GC COLUMNS
PLOT COLUMNS

Top: Kelsea Miller, Caging Technician
Bottom: Kim Shaffer, Manufacturing Group Leader

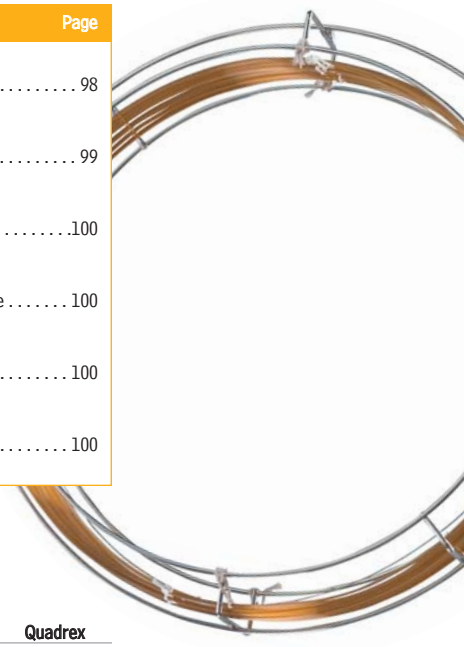
What's NEW? look for this circle

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.	**Reduced particle generation and flow restriction.**
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 minimized.	
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 available.	

Quick Reference Chart

PLOT Column	Application	Page
Rt-Alumina BOND (Na_2SO_4 deactivation)	C1–C5 hydrocarbons. Purity analysis of ethylene, propylene, butenes, butadiene	98
Rt-Msieve 5A	Permanent gas analysis. He, Ne, Ar, O_2, N_2, Xe, Rn, SF6, and CH_4, C_2H_6, CO	99
Rt-Q-BOND	Nonpolar porous polymer. High retention for solvents, alcohols, polar volatiles, CO_2, sulfur, and ppm water in solvents	100
Rt-QS-BOND	Intermediate polarity porous polymer. Neutral solvents, ketones, esters, hydrocarbons, and baseline separation of ethane, ethene, acetylene	100
Rt-S-BOND	Intermediate polarity porous polymer. Light gases in ethylene and propylene, ketones, esters, hydrocarbons	100
Rt-U-BOND	Polar porous polymer. More retention for polar compounds	100



PLOT Column Phase Cross-Reference: Similar Selectivity

Restek	Porous Layer	Agilent/J&W	Supelco	Alltech	Varian/Chrompack	Quadrex
Rt-Alumina BOND (Na_2SO_4 deactivation)	Aluminum oxide	GS-Alumina, HP PLOT S, HP PLOT M	Alumina-PLOT	AT-Alumina	CP-Al_2O_3/NA_2SO_4	——
Rt-Msieve 5A	Molecular sieve 5A	GS-Molsieve, HP PLOT/Molesieve	Molsieve 5A PLOT	AT-Molesieve	CP-Molesieve 5A	PLT-5A
Rt-Q-BOND	DVB porous polymer	——	Supel-Q-PLOT	AT-Q	CP-PoraPlot Q, PoraBond Q	——
Rt-QS-BOND	Intermediate polarity porous polymer	GS-Q	——	——	——	——
Rt-S-BOND	DVB vinylpyridine polymer	——	——	——	CP-PoraPlot S	——
Rt-U-BOND	DVB ethyleneglycol-dimethylacrylate polymer	HP-UPLOT	——	——	CP-PoraPlot U, PoraBond U	——

New Generation Porous Layer Open Tubular (PLOT) Columns

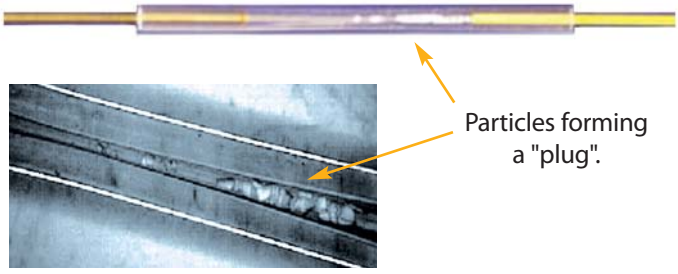
- Stabilized particle layers improve robustness and reproducibility of retention and flow; no retention time changes between columns.
- Fully compatible with valve switching and Deans switching systems.
- Highly efficient, reproducible analyses; ideal for permanent gases, solvents, and hydrocarbons.
- New manufacturing procedure improves performance of porous polymers and molecular sieves.

