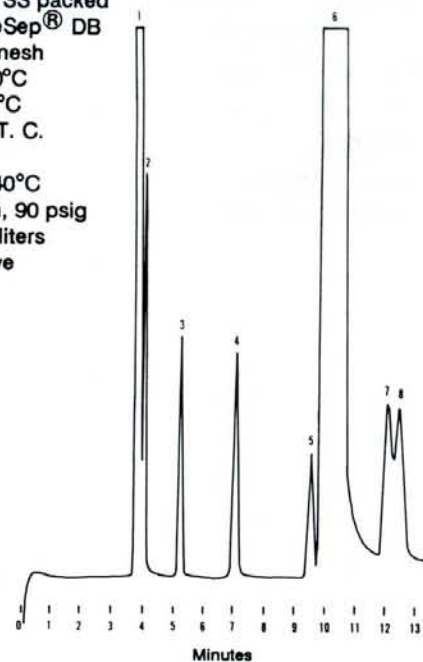


Figure 32**NITRIC OXIDE IN NITROGEN**

Column: 30' x 1/8" SS packed
with HayeSep[®] DB
100/120 mesh

Column Temp: 22°C

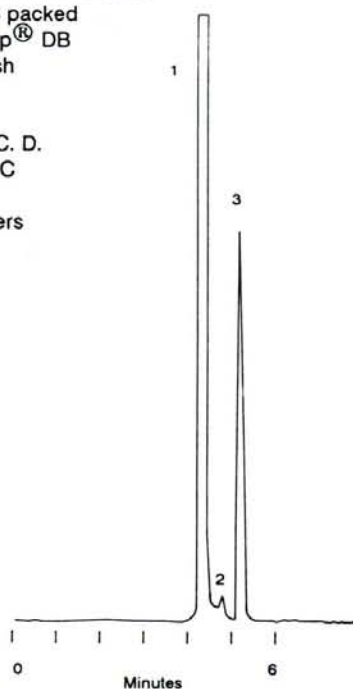
Injector Temp: 22°C

Detector: P.E. 900 T. C. D.
225 ma 140°C

Flow: 30 cc/min

Sample: 100 microliters

1. Nitrogen Balance
2. Argon
3. Nitric Oxide 0.58%

**Figure 33****HYDROGEN IN HELIUM**

Column: 25' x 1/8" SS packed
with HayeSep[®] D
100/120 mesh

Column Temp: 25°C

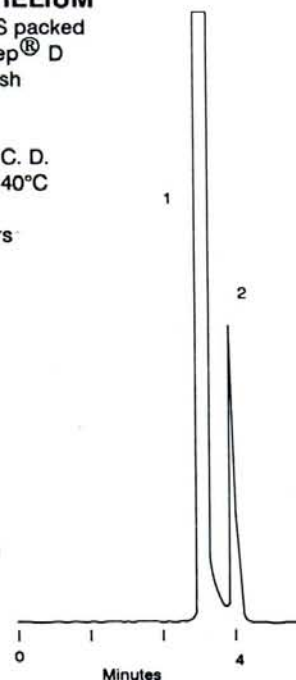
Injector Temp: 25°C

Detector: P.E. 900 T. C. D.
150 ma at 140°C

Flow: 24 cc/min N₂

Sample: 50 microliters
Valco valve

1. Helium Balance
2. Hydrogen 1%

**Figure 34****IMPURITIES IN HYDROGEN**

Column: 25' x 1/8" SS packed
with HayeSep[®] DB
100/120 mesh

Column Temp: 25°C

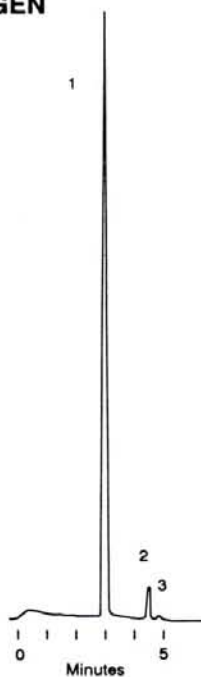
Injector Temp: 25°C

Detector: P.E. 900 T. C. D.
225 ma

Flow: He 25 cc/min

Sample: 250 microliters
Valco valve

1. Hydrogen Balance
2. Nitrogen 80 ppm
3. Oxygen 20 ppm

**Figure 35****AIR IN ARGON**

Column: 30' x 1/8" SS packed
with HayeSep[®] DB
100/120 mesh

Column Temp: 22°C

Injector Temp: 22°C

Detector: P.E. 900 T. C. D.
225 ma 140°C

Flow: He 30 cc/min

Sample: 100 microliters
Valco valve

1. Nitrogen 6000 ppm
2. Oxygen 1600 ppm
3. Argon 25%
4. Helium Balance

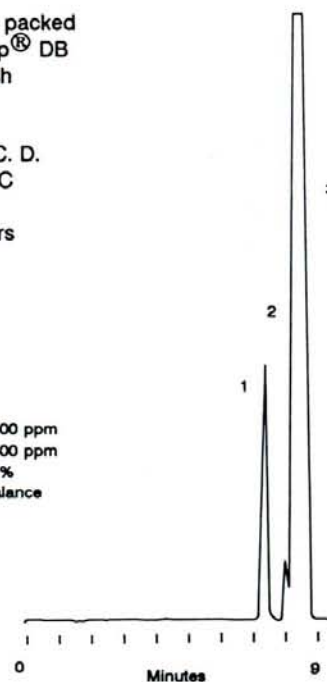


Figure 36**HYDROGEN/AIR 50/50**

Column: 25' x 1/8" SS packed
