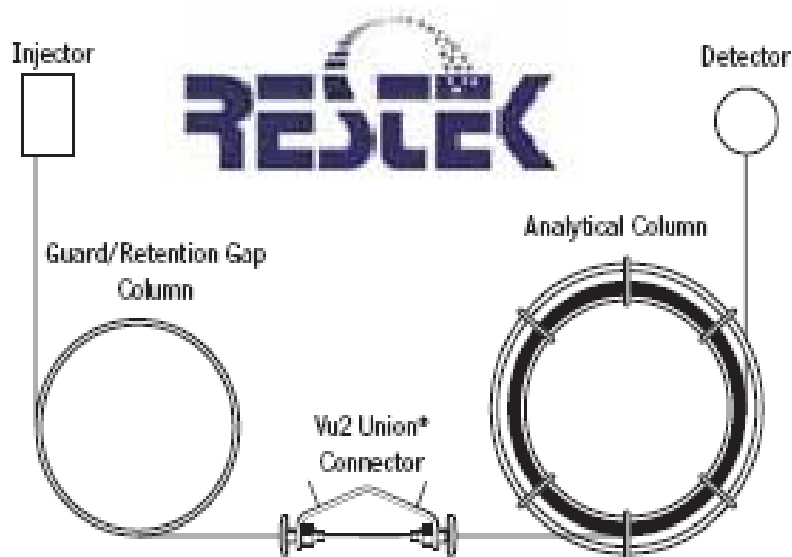


# Guard Columns

## Retention Gaps



Connectors for Fused Silica Columns



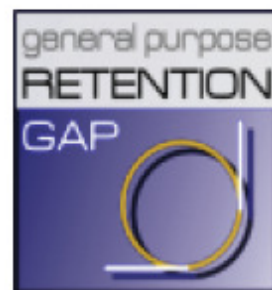
Vu2 Union\* Connector



Press-Tight\* Connectors



MXT\* Union Connector Kit  
for Fused Silica



## Connectors

## Using Guard Columns and Retention Gaps in GC (Part 1)

Jaap de Zeeuw, International GC Consumables Specialist, Restek Corporation



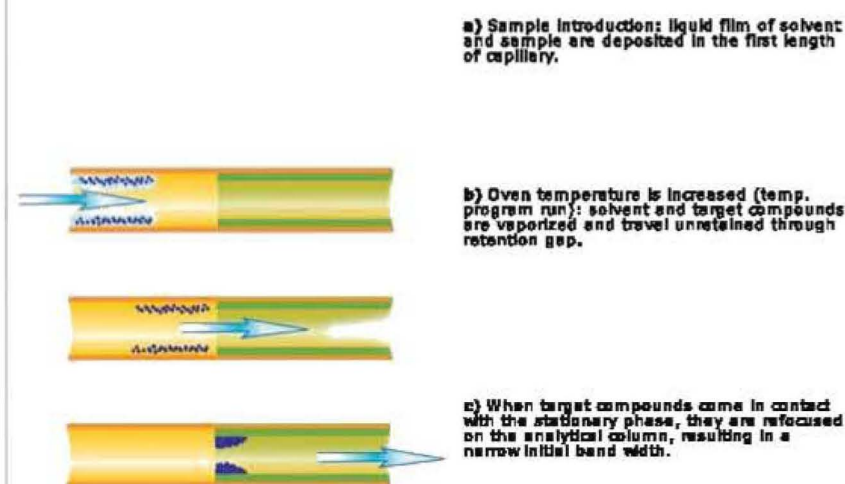
Guard columns and retention gaps are used widely in gas chromatography (GC). Many users have difficulty understanding the difference between these two products, even though there is a significant difference in application. Retention gaps mainly are used for focusing the sample components when introducing a large (liquid) sample directly onto the column. Guard columns are used to protect the analytical column from contamination. When using a retention gap system, the retention gap will also act as a guard column, but its primary function is to create a focusing effect.

Guard columns and retention gaps both must be coupled to the analytical column, and this connection introduces a potential point of risk. A new approach is to integrate the retention gap directly into the analytical column. By applying a "segment" coating technology the stationary phase can be deposited in a certain part of the column allowing a deactivated section at the beginning. Column coupling is not required and maintenance is greatly simplified. In Part 1 of this article we will explore retention gaps and build a foundation for a comparison to guard columns. In Part 2, we will review guard columns and discuss the new segment coating technology.

### Use of retention gaps

In today's laboratory, GC methods must be simple, fast, and low detection limits are required. Besides that, sufficient precision must also be obtained. It all starts by introducing the sample in the smallest possible injection band and making the band migrate through the capillary with minimal loss of the target components. With on-column injection a liquid sample is directly introduced into the capillary column as a liquid while the capillary column is kept at a temperature 10-15°C below the boiling point of the solvent. During this process the sample components are spread in an unreproducible way over the first 20-100cm of capillary while the solvent is evaporating. Parameters like injection speed, carrier gas flow, temperature of solvent and column, type of solvent, and pressure all will affect the injection band width. Additionally, when nonbonded stationary phases are used, the direct contact with liquids will result in a distortion of the stationary phase film and very short column lifetime. The majority of today's stationary phases, like the Rtx® and Rxi® phases, are immobilized by cross- and surface bonding techniques.

**Figure 1.** Retention gaps are used to focus components in a tight band at the beginning of the analytical column.



For proper application of the on-column injection technique, the use of retention gaps is essential.<sup>1, 2</sup> The retention gap consists of a 1-3m length of deactivated capillary that is positioned in front of the analytical column. All the processes described will still take place, but now the components are distributed over the



retention gap. When the oven temperature is increased the sample components will start to move (there is very little retention...that's why it's called a retention "gap"). When reaching the analytical column, the components will focus in the stationary phase resulting in a narrowing of injection band width (Figure 1). As these retention gaps are mainly used for on-column injection, the inside diameter is usually 0.32mm up to 0.53mm since the needle of an on-column syringe must be able to enter the retention gap. For coupling the retention gaps to the analytical column, we need generally coupling devices that can deal with different diameter capillary tubing.

#### **Retention gaps and splitless injection**

While on-column injection minimizes discrimination and provides the best quantitative data, especially for thermolabile components, it can be challenging to perform. Many laboratories will choose a splitless method for ease of use. For splitless injection we generally do not require a retention gap. The sample is injected in a hot injection port, evaporated, and transported with a carrier gas flow of approximately 1mL/min into the capillary. The amount of solvent vapor that enters the column per unit time is much smaller than with on-column injection. Although with splitless injection the oven temperature is also 10-15°C below the boiling point of the solvent, there is little chance of the solvent condensing. The high concentration of solvent entering the capillary column will cause a strong focusing effect for the components, generating a narrow injection band. If, in splitless injection, a method is used where the initial (injection) oven temperature is much lower than the boiling point of the solvent, the risk of solvent condensation (forming a liquid plug) will increase. This can cause unwanted broadening of the injection band. Coupling a retention gap will also fix this problem.

#### **Wettability of the retention gap**

An important factor for good performance is the wettability of the retention gap surface. It is critical that the solvent spread evenly over the surface. This means that nonpolar solvents (hexane, methylene chloride, isooctane, benzene) require non/intermediate deactivated retention gaps and more polar solvents (methanol) will require polar deactivated retention gaps. If the polarity of the retention gap and solvent do not match, the solvent will form droplets inside the capillary. The carrier gas will "push" this droplet along the retention gap into the analytical column. The result is a broadened injection and possibly even peak splitting.

#### **Retention gaps for large volume injection**

Instead of injection of 1µl on a 1-2m retention gap, one can also inject much larger amounts on much longer retention gaps. Here we talk about large volume injection technique where retention gaps of 8-10m are used. Such retention gaps can be loaded with 100-200µl of sample. Injection must be slow to allow the solvent to evaporate while passing through the retention gap. With large volume injection, detection limits can be reduced a factor of 100. The technique requires some skill to optimize all the injection parameters. Additionally, the large volume retention gaps do pollute relatively quickly due to the large amounts of sample introduced.

Guard columns and retention gaps are useful tools to the practicing chemist and it is important to understand the difference between them. In Part 2 of this article we will review guard columns and discuss a new segment coating technology that allows retention gaps and guard columns to be built directly into the analytical column tubing. This new technology eliminates column coupling, substantially reducing analytical problems related to leaks and dead volume.

Read Part 2: [Using Guard Columns and Retention Gaps in GC](#)

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#### **REFERENCES**

1. Grob, K., Journal of Chromatography 237:15 (1982).
2. Hinshaw J., LC/GC Europe 17(9): 460-466 (2004).

## Using Guard Columns and Retention Gaps in GC (Part 2)

Jaap de Zeeuw, International GC Consumables Specialist, Restek Corporation



Guard columns and retention gaps are used widely in gas chromatography (GC). Many users have difficulty understanding the difference between these two products, even though there is a significant difference in application. In [Part 1 of this article](#) we reviewed retention gaps, which mainly are used for focusing the sample components when introducing a large (liquid) sample directly onto the column. In contrast, guard columns are used to protect the analytical column from contamination. Guard columns and retention gaps both must be coupled to the analytical column, and this connection introduces a potential point of risk. A new approach is to integrate the retention gap directly into the analytical column tubing. By applying a "segment" coating technology the stationary phase can be deposited only in a certain part of the column allowing a deactivated section at the beginning. Column coupling is not required and maintenance is greatly simplified. Here we will review guard columns and discuss the new segment coating technology.

### Use of Guard Columns

The purpose of using guard columns is to protect the analytical column from contamination since the sample that is introduced is not always pure. Although the best chromatography is obtained with "clean" samples, the practical situation is that sample clean-up procedures are minimized and relative "dirty" samples are introduced onto the column. Samples can contain particulates, heavy components, derivatization reagents, ionic residues, acids, bases... all these compounds can interfere with the stationary phase and they will influence the separation process. Usually the degradation of column performance is a slow process but it will happen.

Most of the time the impurities accumulate in the first meter(s) of the column and by cutting off this section adequate separation is restored. Many users choose to connect a guard column in front of the analytical column. Such a guard column is deactivated and can be trimmed when contaminated and eventually replaced. Depending on the application, guard columns have a lifetime of 1 week up to 6 months. One has different choices for guard columns; a guard column can consist only of deactivated capillary, or it can be a coated capillary.

**Deactivated capillary tubing:** Deactivated fused silica tubing can be purchased by the meter and then a defined length can be coupled in front of the analytical column. Upon contamination, a section of the guard column is removed. When the whole guard is "consumed" a new guard column can be coupled. The disadvantage of cutting parts off of the guard column is that the column becomes shorter and this may affect retention times. However, if a similar length is always cut from the guard column, the change in retention time becomes very predictable. A deactivated guard column will also result in band focusing. If the injection is not optimal, there will be a focusing effect similar to that of a retention gap.

**Coated capillary tubing:** As the guard column needs to prevent contamination of the analytical column, a coated guard column can help as it has both the surface deactivation and also the stationary phase layer. The easiest and most economical way of using coated guard columns (or precolumns) is to buy two analytical columns. One we will use as a separation column and the second one will be used to make coated guard columns. From this second column we will cut 2m sections and couple a section in front of the analytical separation column. We can run our samples until contamination affects peak shape/response and then we can replace the guard with a new 2m section.

