

# GC COLUMNS

## PLOT COLUMNS

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# Next Generation GC PLOT Columns

- New bonding process minimizes particle release, reducing column blockage and protecting instrument parts.
- More consistent flow means stable retention times in Deans and related flow switching techniques.
- Outstanding peak symmetry improves impurity analysis for gases, solvents, and hydrocarbons.

## Quick Reference Chart

PLOT Column	Application	Page
Rt-Alumina BOND/ MXT-Alumina BOND (Na <sub>2</sub> SO <sub>4</sub> deactivation)	C1–C5 hydrocarbons. Purity analysis of ethylene, propylene, butenes, butadiene .....	108
Rt-Alumina BOND (KCl deactivation)	C1-C10 hydrocarbons, C1-C5 isomers. Purity analysis of ethylene, propylene, butene, butadiene. ....	108
Rt-Alumina BOND (CFC deactivation)	Multi-halogenated alkanes, C1-C-5 range. CFCs (chlorofluorocarbons) .....	108
Rt-Msieve 5A/ MXT-Msieve 5A	Permanent gas analysis (polarity between Q-BOND and S-BOND). 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>2</sub> , CO .....	109
Rt-Q-BOND/ MXT-Q-BOND	Nonpolar porous polymer. High retention for solvents, alcohols, polar volatiles, CO <sub>2</sub> , sulfur, and ppm water in solvents .....	110
Rt-QS-BOND	Intermediate polarity porous polymer. Neutral solvents, ketones, esters, hydrocarbons, and baseline separation of ethane, ethene, acetylene .....	110
Rt-S-BOND/ MXT-S-BOND	Intermediate polarity porous polymer. Light gases in ethylene and propylene, ketones, esters, hydrocarbons .....	110
Rt-U-BOND	Polar porous polymer. More retention for polar compounds .....	110



## PLOT Column Phase Cross-Reference: Similar Selectivity

Restek	Porous Layer	Agilent/J&W	Supelco	Alltech	Varian/Chrompack	Quadrex
Rt-Alumina BOND/Na <sub>2</sub> SO <sub>4</sub> MXT-Alumina BOND	Aluminum oxide	GS-Alumina	Alumina-Sulfate	AT-Alumina	CP-Al <sub>2</sub> O <sub>3</sub> /NA <sub>2</sub> SO <sub>4</sub>	—
Rt-Alumina BOND/KCl	Aluminum oxide	GC-Alumina KCl HP PLOT Al <sub>2</sub> O <sub>3</sub>	Alumina-Chloride	—	CP-Al <sub>2</sub> O <sub>3</sub> /KCl	—
Rt-Alumina BOND/CFC			<b>unique product</b>			
Rt-Msieve 5A MXT-Msieve 5A	Molecular sieve 5A	HP PLOT Molsieve	Molsieve 5A PLOT	AT-Molsieve	CP-Molsieve 5A	PLT-5A
Rt-Q-BOND MXT-Q-BOND	DVB porous polymer	HP PLOT Q	Supel-Q-PLOT	AT-Q	CP-PoraPlot Q, PoraBond Q	—
Rt-QS-BOND	Intermediate polarity porous polymer	GS-Q	—	—	—	—
Rt-S-BOND MXT-S-BOND	DVB vinylpyridine polymer	—	—	—	CP-PoraPlot S	—
Rt-U-BOND	DVB ethyleneglycol- dimethylacrylate polymer	HP-PLOT U	—	—	CP-PoraPlot U, CP-PoraBond U	—



### Next Generation of Porous Layer Open Tubular (PLOT) Columns

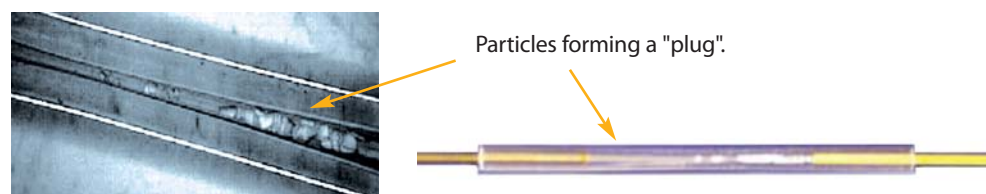
- Stabilized particle layers improve robustness and reproducibility of retention and flow.
- Fully compatible with valve switching and Deans switching systems.
- Highly efficient, reproducible analyses; ideal for permanent gases, solvents, and hydrocarbons.
- New manufacturing procedure reduces particle generation and improves performance of porous polymers, molecular sieves, and PLOT columns.