with HayeSep[®] D
100/120 mesh

Column Temp: 25°C

Injector Temp: 25°C

Detector: P.E. 900 T. C. D.

225 ma 140°C

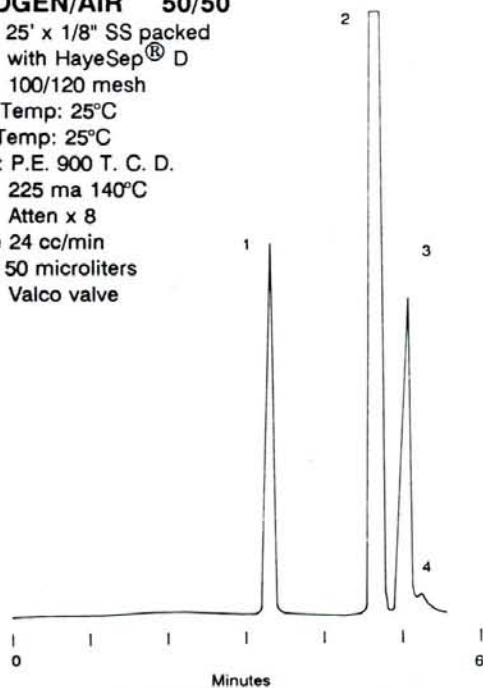
Atten x 8

Flow: He 24 cc/min

Sample: 50 microliters

Valco valve

1. Hydrogen
2. Nitrogen
3. Oxygen
4. Argon

**Figure 37****99.6% OXYGEN**

Column: 30' x 1/8" SS packed
with HayeSep[®] DB
100/120 mesh

Column Temp: 22°C

Injector Temp: 22°C

Detector: P.E. 900 T. C. D.

225 ma 140°C

Flow: He 20 cc/min

Sample: 100 microliters

Valco valve

- | | |
|-------------|---------|
| 1. Nitrogen | 0.4% |
| 2. Oxygen | Balance |

**Figure 38****99.995% ARGON**

Column: 30' x 1/8" SS packed
with HayeSep[®] DB
100/120 mesh

Column Temp: 22°C

Injector Temp: 22°C

Detector: P.E. 900 T. C. D.

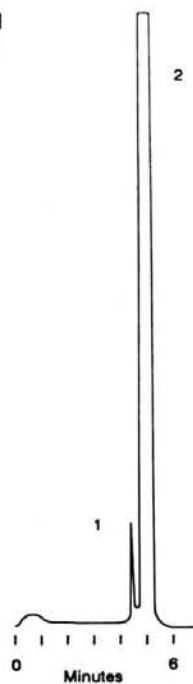
225 ma 140°C

Flow: He 30 cc/min

Sample: 100 microliters

Valco valve

- | | |
|-------------|---------|
| 1. Nitrogen | 50 ppm |
| 2. Argon | Balance |

**Figure 39****IMPURITIES IN NITROGEN TRIFLUORIDE**

Column: 25' x 1/8" SS packed
with HayeSep[®] DB
100/120 mesh

Column Temp: 25°C

Injector Temp: 25°C

Detector: P.E. 900 T. C. D.

275 ma 140°C

Flow: He 30 cc/min

Sample: 250 microliters

Valco valve

Chart Speed: 1 cm/min

- | | |
|-------------------------|---------|
| 1. Nitrogen | 50 ppm |
| 2. Oxygen | 250 ppm |
| 3. Carbon Tetrafluoride | 400 ppm |
| 4. Nitrogen Trifluoride | Balance |