The system we have created will produce reproducible retention times as we always will replace the entire 2m coated guard column. Since the stationary phase is the same on the guard as on the analytical column, there will be no surprises. The coated guard column also will allow more aggressive samples/more contamination before it will give up. Lastly, we are able to cut 15 coated guard columns from a full 30m analytical column...that's also economical! However, if using a coated guard column, there will be no focusing effects.

### Segment Coating Technology Eliminates Problematic Connections

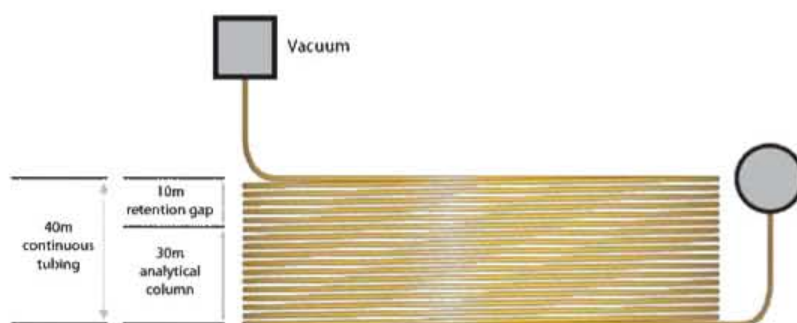
Both retention gaps and guard columns must be coupled to the analytical column. While there are several types of effective coupling devices, all can create dead volume and can be a potential source of leaks and reactivity. Segment coating technology allows the retention gap or guard column to be built directly in the



same piece of tubing as the analytical column, eliminating the connector and associated risks. This technology, available from Restek, is termed Integra-Guard™ or Integra-Gap™ and is based on the static coating method. In this process the capillary column is filled with a coating solution of stationary phase in a volatile solvent. The column is sealed on one end and on the other side a vacuum is applied. The solvent is evaporated and the dissolved polymer is deposited on the inside deactivated wall of the fused silica column. The static coating method allows columns to be coated by segment. When filling, for example, a 40m capillary with the coating solution, only 30m are filled. The first 10m remain uncoated, having only the deactivation treatment (Figure 1). This method deposits the stationary phase only in a designated portion of the capillary, creating the Integra-Guard™ or the Integra-Gap™. The advantages of this technology are clear: eliminating the connector removes a potential source of leaks and reduces dead volume. Additionally, maintenance is faster and simpler since there is no manual connection to make.

Guard columns and retention gaps are useful tools to the practicing chemist, and it is important to understand the difference between them. While they help protect analytical columns and focus samples, respectively, they are also a source of potential problems, such as leaks. Segment coating technology offers a better solution—integrated columns containing both the guard or gap section and the analytical column together in a single piece of tubing. These Integra-Guard™ and Integra-Gap™ columns are a simple, effective solution; they eliminate the risks of a separate connection and provide stable, accurate data.

**Figure 1.** Static coating allows Integra-Gap™ Integrated retention gaps to be built directly into the analytical column tubing.



**Innovative Integra-Guard® Columns**

- No leaks for a more robust method.
- No column connections for easier, faster maintenance.
- No peak distortions due to connector dead volume and thermal capacity.

For analysts who find it inconvenient to make a leak-free connection between the guard column and the analytical column, we offer Integra-Guard® columns. These innovative columns incorporate both guard column and analytical column in a continuous length of tubing, eliminating the connection and all connection-associated problems! The guard column section is marked separately from the analytical column, using high-temperature string.

A wide variety of our Integra-Guard® capillary columns are listed below. The Integra-Guard® column is so economical that we challenge you to compare our price against that of a conventional connection, even if you assemble it yourself. If you are currently using a guard column, or are considering using one, call today and ask about Integra-Guard® columns.

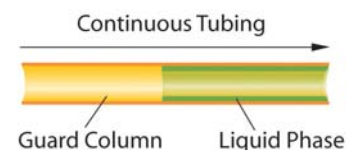
Description	qty.	cat.#	price
<b>Rtx-1</b>			
30m, 0.25mm ID, 0.25µm Rtx-1 w/5m Integra-Guard Column	ea.	10123-124	
30m, 0.53mm ID, 1.00µm Rtx-1 w/5m Integra-Guard Column	ea.	10155-126	
30m, 0.53mm ID, 5.00µm Rtx-1 w/5m Integra-Guard Column	ea.	10179-126	
<b>Rtx-5</b>			
30m, 0.25mm ID, 0.25µm Rtx-5 w/5m Integra-Guard Column	ea.	10223-124	
30m, 0.25mm ID, 0.25µm Rtx-5 w/10m Integra-Guard Column	ea.	10223-127	
30m, 0.25mm ID, 1.00µm Rtx-5 w/5m Integra-Guard Column	ea.	10253-124	
30m, 0.32mm ID, 0.25µm Rtx-5 w/5m Integra-Guard Column	ea.	10224-125	
30m, 0.32mm ID, 1.00µm Rtx-5 w/5m Integra-Guard Column	ea.	10254-125	
30m, 0.53mm ID, 5.00µm Rtx-5 w/5m Integra-Guard Column	ea.	10279-126	
60m, 0.32mm ID, 0.25µm Rtx-5 w/5m Integra-Guard Column	ea.	10227-125	
<b>Rtx-5MS</b>			
15m, 0.25mm ID, 0.25µm Rtx-5MS w/5m Integra-Guard Column	ea.	12620-124	
15m, 0.25mm ID, 0.50µm Rtx-5MS w/10m Integra-Guard Column	ea.	12635-127	
30m, 0.25mm ID, 0.10µm Rtx-5MS w/5m Integra-Guard Column	ea.	12608-124	
30m, 0.25mm ID, 0.25µm Rtx-5MS w/5m Integra-Guard Column	ea.	12623-124	
30m, 0.25mm ID, 0.25µm Rtx-5MS w/10m Integra-Guard Column	ea.	12623-127	
30m, 0.25mm ID, 0.50µm Rtx-5MS w/5m Integra-Guard Column	ea.	12638-124	
30m, 0.25mm ID, 0.50µm Rtx-5MS w/10m Integra-Guard Column	ea.	12638-127	
30m, 0.32mm ID, 0.25µm Rtx-5MS w/5m Integra-Guard Column	ea.	12624-125	
30m, 0.32mm ID, 1.00µm Rtx-5MS w/5m Integra-Guard Column	ea.	12654-125	
<b>Rxi-5Sil MS</b>			
15m, 0.25mm ID, 0.25µm Rxi-5Sil MS w/10m Integra-Guard Column	ea.	13620-127	
30m, 0.25mm ID, 0.25µm Rxi-5Sil MS w/5m Integra-Guard Column	ea.	13623-124	
30m, 0.25mm ID, 0.25µm Rxi-5Sil MS w/10m Integra-Guard Column	ea.	13623-127	
15m, 0.25mm ID, 0.50µm Rxi-5Sil MS w/5m Integra-Guard Column	ea.	13635-124	
30m, 0.25mm ID, 0.50µm Rxi-5Sil MS w/5m Integra-Guard Column	ea.	13638-124	
30m, 0.25mm ID, 0.50µm Rxi-5Sil MS w/10m Integra-Guard Column	ea.	13638-127	
30m, 0.32mm ID, 0.50µm Rxi-5Sil MS w/5m Integra-Guard Column	ea.	13639-125	
30m, 0.32mm ID, 1.00µm Rxi-5Sil MS w/5m Integra-Guard Column	ea.	13654-125	
<b>Rtx-624</b>			
30m, 0.25mm ID, 1.40µm Rtx-624 w/5m Integra-Guard Column	ea.	10968-124	
30m, 0.32mm ID, 1.80µm Rtx-624 w/5m Integra-Guard Column	ea.	10970-125	
30m, 0.53mm ID, 3.00µm Rtx-624 w/5m Integra-Guard Column	ea.	10971-126	
<b>Rtx-1301</b>			
30m, 0.53mm ID, 3.00µm Rtx-1301 w/5m Integra-Guard Column	ea.	16085-126	
<b>Rtx-1701</b>			
30m, 0.25mm ID, 0.25µm Rtx-1701 w/5m Integra-Guard Column	ea.	12023-124	
<b>Stabilwax</b>			
30m, 0.25mm ID, 0.25µm Stabilwax w/5m Integra-Guard Column	ea.	10623-124	
30m, 0.32mm ID, 1.00µm Stabilwax w/5m Integra-Guard Column	ea.	10654-125	
30m, 0.53mm ID, 1.00µm Stabilwax w/5m Integra-Guard Column	ea.	10655-126	

**restek innovation!**

Integra-Guard® Columns: guard columns WITHOUT connections—protecting your analytical column has never been this easy!

**similar products**

DuraGuard, EZ-Guard, Guardian

**Integra-Guard® built-in guard column**

String indicates where the analytical column begins.



Tag indicates guard column end.

Integra-Guard® columns are available for all phases listed, for columns with 0.25, 0.32 or 0.53mm ID. If you don't see what you need here, contact us.



## also available

**Base-deactivated inlet liners**

See page 213.

## did you know?

We test our guard columns/transfer lines with a comprehensive test mix to ensure high inertness.

## also available

**Metal MXT® Guard Columns**

Rugged, flexible, Siltek® treated stainless steel tubing; inertness comparable to fused silica tubing. See **page 114**.

**Base-Deactivated Guard/Retention Gap Columns (fused silica)**

- Tested with a basic amine test mix.
- Excellent inertness for basic compounds.
- Recommended for use with Rtx®-5 Amine, Rtx®-35 Amine, Rtx®-Volatile Amine, and Stabilwax®-DB capillary columns.
- Batch test chromatogram included.
- Maximum temperature: 315 °C.

Chemists using guard columns in the analyses of basic compounds frequently observe peak tailing and low recovery. This happens because conventionally deactivated tubing surfaces can be adsorptive to basic compounds. Restek offers base-deactivated guard columns, as well as base-deactivated inlet liners, for completely inert sample pathways.

Nominal ID	Nominal OD	5-Meter	5-Meter/6-pk.
0.25mm	0.37 ± 0.04mm	10000	10000-600
0.32mm	0.45 ± 0.04mm	10001	10001-600
0.53mm	0.69 ± 0.05mm	10002	10002-600

**Hydroguard® Water-Resistant Guard/Retention Gap Columns/Transfer Lines (fused silica)**

- Extend analytical column lifetime by preventing degradation from harsh “steam-cleaning” water injections.
- Tested with a comprehensive test mix, to ensure high inertness.
- Maximum temperature: 325 °C.

When transfer lines from purge & trap systems, air monitoring equipment, or other instruments carry condensed water vapor, deactivated column tubing quickly becomes active because of the creation of free silanol groups. These silanol groups adsorb active oxygenated compounds, such as alcohols and diols.

Restek chemists have addressed this concern and found a solution—the Hydroguard® deactivation process. A unique deactivation chemistry creates a high-density surface that is not readily attacked by aggressive hydrolysis. The high-density surface coverage of the Hydroguard® deactivation layer effectively prevents water vapor from reaching the fused silica surface beneath. Use Hydroguard® tubing for connecting GCs to:

- Headspace analyzers.
- Air analysis equipment and concentrator units.