Porous layer open tubular (PLOT) columns are very beneficial for solving application problems, especially for the analysis of volatile compounds. PLOT columns have a unique selectivity, allowing for the separation of gaseous compounds at room temperature. Due to the adsorption mechanism of the supports used in PLOT columns, permanent gases and light hydrocarbons can be resolved at room temperature. Columns can then be programmed to higher temperatures to elute higher boiling compounds.

Traditional PLOT Columns Offer Poor Stability

The traditional PLOT column is built with a 5-50µm layer of particles adhered to the tubing walls. Because this layer of particles generally lacks stability, PLOT columns must be used very carefully, as particle release is common and can cause unpredictable changes in retention time and flow behavior. PLOT columns generally must be used in conjunction with particle traps to prevent the contamination of valves, injectors, and GC detectors. Figure 1 shows an example of particle accumulation resulting in a blockage inside a Press-Tight® liner. If particle traps are not used, particles will hit the detector resulting in electronic noise, seen as spikes on the baseline. In the case of valves, particles can become lodged in the valve and result in leaks.

Figure 1 Particles released from traditional PLOT columns can cause blockages.



New Stabilized PLOT Columns Minimize Particle Release

Restek has developed new procedures to manufacture PLOT columns with concentric stabilized adsorption layers. The new generation PLOT columns show a constant flow behavior (permeability) and have significantly improved mechanical stability, resulting in easier operation, better chromatography, and reduced particle release. Greater particle stability means more reproducible retention times, virtually no spiking, and longer column lifetimes. This innovative stabilization chemistry technology is currently applied to Rt®-Alumina BOND, Rt®-MSieve 5A, Rt®-Q-BOND, Rt®-QS-BOND, Rt®-S-BOND, and Rt®-U-BOND columns.

Consistent Flow Restriction Factor (F) Guarantees Reproducible Flow

Thick layers of particles are difficult to deposit in a homogeneous layer and, in traditionally manufactured PLOT columns, this results in variable coating thicknesses. The positions where the layer is thicker act as restrictions and affect flow (Figure 2). Depending on the number and intensity of these restrictions, traditional PLOT columns often show greater variation in flow restriction than wall coated open tubular (WCOT) columns. In practice, conventional PLOT columns with the same dimensions can differ in flow by a factor of 4-6, when operated at the same nominal pressure. For applications where flow is important, such as with Deans switching, the nonreproducible flow behavior of most commercially available PLOT columns is a problem.

Figure 2 Inconsistent coating thicknesses result in restrictions that cause significant variation in flow.

In order to evaluate flow restriction reproducibility, Restek is introducing a new factor: the flow restriction factor (F). The flow restriction factor is based on the retention time of an unretained compound (Equation 1). It can be used to assess the degree of restriction of the column and to evaluate the reproducibility of the column coating process. Percent flow restriction can also be calculated as shown in Equation 2. Figure 3 shows what typically happens when a conventional PLOT column manufacturing process is used. Because of the difference in flow restriction, individual columns have very different flow characteristics. In contrast, Figure 4 shows results for columns generated using the new process (Rt®-QS-BOND, bonded porous polymer). Clearly, the new PLOT column process results in greater consistency in both column coating thickness and flow restriction.

Equation 1 Flow restriction factor (F) is used to demonstrate coating consistency.

$$F = \frac{t_{R1} \text{ of unretained component (uncoated tubing)}}{t_{R2} \text{ of unretained component (coated column)}}$$

t_R = retention time

Note, F values will always be <1 as the coated column always has more restriction than the uncoated column.

Equation 2 Percent flow resctriction of coated column.

$$\% \text{ restriction} = (1 - F) \times 100$$

Figure 3 Traditional PLOT columns show significant flow variability, indicating inconsistent column coating thicknesses (n=12).