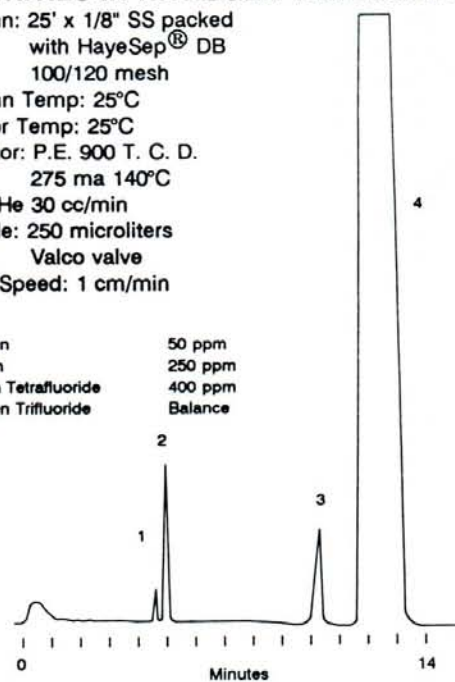


Figure 40**FAST ANALYSIS**

Column: 48" x 1/16" x .04" ID SS
packed with HayeSep® DB
100/120 mesh

Column Temp: 70°C

Injector Temp: 70°C

Detector: P.E. 900 T. C. D.

225 ma 140°C

Flow: He 16 cc/min

Sample: 10 microliters

Valco valve

1. Nitrogen	2.7%
2. Methane	Balance
3. Carbon Dioxide	3.0%
4. Ethane	3.5%

**Figure 41****99.7% CARBON MONOXIDE**

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh

Column Temp: 22°C

Injector Temp: 22°C

Detector: P.E. 900 T. C. D.

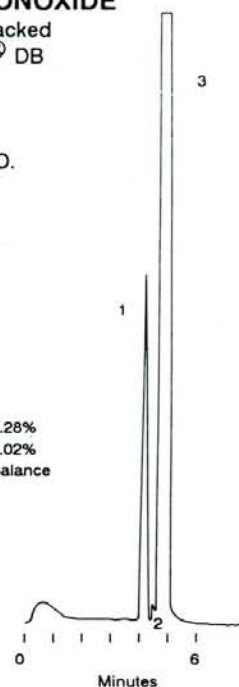
225 ma 140°C

Flow: He 30 cc/min

Sample: 100 microliters

Valco valve

1. Nitrogen	0.28%
2. Oxygen	0.02%
4. Carbon Monoxide	Balance

**Figure 42****SCOTT MIX 234**

Column: 30' x 1/8" SS packed
with HayeSep® DB
100/120 mesh

Column Temp: 22°C

Injector Temp: 22°C

Detector: P.E. 900 T. C. D.

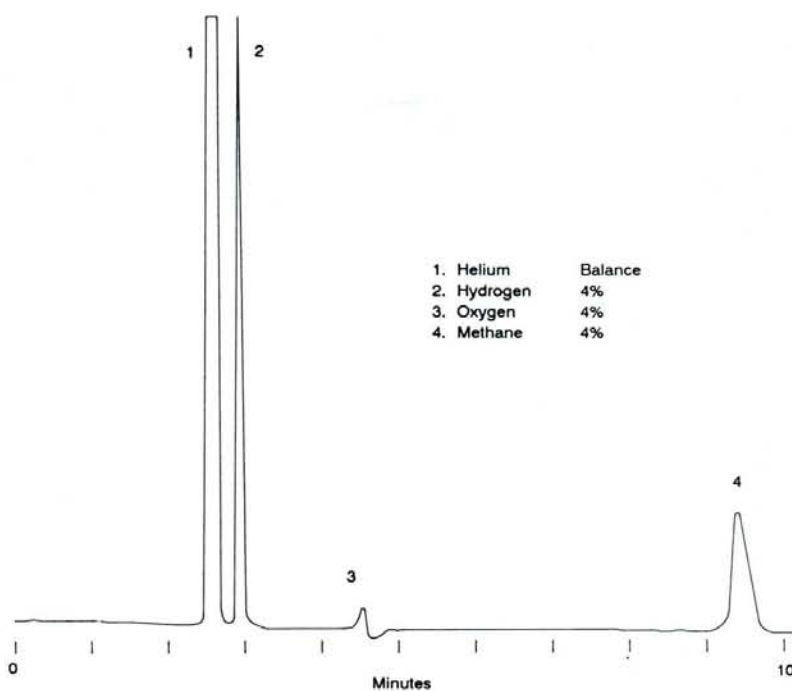
225 ma 140°C

Flow: N₂ 30 cc/min

Sample: 100 microliters

Valco valve

1. Helium	Balance
2. Hydrogen	4%
3. Oxygen	4%
4. Methane	4%



HayeSep® D This new polymer made from high purity divinylbenzene is unavailable anywhere else. It has a high surface area and higher operating temperatures than competitive polymers. Available in four different porosities with surface areas from 790 to over 800 m²/gram, this range allows flexibility, since in water/ethane separations porosity determines the order of elution.

