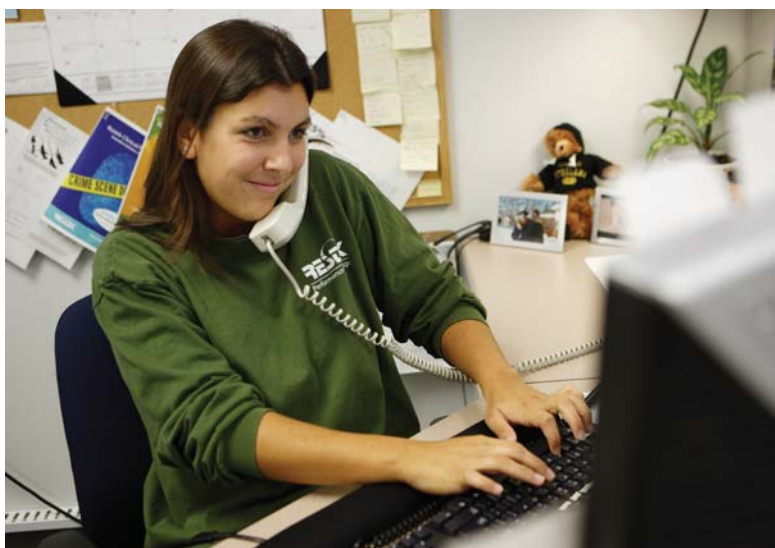


# PLOT Columns



Top: Bob Langford, GC Column  
Manufacturing Technician

Bottom: Stephanie Sunner, Customer  
Service Representative



## Features & Benefits of Restek PLOT Columns

### Features

### Benefits

Highest quality porous materials.

The most consistent and efficient analyses obtainable.

Consistency in porosity and uniformity in particle and pore size are major concerns in designing the solid stationary phase. We developed a unique synthesis and selection technology to yield uniform, small diameter particles that are ideal for a specific separation.

Particles are 100% bonded to the tubing.

No need for particle traps because particle generation is eliminated.

Restek coating and bonding techniques produce strong, uniform particle adherence to the inside of the capillary tubing. Customers have described Restek's Rt™-Msieve 5A PLOT column as "bulletproof," meaning that the stationary phase is bonded so strongly that particle generation is completely eliminated.

Reproducible quality.

Reproducible performance.

Because we use advanced technology to make these columns, the entire manufacturing process is simple and stable. Each step of the column-making process is meticulously quality-checked, allowing Restek to offer the best quality PLOT columns.

## Quick Reference Chart

PLOT Column	Application	Page
Rt™-Alumina	C1–C5 hydrocarbons. purity analysis of ethylene, propylene, butenes, butadiene .....	94–95
Rt™-Msieve 5A	Permanent gas analysis. He, Ne, Ar, O <sub>2</sub> , N <sub>2</sub> , Xe, Rn, SF <sub>6</sub> , and CH <sub>4</sub> , C <sub>2</sub> H <sub>6</sub> , Co .....	96
Rt™-QPLOT	Nonpolar porous polymer. High retention for volatiles, CO <sub>2</sub> , sulfur, and ppm water in solvents .....	97
Rt™-QSPLIT	Intermediate polarity porous polymer. Baseline separation of ethane, ethene, acetylene .....	97
Rt™-SPLOT	Intermediate polarity porous polymer. Light gases in ethylene and propylene, ketones, esters .....	97
Rt™-UPLOT	Polar porous polymer. More retention for polar compounds .....	97

## PLOT Column Phase Cross-Reference: Similar Performance

Restek	Porous Layer	Agilent/J&W	Supelco	Alltech	Varian/Chrompack	Quadrex
Rt™-Alumina	Aluminum oxide	GS-Alumina, HP PLOT S, HP PLOT M	Alumina-PLOT	AT-Alumina	CP-Al <sub>2</sub> O <sub>3</sub> /NA <sub>2</sub> SO <sub>4</sub>	—
Rt™-Msieve 5A	Molecular sieve 5A	GS-Molsieve, HP PLOT/Molesieve	Molsieve 5A PLOT	AT-Molesieve	CP-Molesieve 5A	PLT-5A
Rt™-QPLOT	DVB porous polymer	—	Supel-Q-PLOT	AT-Q	CP-PoraPlot Q, PoraBond Q	—
Rt™-QSPLIT	Intermediate polarity porous polymer	GS-Q	—	—	—	—
Rt™-SPLOT	DVB vinylpyridine polymer	—	—	—	CP-PoraPlot S	—
Rt™-UPLOT	DVB ethyleneglycol- dimethylacrylate polymer	HP-UPLOT	—	—	CP-PoraPlot U, PoraBond U	—