Nominal ID	Nominal OD	5-Meter	5-Meter/6-pk.	10-Meter	30-Meter*	60-Meter*†
0.05mm	0.363 ± 0.012mm	10075				
0.10mm	0.363 ± 0.012mm	10076				
0.15mm	0.363 ± 0.012mm	10077				
0.18mm	0.37 ± 0.04mm	10078				
0.25mm	0.37 ± 0.04mm	10079	10079-600	10082	10085	10088
0.32mm	0.45 ± 0.04mm	10080	10080-600	10083	10086	10089
0.53mm	0.69 ± 0.05mm	10081	10081-600	10084	10087	10090

\*30- and 60-meter lengths are banded in 5-meter sections.

†Recommendation: Cut 60m guard columns into shorter lengths. Using full length may cause peak distortion.

## Fused Silica Guard/Retention Gap Columns

**Rxi® Guard/Retention Gap Columns (fused silica)**

- Extend column lifetime.
- Excellent inertness—obtain lower detection limits for active compounds.
- Sharper chromatographic peaks by utilizing retention gap technology.
- Maximum temperature: 360 °C.

Nominal ID	Nominal OD	5-Meter	5-Meter/6-pk.	10-Meter	10-Meter/6-pk.
0.25mm	0.37 ± 0.04mm	10029	10029-600	10059	10059-600
0.32mm	0.45 ± 0.04mm	10039	10039-600	10064	10064-600
0.53mm	0.69 ± 0.05mm	10054	10054-600	10073	10073-600

**Intermediate-Polarity Deactivated Guard/Retention Gap Columns/Transfer Lines (fused silica)**

- Tested with a comprehensive test mix, to ensure high inertness.
- Useful for a wide range of applications.
- Use with most common solvents.
- Maximum temperature: 325 °C

Nominal ID	Nominal OD	1-Meter	5-Meter	5-Meter/6-pk.
0.025mm	0.363 ± 0.012mm	10097		
0.05mm	0.363 ± 0.012mm	10098	10040	10040-600
0.075mm	0.363 ± 0.012mm	10099		
0.10mm	0.363 ± 0.012mm	10100	10041	
0.15mm	0.363 ± 0.012mm	10101	10042	
0.18mm	0.37 ± 0.04mm	10102	10046	
0.25mm	0.37 ± 0.04mm		10043	10043-600
0.28mm	0.37 ± 0.04mm		10003	10003-600
0.32mm	0.45 ± 0.04mm		10044	10044-600
0.45mm	0.69 ± 0.04mm		10005	10005-600
0.53mm	0.69 ± 0.05mm		10045	10045-600

Nominal ID	Nominal OD	10-Meter	10-Meter/6-pk.	30-Meter*	60-Meter*†
0.25mm	0.37 ± 0.04mm	10049	10049-600	10012	10013
0.32mm	0.45 ± 0.04mm	10048	10048-600	10022	10023
0.53mm	0.69 ± 0.05mm	10047		10032	10033

**Siltek®-Deactivated Guard/Retention Gap Columns/Transfer Lines (fused silica)**

- Tested with a comprehensive test mix, to ensure high inertness.
- Revolutionary deactivation process for superior inertness.
- Analyze active samples accurately; ideal for chlorinated pesticide analysis (reduces endrin breakdown to less than 1%).
- Maximum temperature: 380 °C.

Nominal ID	Nominal OD	5-Meter	10-Meter
0.25mm	0.37 ± 0.04mm	10026	10036
0.32mm	0.45 ± 0.04mm	10027	10037

**Polar-Deactivated Guard/Retention Gap Columns (fused silica)**

- Tested with a comprehensive test mix, to ensure high inertness.
- Polyethylene glycol deactivation layer provides optimum wettability for polar compounds.
- Minimize peak splitting when using polar solvents such as methanol or water.
- Compatible with Stabilwax®, Rtx®-225, and Rt®-2330 capillary columns.
- Maximum temperature: 280 °C.

Nominal ID	Nominal OD	5-Meter	10-Meter	30-Meter*	60-Meter*†
0.25mm	0.37 ± 0.04mm	10065	10068	10014	10015
0.32mm	0.45 ± 0.04mm	10066	10069	10024	10025
0.53mm	0.69 ± 0.05mm	10067	10070	10034	10035

\*30- and 60-meter lengths are banded in 5-meter sections.

†Recommendation: Cut 60m guard columns into shorter lengths. Using full length may cause peak distortion.

**it's a fact**

To eliminate connections, use an Integra-Guard® Column. See **page 35**.

**also available****Metal MXT® Guard/Retention Gap Columns**

Rugged, flexible, Siltek® treated stainless steel tubing; inertness comparable to fused silica tubing. See **page 114**.

**it's a fact**

Use guard columns to:

- Reduce effects of dirty samples on column performance.
- Reduce downtime and maintenance.

**did you know?**

Siltek®-deactivated guard columns minimize breakdown and improve recovery of analytes!

**best choice**

Siltek® treated tubing (cat.# 22505, **page 320**) is recommended for purge and trap transfer lines.





## it's a **fact**

To eliminate connections that may leak and to ensure longer column lifetime, use our unique Integra-Guard® Column. See **page 35**.

### Connectors for Fused Silica Columns



Vu2 Union® Connector  
(See page 289.)



Press-Tight® Connectors  
(See pages 287-288.)



MXT® Union Connector Kit  
for Fused Silica  
(See page 292.)

### Protecting the Analytical Column

The concept of a guard column is to protect the analytical column from becoming contaminated with nonvolatile compounds. The guard column is used to retain non-volatile material, usually in the first 10-20 cm, not allowing this material to elute onto the liquid phase of the analytical column. As the oven temperature increases, the more volatile target compounds vaporize, elute down the guard column, and refocus at the head of the analytical column without interference from the nonvolatile material left behind.

Using guard columns is advantageous, because they prevent contamination that can cause active sites as well as change the conditions of the focusing zone of the analytical column. Another advantage is that the resolution of closely eluting compounds will not be affected when the column is trimmed during maintenance, because the guard column does not contribute to the resolving power of the analytical column. Using guard columns is a simple, cost-effective way to extend analytical column lifetime.

In summary, the retention gap and guard column are essentially the same products, but are used for different purposes. The deactivated tubing helps focus target analytes at the head of the analytical column for on-column and splitless injections, and also prevents nonvolatile material from contaminating the head of the analytical column.

### What type of guard column should be used?

When using a guard column, it is important to match the polarity of the solvent and the polarity of the surface deactivation. Rxi® Guard tubing is good for a wide variety of applications and allows most common solvents (methylene chloride, hexane, isooctane, toluene) to easily wet and create a uniform film on the tubing surface.

If more polar solvents such as methanol or water are used, a polar-deactivated guard column is recommended to allow the solvent to wet the tubing surface. However, polar-deactivated guard columns are not resistant to harsh "water vaporization", which occurs when water in the liquid state is injected into the tubing and rapidly vaporizes (such as in steam cleaning). Hydroguard® deactivation is an alternative for direct aqueous injections. However, a Hydroguard®-deactivated guard column will not allow polar solvents to wet the tubing surface, and may cause solvent beading if the oven temperature is 20°C below the solvent boiling point. Siltek® deactivation creates a highly inert surface for very active compounds such as chlorinated and organophosphorus pesticides. Base-deactivated guard columns reduce adsorption and tailing for amines and other basic compounds.

### How is a guard column connected to the analytical column?

To connect the guard column to the analytical column, Vu2-Union®, Press-Tight®, and other connectors are available. MXT® unions, typically used for connecting metal columns together, are now available for fused silica columns. See pages 287 to 292 for information about these connectors.

## Guard Columns and Retention Gaps

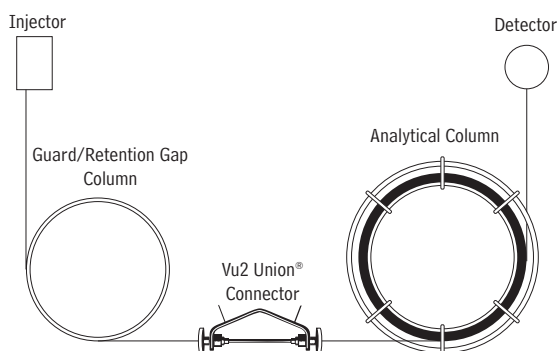
Guard columns and retention gaps are widely used in gas chromatography. The concept of the guard column is to trap nonvolatile material at the head of the column, not allowing the material to reach the analytical column. The concept of the retention gap is to help focus the compounds transferred from the inlet to a small band at the head of the analytical column in order to reduce chromatographic peak broadening. Both concepts (trapping nonvolatile material and refocusing the target analytes) may take place when a piece of deactivated tubing is connected to an analytical column as in Figure 1.

### did you know?

We test our guard columns/ transfer lines with a comprehensive test mix to ensure high inertness.



**Figure 1** A guard/retention gap column connected to an analytical column



### please note

**For superior inertness, try our Siltek® guard columns!**

See page 33 for details.

**Having trouble making a leak-free connection? Try our “built in” Integra-Guard® columns!**

See page 35 for details.

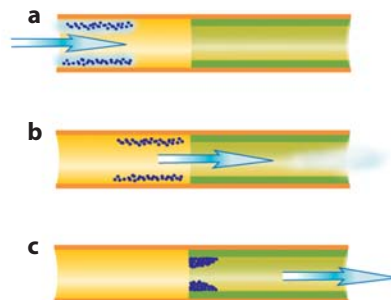
## Analyte Focusing

There are two injection techniques where the retention gap is used to help focus target analytes at the beginning of the analytical column, cool on-column injection and split-less injection.

For cool on-column injection, the purpose of a retention gap is to help focus the sample components when introducing a liquid sample directly into the retention gap. The cool on-column injection is performed by inserting the syringe needle into the retention gap (this can be accomplished with a 0.53mm ID retention gap and a 26s gauge syringe) and transferring the liquid sample directly into the retention gap. The injection is made with the injector and column oven set below the boiling point of the solvent. As the solvent is evaporated, the volatile target analytes migrate in the solvent towards the analytical column, and the heavier analytes will be distributed over the retention gap. As the oven temperature increases, the target analytes vaporize and move unretained down the retention gap column until the compounds reach the liquid stationary phase of the analytical column. At this juncture, the target analytes are trapped/focused by the liquid phase forming a narrow injection band.

The retention gap may also be useful in hot vaporization injections when the transfer of the compounds from the inlet to the column does not form a focused band. Typical applications include water injections or injections using small ID columns, where split or tailing peaks would indicate an unfocused band. In these applications, the target analytes are trapped in a nonuniform or longitudinally diffuse band at the head of the retention gap (Figure 2a). As the oven temperature is increased, the solvent and target compounds are vaporized and move unretained through the retention gap (Figure 2b). When the target compounds come in contact with the stationary phase, they are refocused in a narrow band (Figure 2c), improving the chromatography.

**Figure 2** Retention gaps are used to focus components in a tight band at the beginning of the analytical column.



**a)** Sample introduction: a liquid film of solvent and sample is deposited in the first length of capillary.

**b)** As oven temperature increases, the solvent evaporates and the target compounds elute unretained through the retention gap until they contact the analytical column.

**c)** When target compounds come in contact with the stationary phase, they are refocused on the analytical column, resulting in a narrow initial band width.



### Zero-Dead-Volume Valco® Internal Union

Ends of tubing seat squarely at bottoms of fitting details. 300 series stainless steel. For 1/16" OD tubing. Stainless steel ferrules included.