These D formulations exhibit superior separation characteristics for light gases. Significant separation abilities include the separation of CO and CO₂ from room air at ambient temperatures and the separation of acetylene prior to other C₂'s. HayeSep® D is particularly useful in the separation and analysis of water and hydrogen sulphide.

Comparisons of D Formulations

	Average Diameter (microns)	Bulk Density gram/cc	Porosity %	Surface Area m ² /gram
Dip	.0317	.3283	69.1	774
D	.0308	.3311	70.35	803
D _B	.0332	.3334	64.2	781

Figure 15

SCOTT MIX 237

Column: 20' x 1/8" Ni packed
with HayeSep® D
100/120 mesh

Column Temp: 25°C

Injector Temp: 100°C

Detector: P.E. 900 T.C.

225 ma 140°C

Flow: He 30 cc/min

Sample: Valco valve
50 microliters vapor
(ambient)

1. Nitrogen (balance)
2. Oxygen 7% Att. x8
3. Carbon Monoxide 7% Att. x8
4. Methane 4.5% Att. x4
5. Carbon Dioxide 15% Att. x4

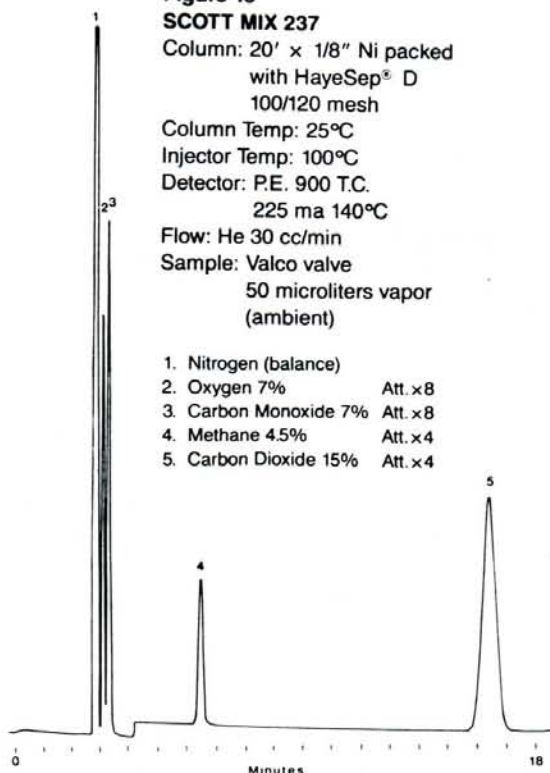


Figure 16

GAS MIXTURE

Column: 10' x 1/8" SS packed
with HayeSep® D
100/120 mesh

Column Temp: 80°C

Injector Temp: 140°C

Detector: P.E. 900 T.C.

225 ma

Att. x 4

Flow: He 30 cc/min

Sample: Valco valve
100 microliters

1. Nitrogen (balance)
2. Carbon Dioxide 2%
3. Nitrous Oxide 3%
4. Water 0.5%
5. Hydrogen Sulphide 3%

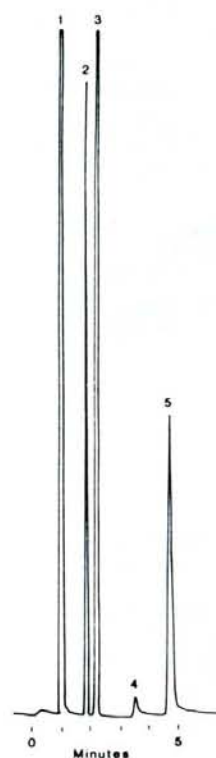


Figure 17

SCOTT MIX 216 (Programmed)

Column: 20' x 1/8" Ni packed
with HayeSep® D
100/120 mesh

Column Temp: 40°C/2 min
programmed
up to 110°C
at 24°C/min

Injector Temp: 100°C

Detector: P.E. 900 T.C.
225 ma 140°C

Flow: He 30 cc/min

Sample: Valco valve
100 microliters
(ambient)

1. Nitrogen (balance)
2. Carbon Monoxide 1% Att. x2
3. Methane 1% Att. x2
4. Carbon Dioxide 1% Att. x2
5. Acetylene 1% Att. x2
6. Ethylene 1% Att. x2
7. Ethane 1% Att. x2