**Rt™-Alumina PLOT Column Characteristics**

1. Highly selective adsorbent for C1-C5 hydrocarbons; separates all unsaturated hydrocarbon isomers at temperatures far above ambient.
2. Reactivity of aluminum oxide stationary phase is minimized so that column response for polar unsaturates, such as dienes, is optimized. Column sensitivity or response ensures a linear and quantitative chromatographic analysis for these compounds.
3. Strong bonding prevents particle generation. The column can be used in valve switching operations, without release of particles that can harm the injection and detection systems.
4. The Rt™-Alumina PLOT column is stable up to 200°C. If water is adsorbed on the column, it can be regenerated by conditioning at 200°C. Full efficiency and selectivity will be restored.

**did you know?**

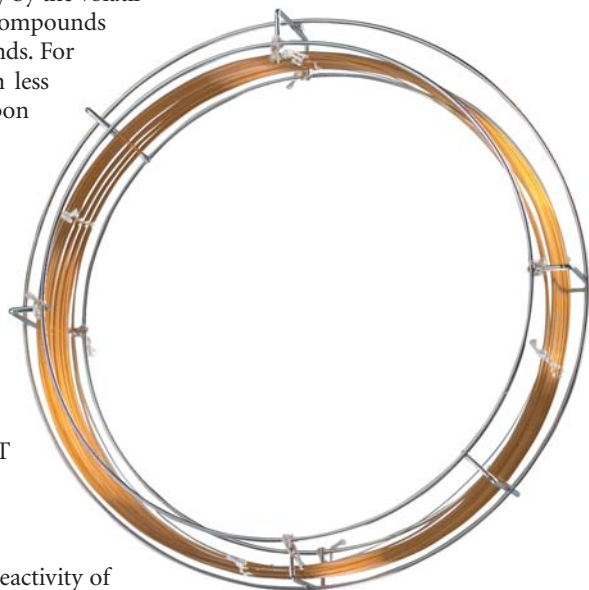
Rt™-Alumina PLOT columns show unique retention characteristics for hydrocarbons.

**Selectivity**

The selectivity of the Rt™-Alumina PLOT column is measured by the retention indices for acetylene and propadiene. These two components are extremely sensitive for a change in selectivity.

For saturates, retention is determined mainly by the volatility of the compound, with less volatile compounds retained longer than more volatile compounds. For example, isoparaffins are less retained than less volatile normal paraffins of similar carbon number.

For unsaturates, retention is strongly influenced by polarity or degree of unsaturation. In general, hydrocarbons having a higher degree of unsaturation are more polar. This polarity comes from the presence of  $\pi$  electrons; the more  $\pi$  electrons present in a compound, the more polar it behaves and the more strongly it is retained. Retention indices for some unsaturates separated on the Rt™-Alumina PLOT column are listed in Table I.

**Sensitivity**

Proper deactivation is critical to minimize reactivity of the aluminum oxide stationary phase and maximize column sensitivity. Quantitation can be done only if the column exhibits linear response, which results from good stationary phase inertness. Rt™-Alumina PLOT columns are specially deactivated and provide high inertness for unsaturates and saturates. In fact, Rt™-Alumina PLOT columns are almost four times more sensitive for unsaturates than other brands on the market. Column sensitivities for various unsaturated hydrocarbons, measured by the peak height ratio based on *n*-butane, are shown in Table I.

**Table I:** Retention indices and column response for unsaturates on an Rt™-Alumina PLOT column at 80°C.

	Ethylene	Acetylene	Propylene	Propadiene
Retention Index	255	421	372	407
Peak Ratio (vs. <i>n</i> -butane)	0.65	0.72	0.84	0.54

**Guaranteed Reproducibility**

Each Rt™-Alumina PLOT column is tested with a hydrocarbon test mix to ensure proper phase thickness and deactivation. Pentane is used to calculate *k* (capacity factor), which is a measure of phase thickness. The ratio of isobutane to acetylene retention is measured to ensure proper deactivation of the alumina oxide layer. The plates per meter value is calculated to evaluate column efficiency.