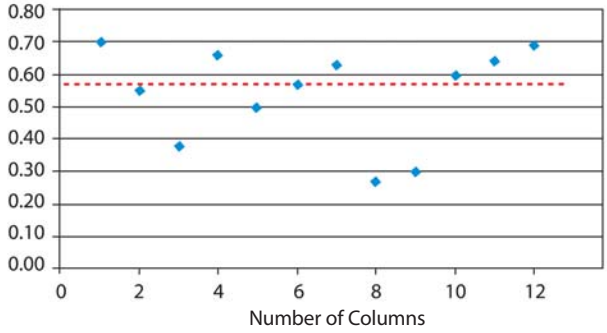
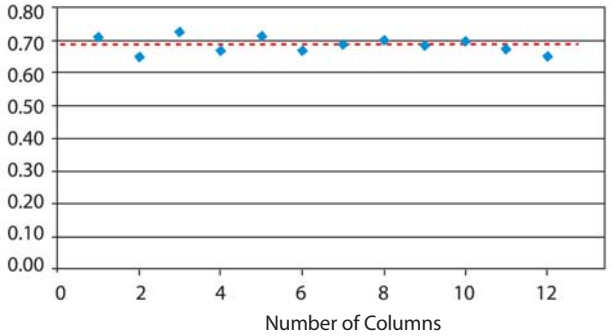


Figure 4 Restek's new stabilized PLOT columns offer consistent flow resistance, giving more reproducible results column-to-column.



In summary, Restek's new PLOT column manufacturing process produces exceptionally robust PLOT columns, featuring concentric stabilized coating layers. These new columns have more consistent flow resistance and are recommended for applications sensitive to variation in retention time or flow. These columns are a significant advance in PLOT column technology and are ideal for more efficient, reproducible analyses of permanent gases, solvents, and hydrocarbons.

Rt®-Alumina BOND Columns

NEW! advanced technology

Details on **pages 96-97**.

did you **know**?

Rt®-Alumina BOND columns show unique retention characteristics for hydrocarbons.

tech tip

Trace water in the carrier gas can affect the selectivity and retention of the Rt®-Alumina BOND 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 BOND column is 200°C. Higher temperatures cause irreversible changes to the porous layer adsorption properties.

NEW! Rt®-Alumina BOND columns now available with KCl deactivation!

Rt®-Alumina BOND Column Characteristics

1. Highly selective for C1-C5 hydrocarbons; separates all unsaturated hydrocarbon isomers above ambient temperatures.
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 BOND 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.

Guaranteed Reproducibility

Each Rt®-Alumina BOND column is tested with a hydrocarbon test mix to ensure proper phase thickness and selectivity. 1,3-Butadiene is used to calculate k (capacity factor), which is a measure of phase thickness. Selectivity is measured using retention indices for propadiene and methyl acetylene. The resolution of *trans*-2-butene and 1-butene is also verified. To measure coating efficiency, plates per meter are checked using 1,3-butadiene.

With our new technology, both Na_2SO_4 and KCl are available with the Rt®-Alumina BOND columns.

Rt®-Alumina BOND Columns (fused silica PLOT)

(Na_2SO_4 deactivation)

ID	df (µm)	temp. limits	30-Meter		50-Meter	
0.32mm	5	to 200°C	19757	enquire	19758	enquire
0.53mm	10	to 200°C	19755	enquire	19756	enquire

Rt®-Alumina BOND Columns (fused silica PLOT)

(KCl deactivation)

ID	df (µm)	temp. limits	30-Meter		50-Meter	
0.32mm	5	to 200°C	19761	enquire	19762	enquire
0.53mm	10	to 200°C	19759	enquire	19760	enquire

Restek Customer Service

In the U.S.

Call: 800-356-1688 (ext. 3) or 814-353-1300 (ext. 3)

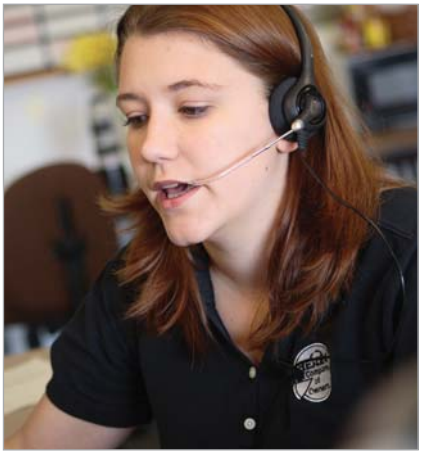
Monday–Friday 8:00 a.m.–6:00 p.m. ET

Fax: 814-353-1309—24-hours a day

Online: www.restek.com—24-hours a day

Outside the U.S.