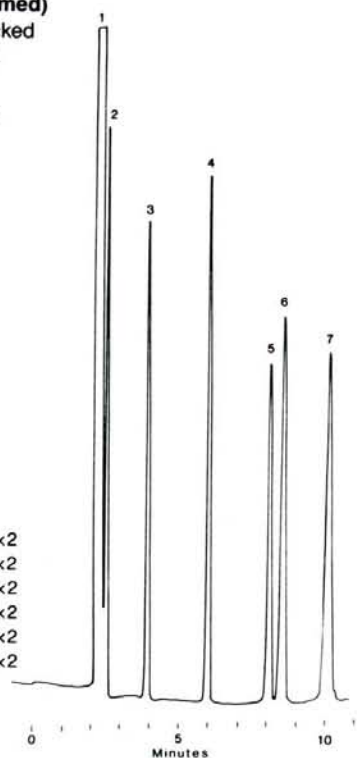


Figure 18

C1 - C2's

Column: 10' x 1/8" SS packed
with HayeSep® D
100/120 mesh

Column Temp: 80°C Isothermal

Detector: 3700 Varian FID

Range: 10⁻¹¹ Att. x 16

Flow: He 35 cc/min

1. Methane 1%
2. Acetylene 1%
3. Ethylene 1%
4. Ethane 1%

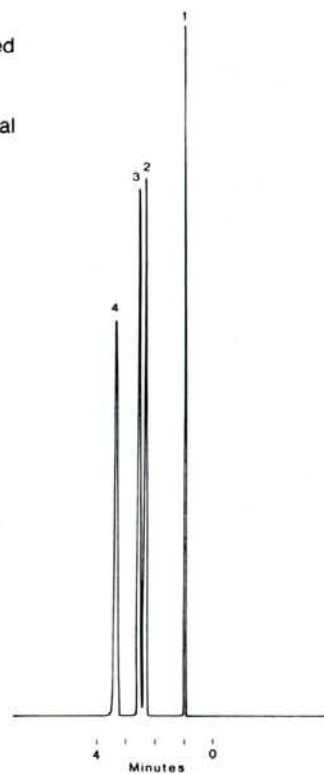


Figure 19

C1 - C5 PARAFFINS

Column: 10' x 1/8" SS
packed with
HayeSep® D
100/120 mesh

Column Temp: 120°C
up to 200°C
at 20°C/min

Detector: 3700 Varian FID

Range: 10⁻¹¹ Att. x 16

Flow: He 35 cc/min

Sample: Valco valve
50 microliters

1. Methane 0.1894%
2. Ethane 0.0965%
3. Propane 0.0989%
4. Isobutane 0.1019%
5. Butane 0.1019%
6. n-Pentane 0.2002%

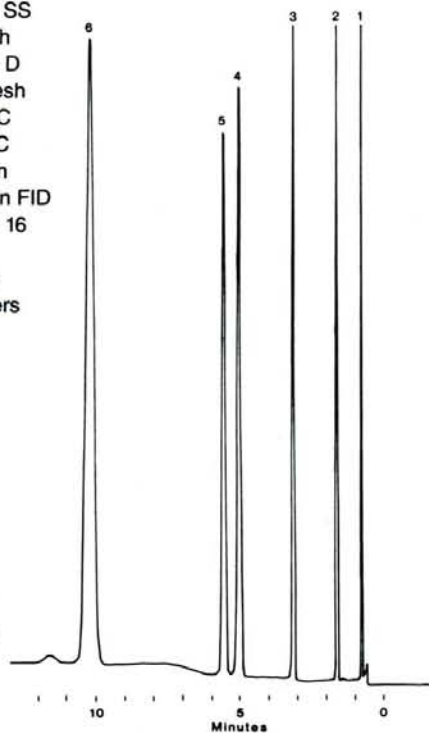


Figure 20

TRACE UNSATURATES

C2 - C6

Column: 10' x 1/8" SS
packed with
HayeSep® D
100/120 mesh

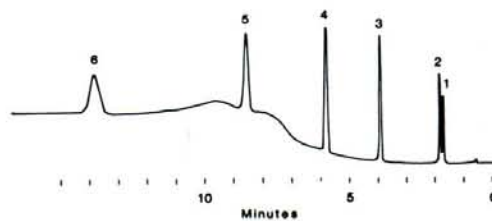
Column Temp: 120°C up to
200°C at 24°C/min

Detector: 3700 Varian FID

Range: 10⁻¹¹ Att. x 16

Flow: He 35 cc/min

1. Acetylene 16 ppm
2. Ethylene 15 ppm
3. Propylene 14.3 ppm
4. 1-Butene 15 ppm
5. 1-Pentene 14.75 ppm
6. 1-Hexene 16 ppm



HayeSep® N, P, Q, R, S, and T These polymers are interchangeable with the Porapak® series for separations of low molecular weight materials containing halogens, sulphurs, water, alcohols, glycols, free fatty acids, esters, ketones and aldehydes.