Description	Union Bore	Valco #	qty.	cat.#	price
Internal Union	0.15mm	ZU1XC	ea.	20147	
Internal Union	0.25mm	ZU1C	ea.	20148	
Internal Union	0.75mm	ZU1	ea.	20149	
Internal Union	1/16"	ZU1T	ea.	20150	



### Zero-Dead-Volume Valco® Internal Reducing Union

Connect two sizes of tubing, using zero-dead-volume fittings on each end. For 1/8" to 1/16" OD tubing. Stainless steel ferrules included.

Description	Union Bore	Valco #	qty.	cat.#	price
Internal Reducing Union	0.25mm	ZRU21C	ea.	20151	
Internal Reducing Union	0.75mm	ZRU21	ea.	20152	
Internal Reducing Union	1/16"	ZRU21T	ea.	20153	



### Zero-Dead-Volume Valco® Internal Tee

Connect three lines. 300 series stainless steel; stainless steel ferrules included. For 1/16" OD tubing.

Description	Union Bore	Valco #	qty.	cat.#	price
Internal Tee	0.25mm	ZT1C	ea.	20154	
Internal Tee	0.75mm	ZT1	ea.	20155	



### Zero-Dead-Volume Valco® Internal Cross

Connect four lines. 300 series stainless steel; stainless steel ferrules included. For 1/16" OD tubing.

Description	Union Bore	Valco #	qty.	cat.#	price
Internal Cross	0.25mm	ZX1C	ea.	20156	
Internal Cross	0.75mm	ZX1	ea.	20157	



### Male Pipe to Valco® Internal Adapter

Makes a minimum volume connection from a female pipe fitting on a pressure gauge or regulator to a Valco® zero-dead-volume fitting. 300 series stainless steel; stainless steel ferrules included.

Description	Fitting Size	Bore	Valco #	qty.	cat.#	price
Male Pipe to Valco	1/4" NPT Male					
Internal Adapter	to 1/16" ZDV	1.0mm	PZA21	ea.	20158	
Male Pipe to Valco	1/4" NPT Male					
Internal Adapter	to 1/16" ZDV	1.0mm	PZA41	ea.	20159	



### Nuts & Ferrules (1/16-Inch Stainless Steel) for Valco® Connectors

Description	Valco #	qty.	cat.#	price
Ferrules, 1/16" Stainless Steel	ZF1-10	10-pk.	20286	
Nuts, 1/16" Stainless Steel	ZN1-10	10-pk.	20287	



### 1/16-Inch Valco® Adaptor Ferrules

Tubing OD	Tubing ID	Valco #	qty.	Valcon Polyimide		Polyimide	
				cat.#	price	cat.#	price
0.25–0.4mm	0.1–0.25mm	FS1.4-5	5-pk.	20142		2-pk.	21015
0.4–0.5mm	0.32mm	FS1.5-5	5-pk.	20143		2-pk.	21016
0.5–0.8mm	0.53mm	FS1.8-5	5-pk.	20144		—	—
0.8mm (1/32")	—	FS1.9-5	5-pk.	20145		—	—

### also available

#### Treated Fittings!

See pages 313-317 for our Siltek®/Sulfinit® treated and Silcosteel®-CR treated fittings, as well as many more brass and stainless steel fittings from Swagelok® and Parker®.





## MXT®-Union Connector Kits for Fused Silica Columns

- Low-dead-volume, leak-tight connection.
- Reusable.
- Siltek® treatment ensures maximum inertness.
- Ideal for connecting a guard column or transfer line to an analytical column.
- Use to oven temperatures of 360 °C.
- Available in union and "Y" configurations.
- Can also be used for fused silica to metal connections.

These MXT® connectors can be used with fused silica tubing, because of a Valcon polyimide 1/32-inch one-piece fused silica adaptor. This unique graphite-reinforced composite allows a capillary column to slide into the adaptor and be locked in place simply by loosening and tightening the fitting.

### MXT®-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT® union, two 1/32-inch nuts and two one-piece fused silica adaptors.



Description	qty.	cat.#	price
For 0.25mm ID Fused Silica Columns	kit	21386	
For 0.32mm ID Fused Silica Columns	kit	21385	
For 0.53mm ID Fused Silica Columns	kit	21384	

### MXT® "Y"-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT® union, three 1/32-inch nuts and three one-piece fused silica adaptors.



Description	qty.	cat.#	price
For 0.25mm ID Fused Silica Columns	kit	21389	
For 0.32mm ID Fused Silica Columns	kit	21388	
For 0.53mm ID Fused Silica Columns	kit	21387	



Adaptor Ferrules



20389

### 1/32-Inch Valco® Adaptor Ferrules (Valcon Polyimide)

Fused silica adaptor ferrules are Valcon polyimide, a unique graphite-reinforced composite, specially prepared to maximize mechanical stability at temperatures to 350 °C. The determining factor for selecting adaptor ferrule size is the fused silica tubing OD.

Tubing OD	Tubing ID	Valco #	qty.	cat.#	price
0.25 ≤ 0.40mm	0.25mm	FS.4-5	5-pk.	20137	
0.40 ≤ 0.50mm	0.32mm	FS.5-5	5-pk.	20140	
0.50 ≤ 0.80mm	0.53mm	ZF.5V-5	5-pk.	20141	
1/8" Replacement Nut			5-pk.	20389	

## MXT® Low-Dead-Volume Connector Kits for Metal Columns

These low-dead-volume connectors are Siltek® treated to make them inert to active compounds, just like our MXT® columns. They can be used at temperatures up to 430 °C without degrading the deactivated layer. Purchase the appropriate ferrules for connecting 0.28, 0.32 or 0.53 mm ID tubing.

### MXT® Low-Dead-Volume Connector Kits for Metal Columns

- Connect a guard column/transfer line to an MXT® stainless steel column.
- Low thermal mass tracks rapid oven temperature programming.
- Stainless steel ferrules and nuts.
- Available in "Y" and union configurations.
- Siltek® treatment ensures ultimate inertness.



Each kit contains the MXT® union, two 1/32-inch ferrules and nuts.

Description	qty.	cat.#	price
For 0.28mm ID MXT Columns	kit	20397	
For 0.32mm ID MXT Columns	kit	20536	
For 0.53mm ID MXT Columns	kit	20394	

### MXT® Low-Dead-Volume "Y" Connector Kits for Metal Columns

Connect two MXT® columns to one inlet or one MXT® column to two detectors.



Each kit contains the MXT® union, three 1/32-inch ferrules and nuts.

Description	qty.	cat.#	price
For 0.28mm ID MXT Columns	kit	20396	
For 0.32mm ID MXT Columns	kit	20537	
For 0.53mm ID MXT Columns	kit	20395	

### Replacement Ferrules (1/32-Inch Stainless Steel) for MXT® Connectors



Ferrule ID	Fits Column ID	qty.	cat.#	price
0.59mm	0.28mm	10-pk.	20398	
0.53mm	0.32mm	10-pk.	20535	
0.79mm	0.53mm	10-pk.	20399	



20427

**Vacuum Vu-Union® Connector for GC/MS Applications**

- Connects analytical column to MS transfer line.
- Use under vacuum conditions.
- Use only with Vu-Union® Vespel®/graphite ferrules (order ferrules separately).
- Includes metal housing body, one deactivated tapered glass insert, and Vu-Union® Helping Hand.
- Fits column ODs from 0.33–0.74 mm (Restek 0.1 mm–0.53 mm ID).

A specifically designed Vu-Union® glass insert permits more torque to be applied to the ferrules without fear of cracking the insert. The hex end nuts enable you to use wrenches to tighten the end fittings.

**Vu-Union® Helping Hand**

The Helping Hand is designed to hold in place the metal housing of the Vacuum Vu-Union® connector. This allows you to easily assemble the columns in the glass insert and tighten the nuts. The Helping Hand is included with the Vacuum Vu-Union® connector.



Description	qty.	cat.#	price
Vacuum Vu-Union Connector (with the Helping Hand)	ea.	20427	
Replacement Inserts	3-pk.	20428	



20422

**Vu-Union® Vespel®/Graphite Ferrules**

- Use with Vacuum Vu-Union® connectors.
- 60% Vespel®/40% graphite.
- 400 °C maximum operating temperature.

Ferrule ID	Fits Column	qty.	cat.#	price
0.3mm	< 0.22mm ID/ < 0.4mm OD	10-pk.	20423	
0.4mm	0.25mm ID/0.4mm OD	10-pk.	20420	
0.5mm	0.32mm ID/0.5mm OD	10-pk.	20421	
0.8mm	0.45/0.53mm ID/0.8mm OD	10-pk.	20422	

**Coupling GC Columns**

An MXT® connector is a good alternative to a glass connector when coupling GC columns. This connector is constructed from stainless steel and will not break; it uses ferrules for sealing. The design ensures low dead volume, and Siltek® treatment ensures the MXT® connector is inert—both features help minimize peak tailing. MXT® connectors can be used to connect metal-to-metal, metal-to-fused silica, or fused silica-to-fused silica tubing. When connecting metal tubing, use 1/32-inch stainless steel ferrules (listed above); for fused silica tubing, use Valcon polyimide adaptor ferrules (see page 292).



20272



20270

**Gerstel GRAPHPACK® 3D/2 Connectors & Ferrules**

GRAPHPACK® technology provides a complete system that quickly and reliably makes a leak-tight, low-dead-volume connection. The central component is a metal-jacketed graphite ferrule—the ideal seal for GC applications.

**Gerstel GRAPHPACK® 3D/2 Connectors**

Description	Fits Column ID	qty.	cat.#	price
GRAPHPACK 3D/2 Connector*	0.25mm to 0.32mm ID	ea.	20272	
GRAPHPACK 3D/2 Connector*	0.45mm to 0.7mm ID	ea.	20273	

**GRAPHPACK® 3D/2 Ferrules**

Ferrule ID	Fits Column ID	qty.	cat.#	price
0.4mm	0.25mm	10-pk.	20271	
0.5mm	0.32mm	10-pk.	20270	
0.8mm	0.45/0.53mm	10-pk.	20274	

\*Use only with GRAPHPACK 3D/2 ferrules.

**GRAPHPACK® 2m Ferrules**

Fits Column ID	Similar to Gerstel part #	qty.	cat.#	price
0.25mm	001805-040-00	10-pk.	22223	
0.32mm	001805-045-00	10-pk.	22224	
0.53mm	001805-007-00	10-pk.	22225	



20146

**Ferrule Removal Kit**

The tapered tools in this kit have teeth designed to grip and remove fused silica adaptor ferrules that have become stuck in the fitting detail. Each kit has two tools: one for removing 1/32-inch adaptor ferrules and one for removing 1/16-inch adaptor ferrules.

Description	Valco #	qty.	cat.#	price
Ferrule Removal Kit	FRK1	kit	20146	



20388

**1/4-Inch–3/16-Inch Open-End Wrenches**

High-quality miniature wrenches to use with MXT® low-dead-volume connectors.

Description	qty.	cat.#	price
1/4"-3/16" Open-End Wrenches	2-piece set	20388	

restek  
innovation!



Fit both Restek cage designs.



Patent pending.

Secure, reliable  
column-to-column  
connections!