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 5-50 $\mu$ m 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<sup>®</sup> 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 PLOT Columns Minimize Particle Release

Restek has developed new procedures to manufacture PLOT columns with concentric stabilized adsorption layers. These 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<sup>®</sup>-Alumina BOND, Rt<sup>®</sup>-Msieve 5A, Rt<sup>®</sup>-Q-BOND, Rt<sup>®</sup>-QS-BOND, Rt<sup>®</sup>-S-BOND, and Rt<sup>®</sup>-U-BOND fused silica columns. It is also available for select metal columns including MXT<sup>®</sup>-Alumina BOND and MXT<sup>®</sup>-Msieve 5A 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.

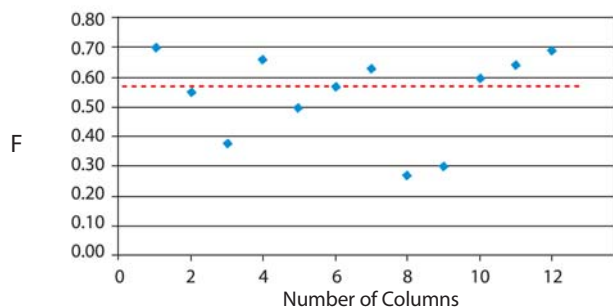


In order to evaluate flow restriction reproducibility, Restek is introducing a new factor: the flow restriction factor (F). This factor is based on the retention time of an unretained marker compound, as measured on both coated and uncoated tubing using the same backpressure setting (Equation 1). For quality control purposes, methane is used as the marker when evaluating porous polymer columns and helium is used for testing Rt®-Msieve 5A columns.

Flow restriction factor determination can be used both to assess the degree of column restriction and to evaluate the reproducibility of the column coating process. Percent flow restriction can also be calculated (Equation 2). Figure 3 shows typical results for PLOT columns manufactured using a conventional process. Because of the difference in flow restriction, individual columns have very different flow characteristics. In contrast, Figure 4 shows results for columns made using the new PLOT column process (Rt®-QS-BOND, bonded porous polymer). Clearly, the new manufacturing process results in greater consistency in both column coating thickness and flow restriction; which, in turn, results in more stable retention times and better performance in Deans switching and related flow switching techniques.



**Figure 3** Traditional PLOT columns show significant flow variability, indicating inconsistent column coating thicknesses.



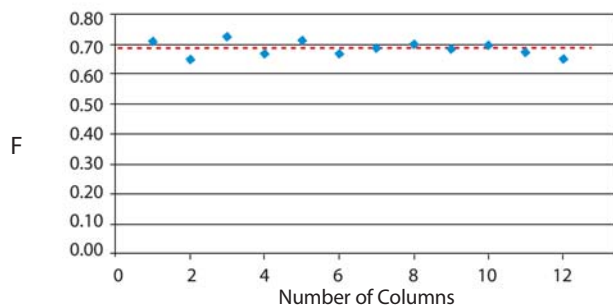
**Equation 1** Flow restriction factor (F) is used to demonstrate coating consistency.

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

$t_R$  = retention time

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

**Figure 4** New PLOT columns from Restek offer consistent flow resistance, giving more reproducible results column-to-column.



**Equation 2** Percent flow restriction of coated column.

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

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.





**NEW!** advanced technology

Details on pages 106-107.

did you know?

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

**i** tech tip

Traces of water in the carrier gas and in the sample will affect the retention and the selectivity of alumina. If exposed to water, the retention times will shorten. The column can be regenerated by conditioning for 15-30 min. at 200 °C under normal carrier gas flow. 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.