Figure 7

AMMONIA

Column: 8' x 1/8" SS packed
with HayeSep® P
60/80 mesh
Column Temp: 80°C
Injector Temp: 150°C
Manifold Temp: 180°C
Detector: T.C. 175 ma 200°C
Flow: He 30 cc/min
Sample: 0.1 microliters of
NH₄OH with on-
column injection

1. Air
2. Ammonia 35%
3. Water 65%

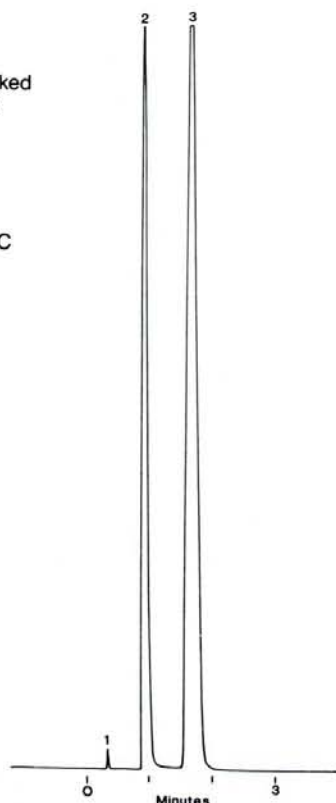


Figure 8

SOLVENTS

Column: 8' x 1/8" SS packed
with HayeSep® P
60/80 mesh
Column Temp: 80°C up to
180°C at
16°C/min
Injector Temp: 150°C
Manifold Temp: 180°C
Detector: 175 ma 200°C
Flow: He 30 cc/min
Sample: 0.2 microliters with
on-column injection

1. Air
2. Water
3. Methanol
4. Ethanol
5. Acetone
6. Chloroform

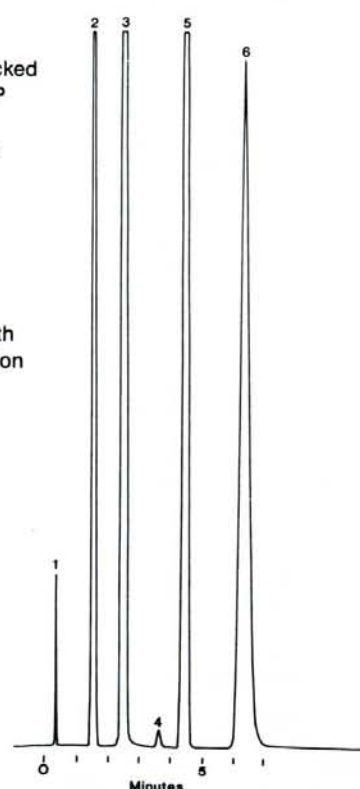


Figure 9

TRACE WATER ANALYSIS

Column: 9' x 1/8" Ni packed
with HayeSep® R
80/100 mesh
Column Temp: 118°C
Flow: He 30 cc/min
Detector: Varian T.C.
with Bendix On-Line
Process Analyzer
Sample: 10 microliters
Ethyl Chloride

1. Air
2. Water 12 ppm
3. Hydrogen Chloride
4. Ethyl Chloride

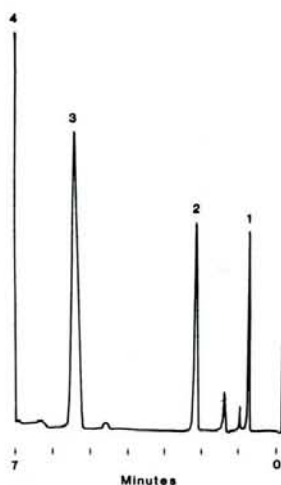


Figure 10

MAPP GAS

Column: 10' x 1/8" SS
packed with
HayeSep® R
Column Temp: 80°C
Flow: He 30 cc/min
Sample: 15 microliters

1. Air
2. Methane
3. Carbon Dioxide
4. Ethane
5. Propylene
6. Propane
7. Propadiene
8. Methyl Acetylene

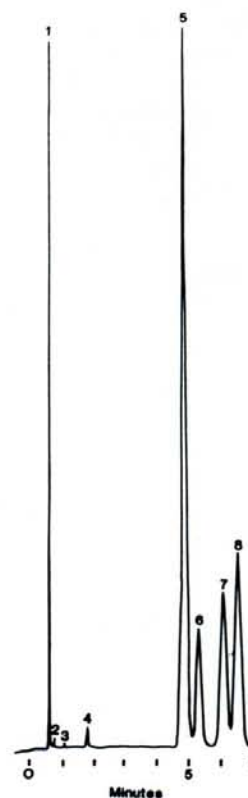


Figure 11
HYDROCARBONS AND
SULPHUR GASES

Column: 8' x 1/8"
packed with
HayeSep[®] Q
80/100 mesh
Column Temp: 90°C
Flow: He 30 cc/min