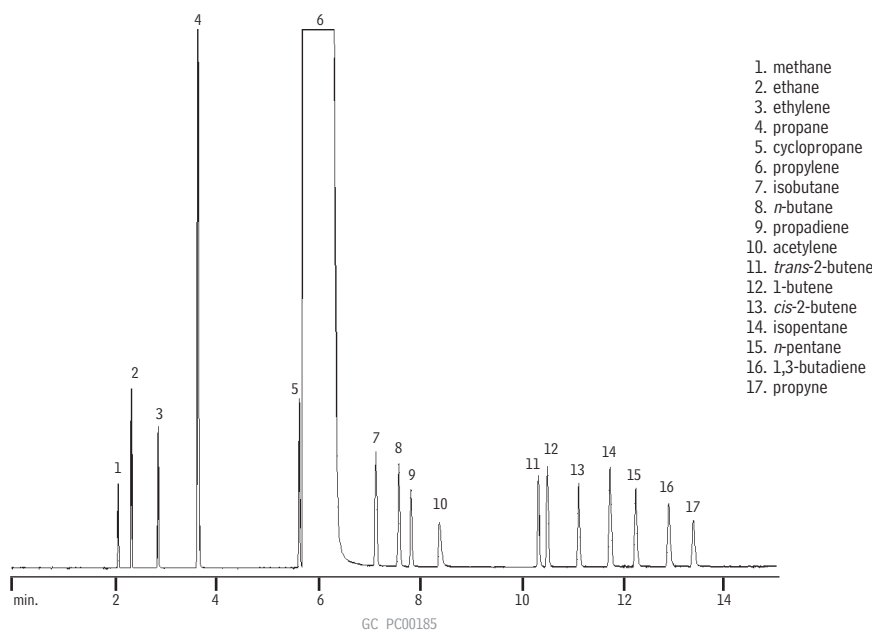
Restek's Rt™-Alumina PLOT columns offer fast and reproducible hydrocarbon stream and purity analyses. The 0.32mm ID Rt™-Alumina PLOT column provides fast and efficient analysis of C1 to C5 hydrocarbons. The higher capacity of the 0.53mm ID Rt™-Alumina PLOT column makes it ideal for purity analysis of many common petrochemicals, such as 1,3-butadiene, ethylene, and propylene (see figure).

**Rt™-Alumina Columns (fused silica PLOT)**(Na<sub>2</sub>SO<sub>4</sub> deactivation)

ID	df (μm)	temp. limits	30-Meter	50-Meter	60-Meter
0.32mm	3	to 200°C	19702	—	19703
0.53mm	6	to 200°C	19700	19701	—



**Neil Mosesman**  
Marketing Manager  
20+ years of service!

**Propylene purity on an Rt™-Alumina PLOT column.**

1. methane
2. ethane
3. ethylene
4. propane
5. cyclopropane
6. propylene
7. isobutane
8. *n*-butane
9. propadiene
10. acetylene
11. *trans*-2-butene
12. 1-butene
13. *cis*-2-butene
14. isopentane
15. *n*-pentane
16. 1,3-butadiene
17. propyne

Column: Rt™-Alumina, 50m, 0.53mm ID (cat.# 19701)  
 Inj.: 100μL hydrocarbon mix (gas-tight syringe)  
 Oven temp.: 40°C (hold 3 min.) to 120°C @ 10°C/min. (hold 5 min.)  
 Inj./det. temp.: 200°C  
 Carrier gas: helium  
 Linear velocity: 37.5cm/sec. set @ 80°C  
 Split flow: 60mL/min.  
 FID sensitivity: 1.28 x 10<sup>10</sup> AFS

**tech tip**

Trace water in the carrier gas can affect the selectivity and retention of the Rt™-Alumina PLOT column. The column can be regenerated by baking out the water (50°C to 200°C @ 8°C/min., 50cm/sec. flow rate). Periodic conditioning ensures excellent run-to-run retention time reproducibility.