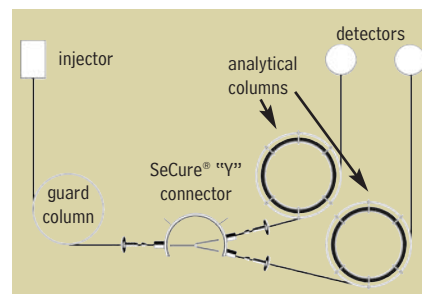
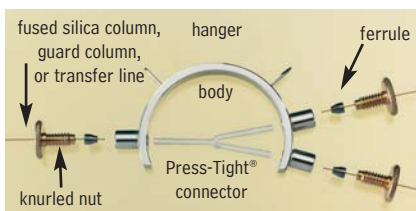
### SeCure® "Y" Connector Kits

- Connect two analytical columns to a transfer line or guard column.
- Use standard "Y" Press-Tight® connectors and 1/16" graphite ferrules.
- Reliable seal integrity, will not unexpectedly disconnect during temperature-programmed analyses.
- Open design allows visual confirmation of the seal for added confidence in the connection.
- Fit both Restek cage designs.

Combine the simplicity of a "Y" Press-Tight® connector with the strength of a metal union. The ferrules and knurled nuts hold the fused silica tubing in place, which prevents the tubing from unexpectedly disconnecting, even at temperatures as high as 400 °C.

The SeCure® "Y" Connector's open design allows visual confirmation of the seal.

Dual-column confirmational analysis with a single injection—one of the SeCure® "Y" connector's many uses.



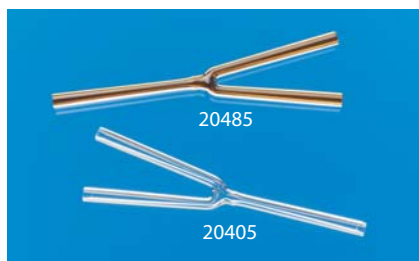
Kits include: SeCure® "Y" connector body, 3 knurled nuts, "Y" Universal Press-Tight® union, 3 ferrules.

Description	Ferrules Fit Column ID	qty.	cat.#	price
SeCure "Y" Connector Kit	0.18/0.25/0.28mm	kit	20276	
SeCure "Y" Connector Kit	0.32mm	kit	20277	
SeCure "Y" Connector Kit	0.45/0.53mm	kit	20278	
Knurled nut		3-pk.	20279	

### Universal "Y" Press-Tight® Connectors

An alternative method of performing dual-column confirmational analyses!

- Split sample flow onto two columns.
- Split a single column flow to two detectors—perform confirmation analysis with a single injection.
- Deactivated Press-Tight® connectors assure better recovery of polar and nonpolar compounds.
- Siltek® treated connectors are ideal for organochlorine pesticides analysis.
- Fit column ODs from 0.33–0.74 mm (Restek 0.1 mm–0.53 mm ID).



Description	ea./price	3-pk./price
Universal "Y" Press-Tight Connector	20405 \$78	20406
Universal "Y" Press-Tight Connector, Deactivated	20405-261 \$79	20406-261
Universal "Y" Press-Tight Connector, Siltek Treated	20485 \$80.50	20486

### Graphite Ferrules

for SeCure® "Y" Connectors

- Preconditioned to minimize out-gassing.
- High-purity, high-density graphite.
- Stable to 450 °C.
- No binders that can off-gas or adsorb analytes.
- Smooth surface and clean edges.



Ferrule ID	Fits Column ID	Graphite 10-pk./price	Graphite 50-pk./price
0.4mm	0.10/0.15/0.18/0.25/0.28mm	20200 \$32	20227
0.5mm	0.32mm	20201 \$32	20228
0.8mm	0.45/0.53mm	20202 \$32	20224

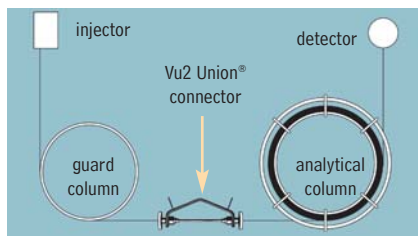


**Vu2 Union® Connectors**

- Connect a guard column to an analytical column.
- Connect a column to a transfer line.
- Connect two columns in series.
- Repair a broken column.
- Fit both Restek cage designs.

Restek's Vu2 Union® connector combines the simplicity of a Press-Tight® union with the strength of a metal union.

A guard column connected to an analytical column by a Vu2 Union® connector.



Fit both Restek cage designs.



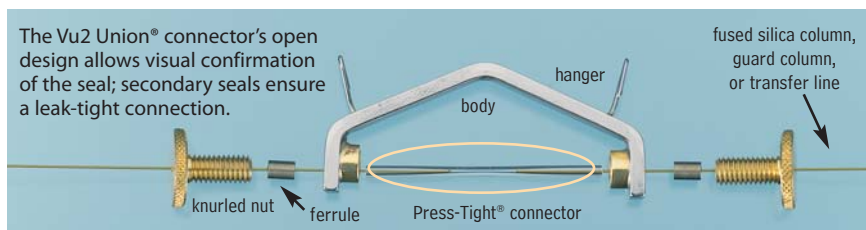
Patent pending.

**How does a Vu2 Union® connector work?**

A Press-Tight® union in the Vu2 Union® connector joins the fused silica ends together; the ferrule and knurled nut at each end of the connector hold the tubing in place via a secondary seal between the ferrule and the Press-Tight® union. Each knurled nut applies independent pressure to each ferrule, to make a leak-tight seal with the column end. These ultra-strong connections will not unexpectedly disconnect under temperature changes, vibrations, or other stresses normally encountered in GC analyses. The open design allows visual confirmation of the seal between the column and the Press-Tight® union, to ensure confidence in the connection. Hang the connector from the column cage, to minimize stress on the connections.

**Who will benefit from using Vu2 Union® connectors?**

Any analyst using guard columns, transfer lines, or restrictor tubing, performing a dual-column analysis with columns connected in series, or seeking to repair a broken column will find Vu2 Union® connectors the simple, reliable, easy-to-use solution to their connection needs.



Secure, reliable  
column-to-column  
connections!

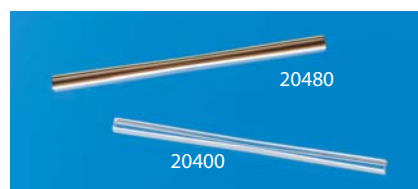
NOTE: This product is not recommended for GC column-to-MS connections—use the Vacuum Vu-Union®. See page 291.

Kits include: Vu2 Union® body, 2 knurled nuts, 2 Press-Tight® unions, and 4 ferrules

Description	Ferrules Fit Column ID	qty.	cat.#	price
Vu2 Union Connector Kit	0.10/0.15mm	kit	22220	
Vu2 Union Connector Kit	0.18/0.28mm	kit	21105	
Vu2 Union Connector Kit	0.32mm	kit	21106	
Vu2 Union Connector Kit	0.45/0.53mm	kit	21107	
Knurled nut		2-pk.	21108	

**Universal Press-Tight® Connectors**

Description	5-pk./price	25-pk./price	100-pk./price
Universal Press-Tight Connectors	20400 \$49.50	20401 \$198	20402
Universal Press-Tight Connectors, Deactivated	20429 \$57.50	20430 \$228	
Universal Press-Tight Connectors, Siltek Treated	20480 \$62	20449 \$259	

**Graphite Ferrules**

for Vu2 Union® Connectors

- High-purity, high-density graphite.
- Stable to 450 °C.
- No binders that can off-gas or adsorb analytes.
- Smooth surface and clean edges.

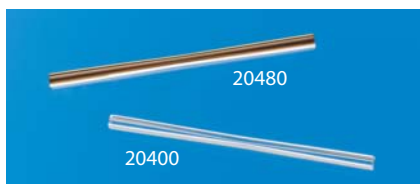
Ferrule ID	Fits Column ID	Graphite 2-pk./price	Graphite 10-pk./price
0.3mm	0.10/0.15mm	22221 \$23	22222
0.4mm	0.18/0.28mm	20280 \$23	20281
0.5mm	0.32mm	20282 \$23	20283
0.8mm	0.45/0.53mm	20284 \$23	20285





### Press-Tight® Connectors

- Deactivated Press-Tight® connectors assure better recovery of polar and nonpolar compounds.
- Siltek® treated connectors are ideal for organochlorine pesticides analysis.
- Fit column ODs from 0.33–0.74 mm (Restek 0.1 mm–0.53 mm ID).



### Universal Press-Tight® Connectors

- Connect a guard column to an analytical column.
- Repair a broken column.
- Connect a column outlet to a transfer line.

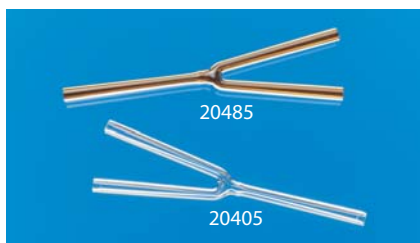
Description	5-pk./price	25-pk./price	100-pk./price
Universal Press-Tight Connectors	20400	20401	20402
Universal Press-Tight Connectors, Deactivated	20429	20430	
Universal Press-Tight Connectors, Siltek Treated	20480	20449	



### Universal Angled Press-Tight® Connectors

- Ideal for connecting a guard column to an analytical column.
- Angle approximates the curvature of a capillary column, reduces strain on column-end connections.

Description	5-pk./price	25-pk./price	100-pk./price
Universal Angled Press-Tight Connectors	20446	20447	20448
Universal Angled Press-Tight Connectors, Deactivated	20446-261	20447-261	20448-261
Universal Angled Press-Tight Connectors, Siltek Treated	20482	20483	20484



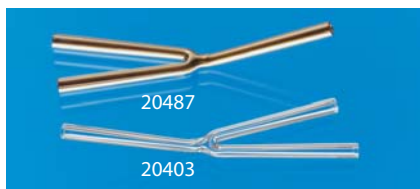
### Universal “Y” Press-Tight® Connectors

An alternative method of performing dual-column confirmational analyses!

- Split sample flow onto two columns.
- Split a single column flow to two detectors—perform confirmation analysis with a single injection.

Description	ea./price	3-pk./price
Universal “Y” Press-Tight Connector	20405	20406
Universal “Y” Press-Tight Connector, Deactivated	20405-261	20406-261
Universal “Y” Press-Tight Connector, Siltek Treated	20485	20486

Single injection confirmational analyses!



### Universal Angled “Y” Press-Tight® Connectors

- Perform confirmation analysis with a single injection.
- Inlet and outlet ends conform to the column curvature—alleviates column-end connection strain.

Description	ea./price	3-pk./price
Universal Angled “Y” Press-Tight Connector	20403	20404
Universal Angled “Y” Press-Tight Connector, Deactivated	20403-261	20404-261
Universal Angled “Y” Press-Tight Connector, Siltek Treated	20487	20469



### Polyimide Resin

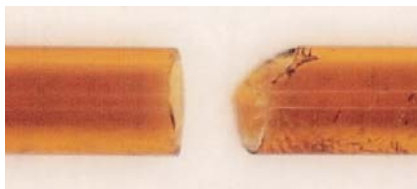
Securely connects a Press-Tight® connector to a fused silica column.

Description	Max. Temp.	qty.	cat.#	price
Polyimide Resin	350°C	5 grams	20445	

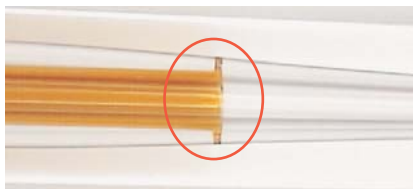
**Restek Press-Tight® Connectors**

Press-Tight® connectors are lightweight, quickly installed, and easy to use. They connect fused silica tubing having outside diameters ranging from 0.33 to 0.74 mm (Restek 0.1 to 0.53 mm ID). Press-Tight® connectors do not cause solvent tailing, or adsorb active compounds.