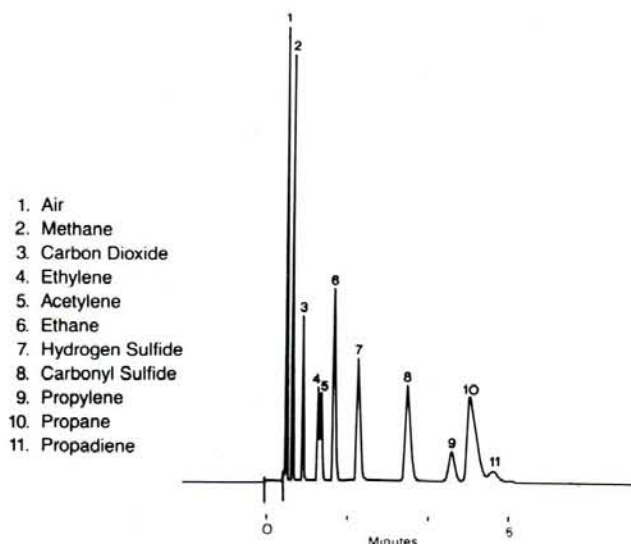


Figure 12
C2's

Column: 5' x 1/8" SS
packed with
HayeSep[®] T
Column Temp: 32°C
Detector: Att. x 216 180°C
Flow: He 30 cc/min
Sample: 50 microliters

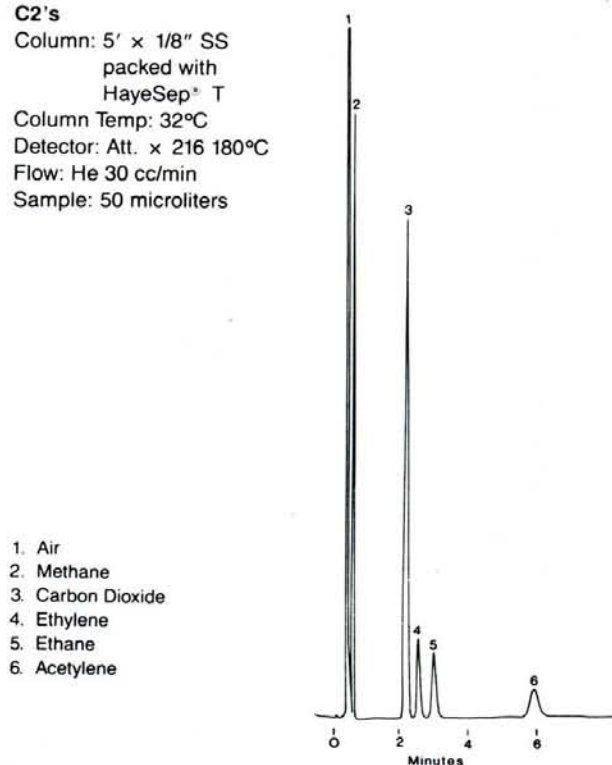


Figure 13
METHANOL IN
PROPYLENE/PROPANE

Column: 5' x 1/8" SS
packed with
HayeSep[®] T
100/120 mesh
Column Temp: 120°C
Injector Temp: 132°C
Detector: P.E. 900 T.C.
225 ma 150°C
Flow: He 30 cc/min

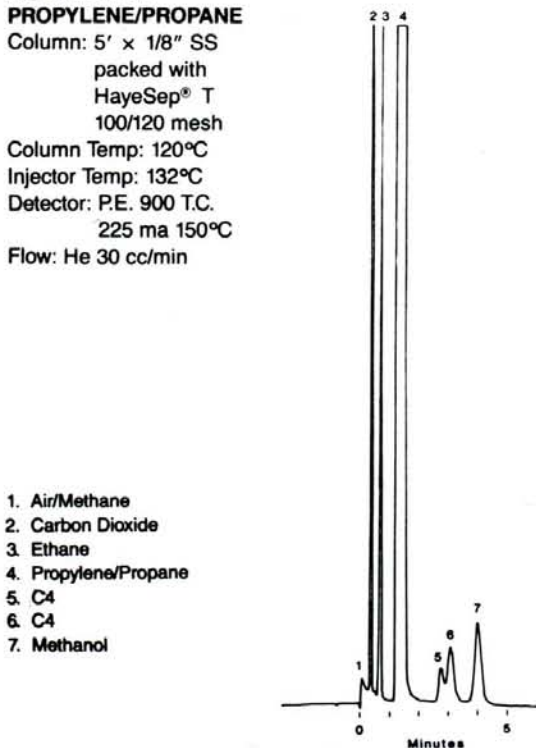
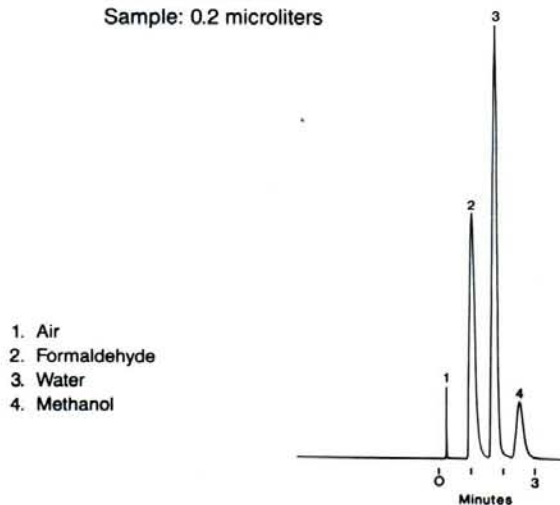