Contact your Restek representative:
Refer to our list on pages 4-5 or visit our website at www.restek.com



Melissa Decker, Customer Service

Rt®-Msieve 5A PLOT Columns

Rt®-Msieve 5A PLOT columns are designed for efficient separation of Ar/O_2 and other permanent gases, including CH_4, C_2H_6, and CO. Special coating and deactivation procedures ensure chromatographic efficiency and the integrity of the porous layer coating. 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_2 and H_2/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.

NEW! advanced technology

Details on pages 96-97.

did you know?

Rt®-Msieve 5A PLOT columns are designed for efficient separation of Ar/O_2 and other permanent gases, including CH_4, C_2H_6, and CO.

Rt®-Msieve 5A Columns (fused silica PLOT)

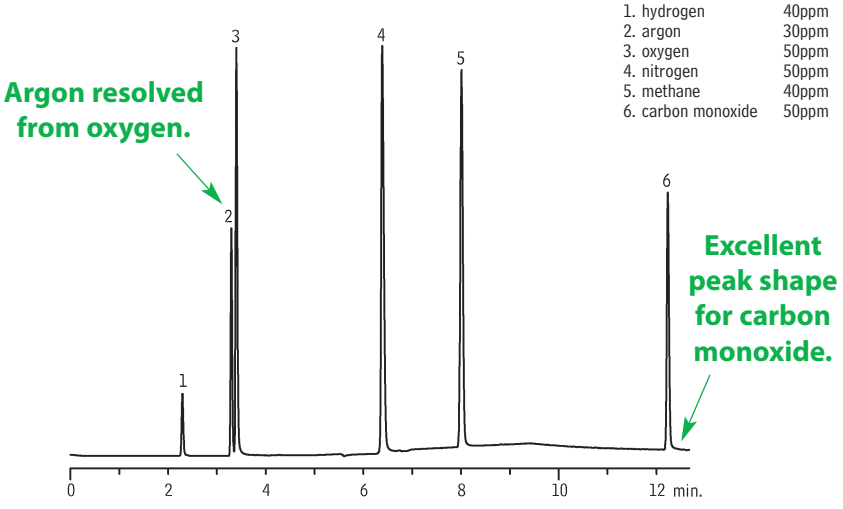
ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	30	to 300°C	19720	19722
0.53mm	50	to 300°C	19721	19723

MXT®-Msieve 5A (Siltek®-treated stainless steel PLOT)

ID	df (µm)	temp. limits	30-Meter	
0.53mm	50	to 300°C	79723	enquire

NEW! Metal PLOT columns are back!

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

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 120 for information.

Searching for a chromatogram?
www.restek.com

Porous Polymer PLOT Columns

Porous Polymers: Rt®-Q-BOND, Rt®-QS-BOND, Rt®-S-BOND, Rt®-U-BOND

Restek chemists have developed a new process for the manufacturing of porous polymer PLOT columns. The process incorporates the particles to the walls of the tubing, so there is virtually no particle generation. Because of the particle adhering to the walls of the tubing, there is reproducible performance from column to column, including selectivity and flow.

NEW! advanced technology

Details on **pages 96-97**.

Rt®-Q-BOND Columns (fused silica PLOT)

100% divinylbenzene

- Nonpolar PLOT column incorporating 100% divinyl benzene.
- Excellent for analysis of C1 to C3 isomers and alkanes up to C12.
- CO_2 and methane separated from $O_2/N_2/CO$ (Note: $O_2/N_2/CO$ not separated at room temperature).
- Use for analysis of oxygenated compounds and solvents.
- Maximum temperature of 320°C.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 300/320°C	19743	19744
0.53mm	20	to 300/320°C	19741	19742

Rt®-QS-BOND Columns (fused silica PLOT)

porous divinyl benzene homopolymer

- Intermediate polarity PLOT column incorporating divinyl benzene homopolymer.
- Separates ethane, ethylene and acetylene to baseline.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 250°C	19739	19740
0.53mm	20	to 250°C	19737	19738