The maximum programmable temperature for an Rt™-Alumina PLOT column is 200°C. Higher temperatures cause irreversible changes to the porous layer adsorption properties.

Table of Contents for  
**Applications**

see pages 518-519

Searching for a chromatogram?

[www.restek.com](http://www.restek.com)

please **note**

Rt™-Msieve 5A PLOT columns are designed for efficient separation of Ar/O<sub>2</sub> and other permanent gases, including CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, and CO.

**tech tip**

Because molecular sieve materials are very hydrophilic, they will adsorb water from the sample or carrier gas. Water contamination can have a detrimental effect on peak symmetry and can reduce the resolution of all compounds. If water contamination occurs, reactivate your Rt™-Msieve 5A PLOT column by conditioning at 300°C with dry carrier gas flow for 3 hours.

did you **know?**

ShinCarbon ST micropacked columns are another alternative for analyzing permanent gases.

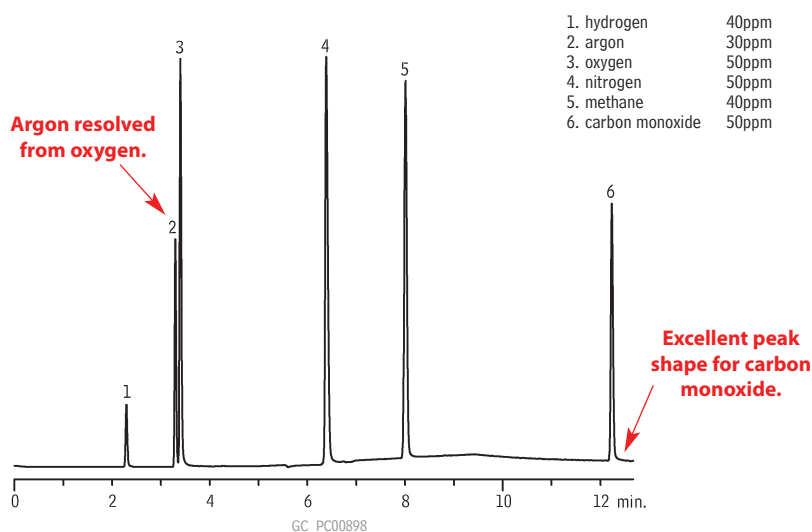
See **page 116** for information.

**Rt™-Msieve 5A PLOT Columns**

Rt™-Msieve 5A PLOT columns are designed for efficient separation of Ar/O<sub>2</sub> and other permanent gases, including CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, and CO. Special coating and deactivation procedures ensure chromatographic efficiency and the integrity of the porous layer coating. The high surface area of the Rt™-Msieve is generated by the pore structure present in the molecular sieve. Only compounds that can enter the pores will be exposed to this surface and will be retained. Molecular sieves have very high retention, allowing separations of permanent gases at temperatures above ambient. Additionally, Restek's unique immobilization process guarantees that the uniform particles remain adhered to the tubing—even after continuous valve-cycling.

Our revolutionary molecular sieve 5A PLOT columns separate Ar/O<sub>2</sub> and H<sub>2</sub>/He at ambient temperature or above (see figure). These columns also are an excellent choice for rapid separation of permanent gases in refinery or natural gas.

Our deactivation technology also allows the CO peak to elute as a sharp peak. This is in contrast with other suppliers where CO often tails badly and cannot be quantified below % levels.

**Permanent gases on an Rt™-Msieve 5A PLOT column.**

Column: Rt™-Msieve 5A, 30m, 0.53mm ID, 50µm (cat.# 19723)  
 Sample: permanent gases (ppm)  
 Inj.: 5µL sample loop, 6-port Valco valve, valve temp.: ambient  
 Inj. temp.: 200°C  
 Carrier gas: helium, constant flow  
 Linear velocity: 5mL/min.  
 Oven temp.: 27°C (hold 5 min.) to 100°C @ 10°C/min. (hold 5 min.)  
 Det.: Valco helium ionization detector @ 150°C

**Rt™-Msieve 5A Columns (fused silica PLOT)**

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	30	to 300°C	19720	19722
0.53mm	50	to 300°C	19721	19723



**Porous Polymers: Rt™-QPLOT, Rt™-QSPLIT, Rt™-SPLOT, and Rt™-UPLOT Columns**

Restek has developed unique polymer technology and coating processes, to make excellent porous polymer PLOT columns. Selectivity is similar to that of Porapak and HayeSep® packings. Unlike molecular sieve and alumina columns, porous polymer PLOT columns are not moisture sensitive, making them particularly useful for applications in which moisture is of major concern.