Figure 14
FORMALDEHYDE

Column: 5' x 1/8" SS packed
with HayeSep[®] T
100/120 mesh
Column Temp: 132°C
Injector Temp: 165°
Detector: P.E. 900 T.C.
175 MA
Att. x 32 180°C
Flow: He 30 cc/min
Sample: 0.2 microliters



HAYESEP RT'S RELATIVE TO C₂H₆

6' X 1/8" ss Columns

HayeSep 80/100 mesh

60°C - 30 cc/min. Helium

Courtesy: Brian Thompson, Varian

Compound	A	B	C	D	DB	DIP
CF ₄	.13	.10	.08	.10	.10	.10
CH ₄	.09	.12	.11	.11	.11	.12
CO ₂	.54	.32	.47	.31	.30	.30
N ₂ O	.62	.44	.59	.42	.42	.43
F116	.63	.49	.45	.51	.52	.53
C ₂ H ₂	1.29	.65	1.03	.64	.62	.64
SF ₆	.81	.65	.64	.68	.68	.68
C ₂ H ₄	.81	.71	.75	.70	.70	.70
NH ₃	1.58	.71	1.21	.90	.65	.98
F13	1.10	.90	.84	.87	.88	.90
C ₂ H ₆	1.00	1.00	1.00	1.00	1.00	1.00
H ₂ O	7.06	1.14	5.31	1.08	.95	1.10
H ₂ S	2.06	1.45	2.20	1.36	1.35	1.39
COS	3.02	2.59	3.10	2.56	2.58	2.59
F22	7.63	3.11	6.34	3.30	3.31	3.35
C ₃ H ₆	4.70	3.75	4.41	4.01	4.11	4.10
C ₃ H ₈	4.94	4.43	4.70	4.73	4.84	4.84
SO ₂	10.23	3.84	5.31	3.67	3.82	3.68
PD	6.19	4.63	5.80	4.79	4.87	4.90
MA	8.09	4.70	7.03	4.92	4.96	5.00
CP	5.90	5.02	5.89	5.18	5.32	5.26
F12	7.83	5.71	6.79	6.38	6.47	6.46
IC ₄	17.92	14.73	16.21	16.74	17.18	17.32
1, 3 BD	24.94	16.00	22.93	18.62	19.10	19.48
F114	27.35	18.35	21.46	21.48	22.11	22.88
NC ₄	23.60	19.33	21.21	22.26	22.66	23.01

RELATIVE RETENTION TIMES

Ethane = 1.00

Columns 6' x 1/8" SS 65°C

He 30 cc/min

Compound	N	Q	R	S	T
Hydrogen	0.19	.143	0.17	.19	.21
Air	0.23	.186	0.2	.21	.25
Nitric oxide	0.25	.217	0.21	.23	.33
Methane	0.30	.256	0.28	0.3	.35
Carbon dioxide	0.71	0.45	0.50	0.52	0.85
Nitrous oxide	0.80	0.57	0.59	0.59	—
Ethylene	0.83	0.74	0.78	0.78	0.9
Acetylene	1.41	0.74	1.0	0.87	2.11
Ethane	1.0	1.0	1.0	1.0	1.0
Water	10.1	1.45	6.8	4.12	19.1
Hydrogen sulphide	2.1	1.40	1.73	1.87	2.88
Hydrogen cyanide	19.3	2.31	15.6	8.26	28.8
Carbonyl sulphide	2.82	2.33	2.46	2.63	3.4
Sulphur dioxide	12.0	3.05	9.78	17.8	19.0
Propylene	4.66	3.20	3.45	3.65	4.91
Propane	4.66	3.67	3.88	4.1	4.63
Propadiene	6.50	4.12	4.39	4.7	7.55
Methylacetylene	9.5	4.12	4.84	5.14	11.3
Methyl chloride	7.43	3.93	4.67	4.92	9.2
Vinyl chloride	14.9	6.04	9.04	9.7	17.3
Ethylene oxide	17.7	6.06	8.78	9.7	23.3
Ethyl chloride	35.0	12.25	19.3	20.7	43.2
Carbon disulphide	—	32.4	—	—	40.7