**Rt®-Alumina BOND Columns**

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.
5. High capacity and loadability give exceptionally symmetric peaks; ideal for volatile hydrocarbon separations at percent levels, as well as impurity analyses at ppm concentrations.

**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. Extensive testing assures reproducible retention times and predictable flow behavior column-to-column.

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

(Na<sub>2</sub>SO<sub>4</sub> deactivation)

- Acetylene/propadiene elute after butanes (impurities in acetylene/propadiene).
- Best separation for butene isomers (impurities in butene streams).
- Methyl acetylene elutes after 1,3-butadiene.
- Cyclopropane (impurity in propylene) elutes well before propylene.

ID	df	temp. limits	30-Meter	50-Meter
0.25mm	4µm	to 200°C	19775	
0.32mm	5.00µm	to 200°C	19757	19758
0.53mm	10µm	to 200°C	19755	19756

**Rt®-Alumina BOND/KCl Columns (fused silica PLOT)**

(KCl deactivation)

- Acetylene elutes before C4 hydrocarbons (impurities in butane/isobutane).
- Methyl acetylene (impurity in 1,3-butadiene) elutes before 1,3-butadiene.

ID	df	temp. limits	30-Meter	50-Meter
0.25mm	4µm	to 200°C	19776	
0.32mm	5.00µm	to 200°C	19761	19762
0.53mm	10µm	to 200°C	19759	19760



**Rt®-Alumina BOND/CFC Columns (fused silica PLOT)**

- Improved inertness for halogenated compounds such as CFCs.
- Highly selective alumina based column, separates most CFCs.
- High retention and capacity for CFCs.

ID	df	temp. limits	30-Meter
0.53mm	10µm	to 200°C	19763



**MXT®-Alumina BOND/Na<sub>2</sub>SO<sub>4</sub> Columns (Siltek®-treated stainless steel PLOT)**

Advantages of metal MXT® PLOT columns include:

- Can be made in small coil diameters—perfect for tight spaces.
- Will not spontaneously break, making them ideal for rugged environments.
- Designed for robust performance in process GCs and field instruments.

ID	df (µm)	temp. limits	3.5" coil	7" diameter 11-pin cage
			30-Meter	30-Meter
0.53mm	10µm	to 200°C	79714-273	79714



for more info

For more information on Rt®-Alumina BOND/CFC columns, see page 74.



### Molecular Sieve 5A PLOT Columns

Restek's molecular sieve 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. Molecular sieves have very high retention, allowing separations of permanent gases at temperatures above ambient. Additionally, our 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.

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

ID	df	temp. limits	15-Meter	30-Meter
0.25mm	20µm	to 300°C	19773	
0.32mm	30µm	to 300°C	19720	19722
0.53mm	50µm	to 300°C	19721	19723

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

Advantages of metal MXT® PLOT columns include:

- Can be made in small coil diameters—perfect for tight spaces.
- Will not spontaneously break, making them ideal for rugged environments.
- Designed for robust performance in process GCs and field instruments.
- Available in 3.5" coil diameter or 7" diameter 11-pin cage.

ID	df	temp. limits	15-Meter	3.5" coil 30-Meter	7" diameter 11-pin cage 30-Meter
0.25mm	20µm	to 300°C	79717		
0.53mm	50µm	to 300°C		79723-273	79723



advanced technology

Details on pages 106-107.