Press-Tight® connectors most often are used to connect a guard column to an analytical column. They also are used to connect columns differing in polarity, for unique separations, or to repair a broken column.



Make a clean, square cut for optimum connector performance. The cut on the right will produce a poor seal.



A brown ring indicates a proper seal.

**Obtaining a leak-tight seal:**

To achieve optimum performance from these connectors, begin with a properly cut fused silica column or retention gap end. Even if you use polyimide resin (cat.# 20445, page 288) for extra insurance, a poorly cut capillary column will make an inadequate seal.

Press the cut ends into the connector, then establish a flow, and leak-check the seal with a Restek Electronic Leak Detector (cat.# 22839, page 273) before heating the system. The seal is made permanent as the polyimide resin coating on the column bonds to the inner surface of the connector after several thermal cycles to 200 °C.

**What is the maximum temperature for a Press-Tight® connector?**

Press-Tight® connectors are effective at oven temperatures to 325 °C, the temperature at which the polyimide coating on the column decomposes and the connection will begin to leak. We strongly recommend using a Vu2 Union® (page 289) or SeCure® “Y” Connector (page 290) connector if oven temperatures will exceed 325 °C for prolonged periods of time.

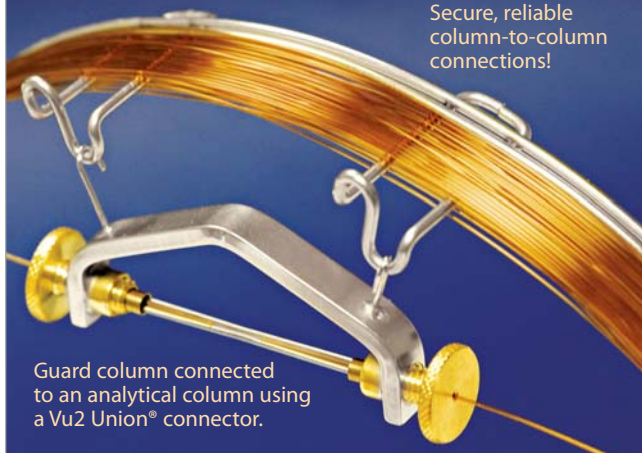
**Can Press-Tight® connectors be used with MXT® columns?**

No. To achieve a leak-tight fused silica to stainless steel connection, we recommend an MXT® connector (see page 292).

Turn the page for a complete list of Restek Press-Tight® Connectors.

**Let Restek Make the Connection!**

Secure, reliable column-to-column connections!



Guard column connected to an analytical column using a Vu2 Union® connector.

Restek will connect a guard column/transfer line to any analytical column, using a Vu2 Union® connector. We will leak-check the connection and confirm analytical integrity by analyzing a test mixture. To order a preconnected guard column/transfer line, add the three-digit suffix from the chart below to any analytical column catalog number. Example: A 5 m, 0.32 mm ID guard column connected to a 30 m, 0.32 mm ID, 1.0 µm Rtx®-5 column is cat.# 10254-163.

5m Guard Column	cat.# suffix	Additional Cost*
0.15mm ID	-160	
0.18mm ID	-161	
0.25mm ID	-162	
0.32mm ID	-163	
0.53mm ID	-164	
10m Guard Column	cat.# suffix	Additional Cost*
0.25mm ID	-165	
0.32mm ID	-166	
0.53mm ID	-167	

Guard columns listed are intermediate polarity (IP) deactivated.

For more information about guard columns and other deactivations, see pages 31–35.

\*Additional cost will be added to the price of the column.



Retention GAPS → RETENTION-GAP DPTMDS



View Full-Size  
Image

## RETENTION-GAP DPTMDS

*Deactivation for General Purpose*

*Support*

*The Retention Gap Effects - Guide to Use of Retention Gaps (PDF File)*

Description	Internal Diameter	Length	Code #	Q.ta	
RET. GAP DPTMDS	0.25 mm	1 m	RETG.DPTMDS.025.1		
RET. GAP DPTMDS	0.25 mm	10 m	RETG.DPTMDS.025.10		
RET. GAP DPTMDS	0.25 mm	2 m	RETG.DPTMDS.025.2		
RET. GAP DPTMDS	0.25 mm	20 m	RETG.DPTMDS.025.20		
RET. GAP DPTMDS	0.25 mm	5 m	RETG.DPTMDS.025.5		
RET. GAP DPTMDS	0.25 mm	50 m	RETG.DPTMDS.025.50		
RET. GAP DPTMDS	0.32 mm	1 m	RETG.DPTMDS.032.1		

RET. GAP DPTMDS	0.32 mm	10 m	RETG.DPTMDS.032.10		
RET. GAP DPTMDS	0.32 mm	2 m	RETG.DPTMDS.032.2		
RET. GAP DPTMDS	0.32 mm	20 m	RETG.DPTMDS.032.20		
RET. GAP DPTMDS	0.32 mm	5 m	RETG.DPTMDS.032.5		
RET. GAP DPTMDS	0.32 mm	50 m	RETG.DPTMDS.032.50		
RET. GAP DPTMDS	0.53 mm	1 m	RETG.DPTMDS.053.1		
RET. GAP DPTMDS	0.53 mm	10 m	RETG.DPTMDS.053.10		
RET. GAP DPTMDS	0.53 mm	2 m	RETG.DPTMDS.053.2		
RET. GAP DPTMDS	0.53 mm	20 m	RETG.DPTMDS.053.20		
RET. GAP DPTMDS	0.53 mm	5 m	RETG.DPTMDS.053.5		

**You may also be interested in this/these product(s):**

PRESS-FIT UNION



Retention GAPS → RETENTION-GAP HMDS



[View Full-Size Image](#)

## RETENTION-GAP HMDS

*Specific Deactivation for Apolar Solvents Injections*

[Support](#)

*The Retention Gap Effects - Guide to Use of Retention Gaps (PDF File)*

Description	Internal Diameter	Length	Code #	Q.ta	
RET. GAP HMDS	0.25 mm	1 m	RETG.HMDS.025.1		
RET. GAP HMDS	0.25 mm	10 m	RETG.HMDS.025.10		
RET. GAP HMDS	0.25 mm	2 m	RETG.HMDS.025.2		
RET. GAP HMDS	0.25 mm	20 m	RETG.HMDS.025.20		
RET. GAP HMDS	0.25 mm	5 m	RETG.HMDS.025.5		
RET. GAP HMDS	0.25 mm	50 m	RETG.HMDS.025.50		



RET. GAP HMDS	0.32 mm	1 m	RETG.HMDS.032.1		
RET. GAP HMDS	0.32 mm	10 m	RETG.HMDS.032.10		
RET. GAP HMDS	0.32 mm	2 m	RETG.HMDS.032.2		
RET. GAP HMDS	0.32 mm	20 m	RETG.HMDS.032.20		
RET. GAP HMDS	0.32 mm	5 m	RETG.HMDS.032.5		
RET. GAP HMDS	0.32 mm	50 m	RETG.HMDS.032.50		
RET. GAP HMDS	0.53 mm	1 m	RETG.HMDS.053.1		
RET. GAP HMDS	0.53 mm	10 m	RETG.HMDS.053.10		
RET. GAP HMDS	0.53 mm	2 m	RETG.HMDS.053.2		
RET. GAP HMDS	0.53 mm	20 m	RETG.HMDS.053.20		
RET. GAP HMDS	0.53 mm	5 m	RETG.HMDS.053.5		

**You may also be interested in this/these product(s):**

PRESS-FIT UNION



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PRESS-FIT "Y" 3 Ways



Retention GAPS → RETENTION-GAP CARBOWAX



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## RETENTION-GAP CARBOWAX

*Specific deactivation for Polar Solvents Injections*

[Support](#)

*The Retention Gap Effects - Guide to Use of Retention Gaps (PDF File)*

Description	Internal Diameter	Length	Code #	Q.ta	
RET. GAP CARBOWAX	0.25 mm	1 m	RETG.WAX.025.1		
RET. GAP CARBOWAX	0.25 mm	10 m	RETG.WAX.025.10		
RET. GAP CARBOWAX	0.25 mm	2 m	RETG.WAX.025.2		
RET. GAP CARBOWAX	0.25 mm	20 m	RETG.WAX.025.20		
RET. GAP CARBOWAX	0.25 mm	5 m	RETG.WAX.025.5		
RET. GAP CARBOWAX	0.25 mm	50 m	RETG.WAX.025.50		
RET. GAP CARBOWAX	0.32 mm	1 m	RETG.WAX.032.1		

RET. GAP CARBOWAX	0.32 mm	10 m	RETG.WAX.032.10		
RET. GAP CARBOWAX	0.32 mm	2 m	RETG.WAX.032.2		
RET. GAP CARBOWAX	0.32 mm	20 m	RETG.WAX.032.20		
RET. GAP CARBOWAX	0.32 mm	5 m	RETG.WAX.032.5		
RET. GAP CARBOWAX	0.32 mm	50 m	RETG.WAX.032.50		
RET. GAP CARBOWAX	0.53 mm	1 m	RETG.WAX.053.1		
RET. GAP CARBOWAX	0.53 mm	10 m	RETG.WAX.053.10		
RET. GAP CARBOWAX	0.53 mm	2 m	RETG.WAX.053.2		
RET. GAP CARBOWAX	0.53 mm	20 m	RETG.WAX.053.20		
RET. GAP CARBOWAX	0.53 mm	5 m	RETG.WAX.053.5		

**You may also be interested in this/these product(s):**

PRESS-FIT UNION





PRESS-FIT Micro-Unions → PRESS-FIT UNION



View Full-Size  
Image

## PRESS-FIT UNION

Description	Diameter IN	Diameter OUT	N. Pieces Package	Code #	Q.ta
PRESS-FIT UNION	0.05 mm	0.05 mm	10 pezzi	PFITUN.005.005.10	
PRESS-FIT UNION	0.05 mm	0.1 mm	10 pezzi	PFITUN.005.010.10	
PRESS-FIT UNION	0.05 mm	0.25 mm	10 pezzi	PFITUN.005.025.10	
PRESS-FIT UNION	0.05 mm	0.32 mm	10 pezzi	PFITUN.005.032.10	
PRESS-FIT UNION	0.05 mm	0.53 mm	10 pezzi	PFITUN.005.053.10	
PRESS-FIT UNION	0.10 mm	0.1 mm	10 pezzi	PFITUN.010.010.10	
PRESS-FIT UNION	0.10 mm	0.25 mm	10 pezzi	PFITUN.010.025.10	
PRESS-FIT UNION	0.10 mm	0.32 mm	10 pezzi	PFITUN.010.032.10	
PRESS-FIT UNION	0.10 mm	0.53 mm	10 pezzi	PFITUN.010.053.10	
PRESS-FIT UNION	0.25 mm	0.25 mm	10 pezzi	PFITUN.025.025.10	
PRESS-FIT UNION	0.25 mm	0.32 mm	10 pezzi	PFITUN.025.032.10	