Rt®-S-BOND Columns (fused silica PLOT)

divinylbenzene 4-vinylpyridine

- Midpolarity PLOT column, incorporating divinyl benzene 4-vinylpyridine.
- Use for the analysis of nonpolar and polar compounds.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 250°C	19747	19748
0.53mm	20	to 250°C	19745	19746

Rt®-U-BOND Columns (fused silica PLOT)

divinylbenzene ethylene glycol/dimethylacrylate

- Polar PLOT column, incorporating divinylbenzene ethylene glycol/dimethylacrylate.
- Use for the analysis of polar and nonpolar compounds.

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.32mm	10	to 190°C	19751	19752
0.53mm	20	to 190°C	19749	19750

NEW!

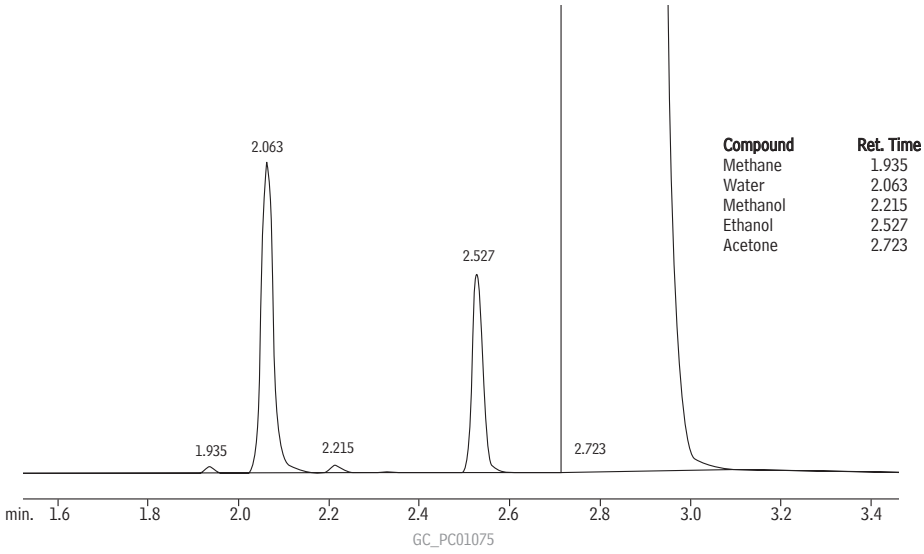
PLOT Column Particle Trap

- Includes two Press-Tight® connectors and a 2.5m column.
- Connect particle trap between column and detector or valve.
- Eliminates detector spikes and scratches in valve rotors.

The technology used to adhere particles in PLOT columns is excellent; however, there is still a possibility for particles to dislodge. When using PLOT columns with a valve-switching system or GC/MS, we recommend using a particle trap at the outlet end of the column.

Description	qty.	cat.#	price
PLOT Column Particle Trap, 2.5m, 0.32mm ID w/2 Press-Tight Connectors	ea.	19753	enquire
PLOT Column Particle Trap, 2.5m, 0.53mm ID w/2 Press-Tight Connectors	ea.	19754	enquire

Water and ethanol in acetone on an Rt®-Q-BOND PLOT column.



Compound	Ret. Time
Methane	1.935
Water	2.063
Methanol	2.215
Ethanol	2.527
Acetone	2.723

Column:	Rt®-Q-BOND, 30m, 0.53mm ID, 20µm (cat.# 19742)
Sample:	0.5% water and ethanol in acetone
Inj.:	3µL split (split ratio 11:1), 4mm single gooseneck liner w/ wool (cat.# 22405)
Inj. temp.:	250°C
Carrier gas:	helium, constant flow
Linear velocity:	28.7cm/sec. @ 200°C
Oven temp.:	200°C, isothermal
Det.:	TCD @ 260°C

"Our chemists and process engineers are dedicated to effective scale-up and continuous process improvement. We make sure the exceptional performance of Restek products is maintained from development all the way through manufacturing."

Restek's Process Development Group
pictured: Steve Constable, Wendy Henninger, Brian Salisbury, Rick Crago, Jennifer Weston, Tom Vezza (not pictured: Greg Hargrove)