### did you know?

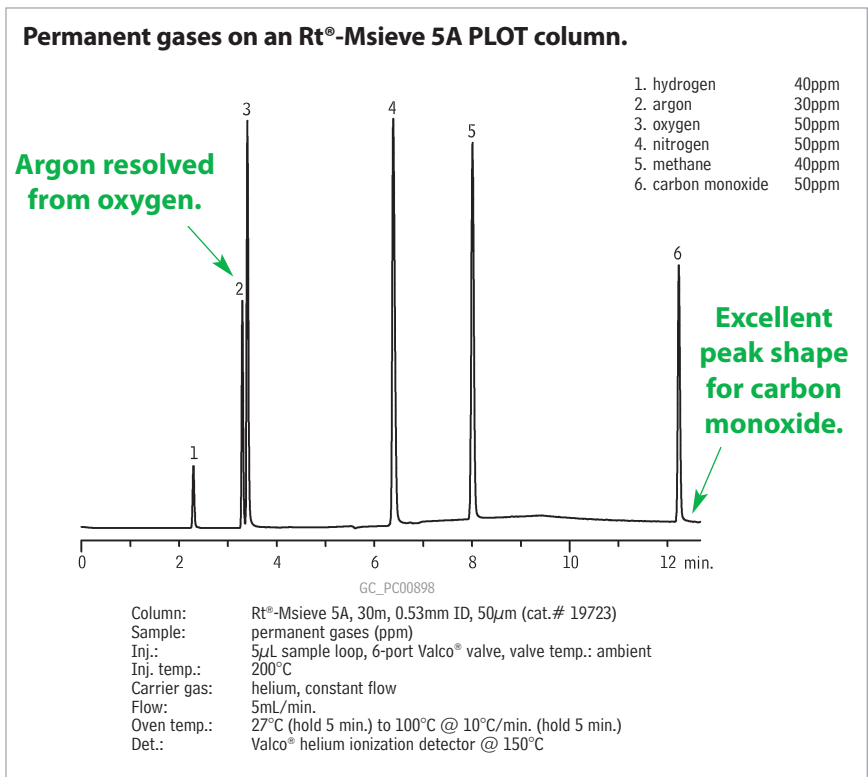
Rt®-Msieve 5A PLOT columns are designed for efficient separation of Ar/O<sub>2</sub> and other permanent gases, including CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, and CO.



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.



Carbon dioxide will not elute from molecular sieve columns. Rt®-Q-BOND is a good choice for this analysis.



### did you know?

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

See page 130 for information.





advanced  
 technology

Details on pages 106-107.



For more chromatograms, see pages 652, 654 and 701-703, or use our chromatogram search tool at [www.restek.com/chromatograms](http://www.restek.com/chromatograms)

least polar



most polar

**Porous Polymers: Rt<sup>®</sup>-Q-BOND, Rt<sup>®</sup>-QS-BOND, Rt<sup>®</sup>-S-BOND, Rt<sup>®</sup>-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.

**Rt<sup>®</sup>-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.
- High retention for CO<sub>2</sub> simplifies gas analysis; CO<sub>2</sub> and methane separated from O<sub>2</sub>/N<sub>2</sub>/CO (Note: O<sub>2</sub>/N<sub>2</sub>/CO not separated at room temperature).
- Use for analysis of oxygenated compounds and solvents.
- Maximum temperature of 300 °C.

ID	df	temp. limits	15-Meter	30-Meter
0.25mm	8µm	to 280/300°C	19764	19765
0.32mm	10µm	to 280/300°C	19743	19744
0.53mm	20µm	to 280/300°C	19741	19742

**Rt<sup>®</sup>-QS-BOND Columns (fused silica PLOT)**

porous divinyl benzene homopolymer

- Intermediate polarity PLOT column incorporating low 4-vinyl pyridine.
- Separates ethane, ethylene and acetylene to baseline.

ID	df	temp. limits	15-Meter	30-Meter
0.25mm	8µm	to 250°C	19767	19768
0.32mm	10µm	to 250°C	19739	19740
0.53mm	20µm	to 250°C	19737	19738

**Rt<sup>®</sup>-S-BOND Columns (fused silica PLOT)**

divinylbenzene 4-vinylpyridine

- Midpolarity PLOT column, incorporating high 4-vinyl pyridine.
- Use for the analysis of nonpolar and polar compounds.