Chromatographic selectivity, in terms of polarity or chemical functionality, can be modified by incorporating polar functional groups in the styrene/divinylbenzene matrix. The least polar, or nonpolar, Rt™-QPLOT columns are made with divinylbenzene. Rt™-SPLOT columns incorporate 4-vinylpyridine, providing intermediate polarity. The new Rt™-QSPLIT column has been engineered to have a polarity between the Rt™-QPLOT and Rt™-SPLOT columns. The Rt™-QSPLIT column fully resolves ethylene, acetylene, and ethane. Highly-polar Rt™-UPLOT columns are modified with an ethylene glycol/dimethylacrylate functional group to provide excellent selectivity for unsaturated compounds.

Use these porous PLOT columns for a wide variety of separations. Permanent gases can be separated at subambient temperatures. Inorganic gases such as CO<sub>2</sub> can be easily analyzed on porous polymer columns. For hydrocarbon analysis, tremendous versatility based on a choice of selectivity is advantageous. These columns also are designed for analysis of various polar and nonpolar solvents.

**Rt™-QPLOT Columns (fused silica PLOT)**

100% divinylbenzene

ID	df (μm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 250°C	19717	19718
0.53mm	20	to 250°C	19715	19716

**Rt™-QSPLIT Columns (fused silica PLOT)**

porous divinyl benzene homopolymer

ID	df (μm)	temp. limits	15-Meter	30-Meter
0.32mm	10	-60 to 270/290°C	19739	19740
0.53mm	20	-60 to 270/290°C	19737	19738

**Rt™-SPLOT Columns (fused silica PLOT)**

divinylbenzene 4-vinylpyridine

ID	df (μm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 250°C	19711	19710
0.53mm	20	to 250°C	19713	19712

**Rt™-UPLOT Columns (fused silica PLOT)**

divinylbenzene ethylene glycol/dimethylacrylate

ID	df (μm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 190°C	19725	19724
0.53mm	20	to 190°C	19727	19726

did you know?

New purification techniques have improved the peak shapes for polar compounds on our Rt™-QPLOT columns.

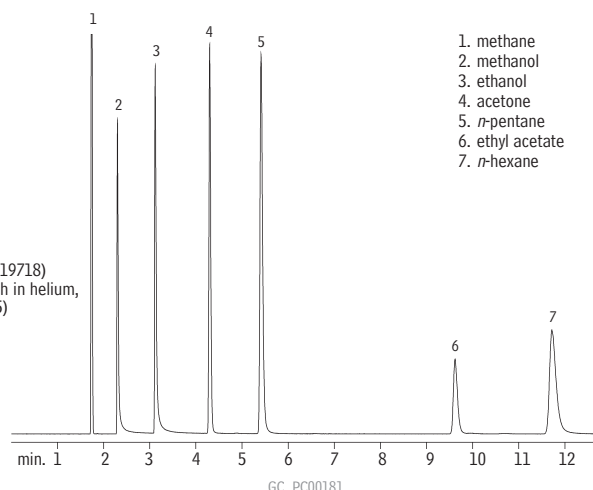
new!

Intermediate polarity porous polymer Rt™-QSPLIT Columns—100% resolution of ethylene, acetylene, and ethane.

please note

Our porous polymer PLOT columns are not moisture sensitive, making them ideal for applications in which moisture is of major concern.

**Solvents on the nonpolar Rt™-QPLOT column.**



Column: Rt™-QPLOT, 30m, 0.32mm ID (cat.# 19718)  
 Inj.: 20μL split injection, 50ppm (w/v) each in helium, Cyclosplitter® inlet liner (cat.# 20755)  
 Oven temp.: 150°C  
 Inj./det. temp.: 200°C  
 Carrier gas: hydrogen  
 Det.: FID  
 Split ratio: 20/1

Table of Contents for **Applications** see pages 518-519