ID	df	temp. limits	15-Meter	30-Meter
0.25mm	8µm	to 250°C	19769	19770
0.32mm	10µm	to 250°C	19747	19748
0.53mm	20µm	to 250°C	19745	19746

**Rt<sup>®</sup>-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	temp. limits	15-Meter	30-Meter
0.25mm	8µm	to 190°C	19771	19772
0.32mm	10µm	to 190°C	19751	19752
0.53mm	20µm	to 190°C	19749	19750

**Advantages of Metal MXT<sup>®</sup> PLOT columns include:**

- Can be made in small coil diameters—perfect for tight spaces.
- Will not spontaneously break, making them ideal for rugged environments.
- Designed for robust performance in process GCs and field instruments.
- Available in 3.5" coil diameter or 7" diameter 11-pin cage.

**MXT<sup>®</sup>-Q-BOND Columns (Siltek<sup>®</sup>-treated stainless steel PLOT)**

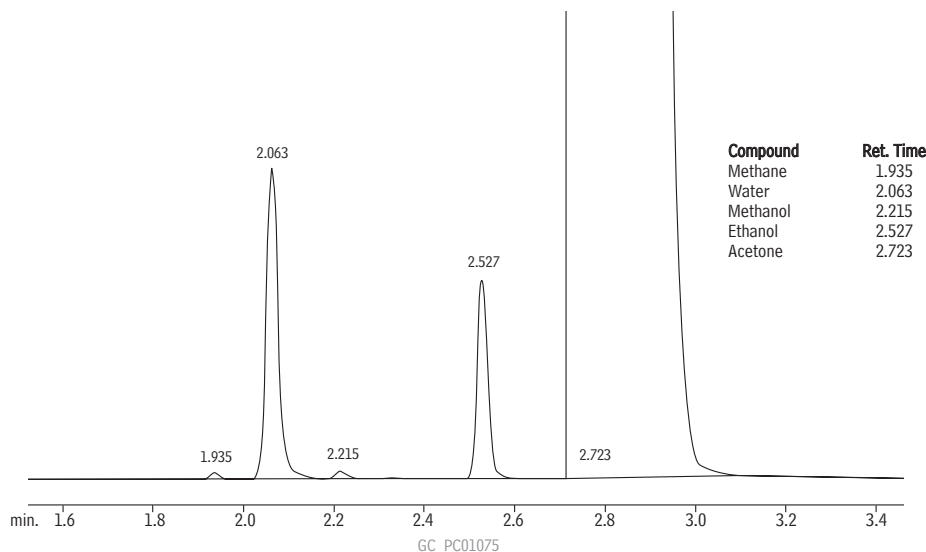
ID	df	temp. limits	15-Meter	3.5" coil	7" diameter 11-pin cage
				30-Meter	30-Meter
0.25mm	8µm	to 300/320°C	79718		
0.53mm	20µm	to 300/320°C		79716-273	79716

**MXT<sup>®</sup>-S-BOND Columns (Siltek<sup>®</sup>-treated stainless steel PLOT)**

ID	df	temp. limits	3.5" coil	7" diameter 11-pin cage
			30-Meter	30-Meter
0.53mm	20µm	to 250°C	79712-273	79712



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



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



**PLOT Column Particle Trap**

- Includes two Press-Tight® connectors and a 2.5 m column.
- Protects detector and valves; connects 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 extreme pressure shocks and gas flow changes are anticipated. This sometimes happens when valve backflush or MS detection is used. In those extreme cases, using particle traps is recommended.



Particle Trap

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

**Restek Customer Service**

**In the U.S.**

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

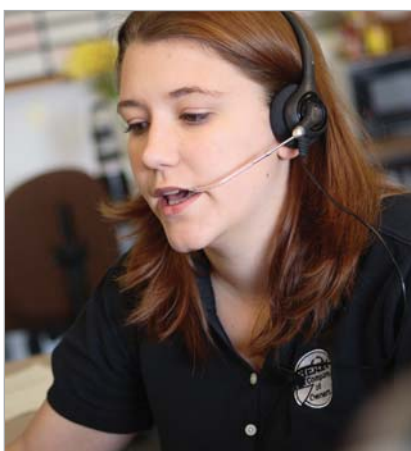
Monday–Friday 8:00 a.m.–6:00 p.m. ET

Fax: 814-353-1309—24-hours a day

Online: www.restek.com—24-hours a day

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Melissa Decker, Customer Service