PRESS-FIT UNION	0.25 mm	0.53 mm	10 pezzi	PFITUN.025.053.10		
PRESS-FIT UNION	0.32 mm	0.32 mm	10 pezzi	PFITUN.032.032.10		
PRESS-FIT UNION	0.32 mm	0.53 mm	10 pezzi	PFITUN.032.053.10		
PRESS-FIT UNION	0.53 mm	0.53 mm	10 pezzi	PFITUN.053.053.10		
PRESS-FIT UNION	0.05 mm	0.05 mm	5 pezzi	PFITUN.005.005.5		
PRESS-FIT UNION	0.05 mm	0.1 mm	5 pezzi	PFITUN.005.010.5		
PRESS-FIT UNION	0.05 mm	0.25 mm	5 pezzi	PFITUN.005.025.5		
PRESS-FIT UNION	0.05 mm	0.32 mm	5 pezzi	PFITUN.005.032.5		
PRESS-FIT UNION	0.05 mm	0.53 mm	5 pezzi	PFITUN.005.053.5		
PRESS-FIT UNION	0.10 mm	0.1 mm	5 pezzi	PFITUN.010.010.5		
PRESS-FIT UNION	0.10 mm	0.25 mm	5 pezzi	PFITUN.010.025.5		
PRESS-FIT UNION	0.10 mm	0.32 mm	5 pezzi	PFITUN.010.032.5		
PRESS-FIT UNION	0.10 mm	0.53 mm	5 pezzi	PFITUN.010.053.5		
PRESS-FIT UNION	0.25 mm	0.25 mm	5 pezzi	PFITUN.025.025.5		
PRESS-FIT UNION	0.25 mm	0.32 mm	5 pezzi	PFITUN.025.032.5		
PRESS-FIT UNION	0.25 mm	0.53 mm	5 pezzi	PFITUN.025.053.5		
PRESS-FIT UNION	0.32 mm	0.32 mm	5 pezzi	PFITUN.032.032.5		
PRESS-FIT UNION	0.32 mm	0.53 mm	5 pezzi	PFITUN.032.053.5		
PRESS-FIT UNION	0.53 mm	0.53 mm	5 pezzi	PFITUN.053.053.5		
PRESS-FIT UNION	0.05 mm	0.05 mm	20 pezzi	PFITUN.005.005.20		
PRESS-FIT UNION	0.05 mm	0.1 mm	20 pezzi	PFITUN.005.010.20		

PRESS-FIT UNION	0.05 mm	0.25 mm	20 pezzi	PFITUN.005.025.20		
PRESS-FIT UNION	0.05 mm	0.32 mm	20 pezzi	PFITUN.005.032.20		
PRESS-FIT UNION	0.05 mm	0.53 mm	20 pezzi	PFITUN.005.053.20		
PRESS-FIT UNION	0.10 mm	0.1 mm	20 pezzi	PFITUN.010.010.20		
PRESS-FIT UNION	0.10 mm	0.25 mm	20 pezzi	PFITUN.010.025.20		
PRESS-FIT UNION	0.10 mm	0.32 mm	20 pezzi	PFITUN.010.032.20		
PRESS-FIT UNION	0.10 mm	0.53 mm	20 pezzi	PFITUN.010.053.20		
PRESS-FIT UNION	0.25 mm	0.25 mm	20 pezzi	PFITUN.025.025.20		
PRESS-FIT UNION	0.25 mm	0.32 mm	20 pezzi	PFITUN.025.032.20		
PRESS-FIT UNION	0.25 mm	0.53 mm	20 pezzi	PFITUN.025.053.20		
PRESS-FIT UNION	0.32 mm	0.32 mm	20 pezzi	PFITUN.032.032.20		
PRESS-FIT UNION	0.32 mm	0.53 mm	20 pezzi	PFITUN.032.053.20		
PRESS-FIT UNION	0.53 mm	0.53 mm	20 pezzi	PFITUN.053.053.20		



PRESS-FIT Micro-Unions -> PRESS-FIT "Y" 3 Ways



## PRESS-FIT "Y" 3 Ways

image							
Description	Single Way Diameter	Diameter 1	Diameter 2	N. Pieces	Package	Code #	Q.ta
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.05 mm	1 pezzo		PFITY.005.005.005.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.10 mm	1 pezzo		PFITY.005.005.010.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.25 mm	1 pezzo		PFITY.005.005.025.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.32 mm	1 pezzo		PFITY.005.005.032.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.53 mm	1 pezzo		PFITY.005.005.053.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.10 mm	1 pezzo		PFITY.005.010.010.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.25 mm	1 pezzo		PFITY.005.010.025.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.32 mm	1 pezzo		PFITY.005.010.032.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.53 mm	1 pezzo		PFITY.005.010.053.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.25 mm	0.25 mm	1 pezzo		PFITY.005.025.025.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.25 mm	0.32 mm	1 pezzo		PFITY.005.025.032.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.25 mm	0.53 mm	1 pezzo		PFITY.005.025.053.1	
PRESS-FIT Y 3 Vie	0.05 mm	0.32 mm	0.32 mm	1 pezzo		PFITY.005.032.032.1	

PRESS-FIT Y 3 Vie	0.05 mm	0.32 mm	0.53 mm	1 pezzo	PFITY.005.032.053.1		
PRESS-FIT Y 3 Vie	0.05 mm	0.53 mm	0.53 mm	1 pezzo	PFITY.005.053.053.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.05 mm	1 pezzo	PFITY.010.005.005.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.10 mm	1 pezzo	PFITY.010.005.010.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.25 mm	1 pezzo	PFITY.010.005.025.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.32 mm	1 pezzo	PFITY.010.005.032.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.53 mm	1 pezzo	PFITY.010.005.053.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.10 mm	1 pezzo	PFITY.010.010.010.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.25 mm	1 pezzo	PFITY.010.010.025.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.32 mm	1 pezzo	PFITY.010.010.032.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.53 mm	1 pezzo	PFITY.010.010.053.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.25 mm	0.25 mm	1 pezzo	PFITY.010.025.025.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.25 mm	0.32 mm	1 pezzo	PFITY.010.025.032.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.25 mm	0.53 mm	1 pezzo	PFITY.010.025.053.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.32 mm	0.32 mm	1 pezzo	PFITY.010.032.032.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.32 mm	0.53 mm	1 pezzo	PFITY.010.032.053.1		
PRESS-FIT Y 3 Vie	0.10 mm	0.53 mm	0.53 mm	1 pezzo	PFITY.010.053.053.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.05 mm	1 pezzo	PFITY.025.005.005.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.10 mm	1 pezzo	PFITY.025.005.010.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.25 mm	1 pezzo	PFITY.025.005.025.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.32 mm	1 pezzo	PFITY.025.005.032.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.53 mm	1 pezzo	PFITY.025.005.053.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.10 mm	1 pezzo	PFITY.025.010.010.1		

PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.25 mm	1 pezzo	PFITY.025.010.025.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.32 mm	1 pezzo	PFITY.025.010.032.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.53 mm	1 pezzo	PFITY.025.010.053.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.25 mm	0.25 mm	1 pezzo	PFITY.025.025.025.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.25 mm	0.32 mm	1 pezzo	PFITY.025.025.032.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.25 mm	0.53 mm	1 pezzo	PFITY.025.025.053.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.32 mm	0.32 mm	1 pezzo	PFITY.025.032.032.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.32 mm	0.53 mm	1 pezzo	PFITY.025.032.053.1		
PRESS-FIT Y 3 Vie	0.25 mm	0.53 mm	0.53 mm	1 pezzo	PFITY.025.053.053.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.05 mm	0.05 mm	1 pezzo	PFITY.032.005.005.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.05 mm	0.10 mm	1 pezzo	PFITY.032.005.010.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.05 mm	0.25 mm	1 pezzo	PFITY.032.005.025.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.05 mm	0.32 mm	1 pezzo	PFITY.032.005.032.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.05 mm	0.53 mm	1 pezzo	PFITY.032.005.053.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.10 mm	0.10 mm	1 pezzo	PFITY.032.010.010.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.10 mm	0.25 mm	1 pezzo	PFITY.032.010.025.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.10 mm	0.32 mm	1 pezzo	PFITY.032.010.032.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.10 mm	0.53 mm	1 pezzo	PFITY.032.010.053.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.25 mm	0.25 mm	1 pezzo	PFITY.032.025.025.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.25 mm	0.32 mm	1 pezzo	PFITY.032.025.032.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.25 mm	0.53 mm	1 pezzo	PFITY.032.025.053.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.32 mm	0.32 mm	1 pezzo	PFITY.032.032.032.1		
PRESS-FIT Y 3 Vie	0.32 mm	0.32 mm	0.53 mm	1 pezzo	PFITY.032.032.053.1		



PRESS-FIT Y 3 Vie	0.32 mm	0.53 mm	0.53 mm	1 pezzo	PFITY.032.053.053.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.05 mm	0.05 mm	1 pezzo	PFITY.053.005.005.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.05 mm	0.10 mm	1 pezzo	PFITY.053.005.010.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.05 mm	0.25 mm	1 pezzo	PFITY.053.005.025.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.05 mm	0.32 mm	1 pezzo	PFITY.053.005.032.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.05 mm	0.53 mm	1 pezzo	PFITY.053.005.053.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.10 mm	0.10 mm	1 pezzo	PFITY.053.010.010.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.10 mm	0.25 mm	1 pezzo	PFITY.053.010.025.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.10 mm	0.32 mm	1 pezzo	PFITY.053.010.032.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.10 mm	0.53 mm	1 pezzo	PFITY.053.010.053.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.25 mm	0.25 mm	1 pezzo	PFITY.053.025.025.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.25 mm	0.32 mm	1 pezzo	PFITY.053.025.032.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.25 mm	0.53 mm	1 pezzo	PFITY.053.025.053.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.32 mm	0.32 mm	1 pezzo	PFITY.053.032.032.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.32 mm	0.53 mm	1 pezzo	PFITY.053.032.053.1		
PRESS-FIT Y 3 Vie	0.53 mm	0.53 mm	0.53 mm	1 pezzo	PFITY.053.053.053.1		
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.05 mm	5 pezzi	PFITY.005.005.005.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.10 mm	5 pezzi	PFITY.005.005.010.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.25 mm	5 pezzi	PFITY.005.005.025.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.32 mm	5 pezzi	PFITY.005.005.032.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.05 mm	0.53 mm	5 pezzi	PFITY.005.005.053.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.10 mm	5 pezzi	PFITY.005.010.010.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.25 mm	5 pezzi	PFITY.005.010.025.5		

PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.32 mm	5 pezzi	PFITY.005.010.032.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.10 mm	0.53 mm	5 pezzi	PFITY.005.010.053.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.25 mm	0.25 mm	5 pezzi	PFITY.005.025.025.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.25 mm	0.32 mm	5 pezzi	PFITY.005.025.032.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.25 mm	0.53 mm	5 pezzi	PFITY.005.025.053.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.32 mm	0.32 mm	5 pezzi	PFITY.005.032.032.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.32 mm	0.53 mm	5 pezzi	PFITY.005.032.053.5		
PRESS-FIT Y 3 Vie	0.05 mm	0.53 mm	0.53 mm	5 pezzi	PFITY.005.053.053.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.05 mm	5 pezzi	PFITY.010.005.005.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.10 mm	5 pezzi	PFITY.010.005.010.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.25 mm	5 pezzi	PFITY.010.005.025.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.32 mm	5 pezzi	PFITY.010.005.032.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.05 mm	0.53 mm	5 pezzi	PFITY.010.005.053.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.10 mm	5 pezzi	PFITY.010.010.010.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.25 mm	5 pezzi	PFITY.010.010.025.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.32 mm	5 pezzi	PFITY.010.010.032.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.10 mm	0.53 mm	5 pezzi	PFITY.010.010.053.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.25 mm	0.25 mm	5 pezzi	PFITY.010.025.025.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.25 mm	0.32 mm	5 pezzi	PFITY.010.025.032.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.25 mm	0.53 mm	5 pezzi	PFITY.010.025.053.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.32 mm	0.32 mm	5 pezzi	PFITY.010.032.032.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.32 mm	0.53 mm	5 pezzi	PFITY.010.032.053.5		
PRESS-FIT Y 3 Vie	0.10 mm	0.53 mm	0.53 mm	5 pezzi	PFITY.010.053.053.5		

PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.05 mm	5 pezzi	PFITY.025.005.005.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.10 mm	5 pezzi	PFITY.025.005.010.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.25 mm	5 pezzi	PFITY.025.005.025.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.32 mm	5 pezzi	PFITY.025.005.032.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.05 mm	0.53 mm	5 pezzi	PFITY.025.005.053.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.10 mm	5 pezzi	PFITY.025.010.010.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.25 mm	5 pezzi	PFITY.025.010.025.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.32 mm	5 pezzi	PFITY.025.010.032.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.10 mm	0.53 mm	5 pezzi	PFITY.025.010.053.5		
PRESS-FIT Y 3 Vie	0.25 mm	0.25 mm	0.25 mm	5 pezzi	PFITY.025.025.025.5		
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## PRESS-FIT Multiways Connectors

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## Connections

In this month's "GC Connections," the author examines the effects on retention times and peak shapes when a retention gap is added to a capillary column.

# The Retention Gap Effect

A reader sent me the following question by e-mail:

As I read the recent article about the anatomy of a peak (1), I had to ask the following question: "How does an inert precolumn influence the calculation of, for example, the plate height?" Let's assume the main column has an inner diameter of 0.25 mm and a length of 25 m, and the inert precolumn has an inner diameter of 0.25 mm and is 5-m long. Do you then take 25 m or 30 m for calculating the plate height? I have never found this case mentioned in a gas chromatography book.

This and some related issues arise whenever using a precolumn, which also is called a retention gap. Retention gaps serve as depositories for nonvolatile residues that escape from the inlet system, as well as provide a means for consolidation of over-long or uneven injection profiles; the name comes from this second application. They protect the column from contamination as well as sharpen peaks from splitless or on-column injections. Chromatographers can trim the beginning of a retention gap as it becomes contaminated or simply replace it altogether instead of having to trim or replace the analytical column itself, thereby extending column life.

In practice, a retention gap can be used with either isothermal or temperature-programmed elution. In the case of splitless injection, the column is nearly always temperature-programmed, but in many other applications, isothermal operation is acceptable. I have limited this discussion on retention gaps to isothermal operation, but the conclusions should be valid for temperature programming as well.

Many labs will determine the apparent plate height of a peak or peaks in a quality-check mixture as part of standard operating procedures. By monitoring the plate height as well as related performance measures

such as peak tailing and peak-to-peak resolution, analysts can track column degradation and anticipate failures before they occur (1). To compute the plate height, however, the length of the column must be known. The reader's question thus arises when adding a retention gap.

The question can be expanded to encompass the following: What are the effects of a retention gap, if any, on the theoretical plate height and other column metrics? Is there any significant reason to include the retention gap length in plate height calculations from observed peaks?

Deciding on the best way to compute the minimum plate height involves consideration of how peaks disperse as they move along the uncoated precolumn and the main column. The effect of the plate height calculation on column suitability is another consideration. The related question of what happens to retention times also provides some interesting insights. To better understand what is happening, though, we will need to recall some gas chromatography (GC) theory and develop a model for a retention gap-column ensemble.

### Measuring the Height of One Theoretical Plate

Before wandering off into the forests of GC theory, let us review some chromatogram measurements that will help evaluate the effects of adding a precolumn. Peak widths, the number of theoretical plates, the height equivalent to one theoretical plate, and some retention parameters such as the average carrier gas linear velocity, retention times, retention factors, and the unretained peak time all are useful parameters that chromatographers can measure or calculate easily from a chromatogram. With this information in hand, we can proceed to discuss the effects of adding an uncoated precolumn.

**Virtual chromatography:** In this case, GC theory should provide a suitable answer to the questions. Going into the lab and

performing a series of experiments would no doubt give a better answer, but here we will have to make do with computer simulations of example chromatograms with and without a retention gap. Figure 1a shows such a chromatogram with four peaks: one at the unretained peak time, one midway along, and two that are adjacent but fully resolved from each other. The peaks' measured metrics are listed in Table Ia. These peaks represent typical isothermal chromatography on a 25 m  $\times$  0.25 mm capillary column with a thin 0.25- $\mu$ m stationary-phase film but without an uncoated precolumn.

The first peak in Figure 1 represents an unretained peak, such as methane, that occupies only the mobile phase during its passage through the column. From its retention time  $t_M$  and column length  $L$ , we can determine the average carrier gas linear velocity  $\bar{u}$ :

$$\bar{u} = \frac{L}{t_M} \quad [1]$$

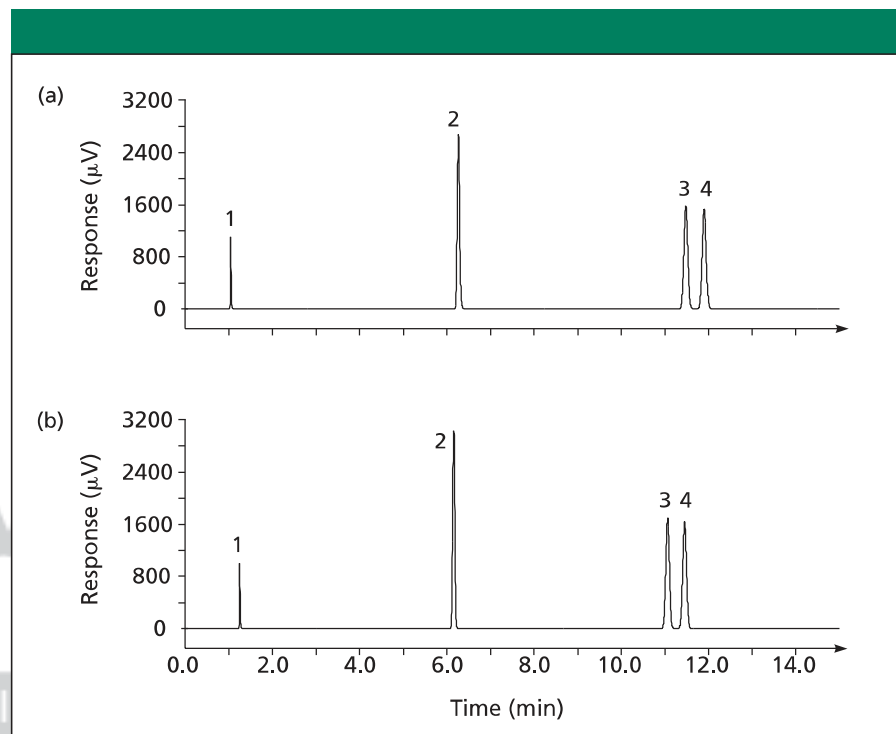
To simplify this discussion, we will keep the average velocity constant at 40 cm/s when adding the retention gap.

The average velocity is calculated from the total time that an unretained peak takes to be eluted. However, the carrier gas velocity is not the same along the entire length of the column. It starts out slower at the entrance and speeds up towards the exit. Measuring the exit or entrance velocities directly is not simple. I do not know of anyone who has tried it. Instead, chromatographers measure the average value from the unretained peak time and then calculate the localized carrier gas velocity as desired. The velocities at several points along the column are relevant to this discussion; at the inlet, at the outlet, and at the retention gap-column junction. These values, plus some other information, will allow us to calculate the effects of the retention gap on retention and peak shapes.

The unretained peak time and the retention times  $t_R$  of each of the peaks enter into the calculation of the retention factor  $k$ :

$$k = \frac{t_R - t_M}{t_M} \quad [2]$$

The retention factor is the number of multiples of the unretained peak time that a retained peak spends in the stationary phase as it transits through the column. The retention factor is independent of the



**Figure 1:** Effect of a retention gap on retention and peak shape. (a) 25 m  $\times$  0.25 mm, 0.25- $\mu$ m  $d_f$  column, 17.75 psig inlet pressure and (b) same column as (a) with a 5 m  $\times$  0.25 mm uncoated retention gap added to the beginning, 21.6 psig inlet pressure. Conditions for (a) and (b): helium carrier gas, 40 cm/s, 100  $^{\circ}$ C. Peak profiles calculated from theoretical  $H$  values assuming 83% coating efficiency.

unretained peak time and gas velocity and makes it easier to compare results between columns of different length or with different carrier gas conditions. Note, however, that retention factors do depend strongly upon the type of stationary phase, the column temperature, and the amount of stationary phase relative to the gas volume of the column. I will keep the temperature and the analytical column stationary-phase film thickness constant for the purpose of this discussion. Adding the uncoated restrictor will change the ratio of stationary phase to gas volume, so  $k$  values should be expected to change.

In addition to retention-related metrics, GC users also measure peak widths and calculate some data about their shapes and their resolution relative to other peaks. The peak width at half-height  $w_h$  is measured the most often and is the easiest way to determine peak-shape metric. The peak width at half-height does not signify anything by itself, but in concert with retention time information, it can tell us how many theoretical plates  $N_{exp}$  are observed experimentally:

$$N_{exp} = 5.545 \left( \frac{t_R}{w_h} \right)^2 \quad [3]$$

From the number of theoretical plates and the length of the column  $L$ , we can calculate the measured height — the length along the column — equivalent to one average theoretical plate  $H_{exp}$ :

$$H_{exp} = \frac{L}{N_{exp}} \quad [4]$$

Finally, we can determine the resolution  $R_S$  between two adjacent peaks from their retention times and widths at the half-height:

$$R_{s,3,4} = 1.177 \frac{t_{R,4} - t_{R,3}}{w_{h,4} + w_{h,3}} \quad [5]$$

In equation 5, the subscripts 3 and 4 refer to the third and fourth peaks in Figure 1. A resolution of greater than 1.5 is considered baseline resolution. See reference 1 for a more detailed discussion of the significance of  $N$ ,  $H$ , and  $R$ . Table Ia lists these values as measured for the peaks in Figure 1a.



## Adding the Gap

Consider what happens to the observed performance when a retention gap is added to the front of the column, ignoring for the moment the peak focusing that the operator might invoke deliberately. By definition, the retention gap will not retain any of the peaks: they all will fly through the retention gap in the same time period. As they pass through the retention gap, they will experience some degree of broadening. Then they all will encounter the analytical column at the same time.

One approach to answering the retention gap question considers the retention gap and the analytical column as acting separately but in series. We can model the overall ensemble behavior and compare it with the column alone by computing the peaks' retention and broadening behaviors on the retention gap first and then feeding the peaks to the analytical column entrance as they exit from the retention gap.

**Retention times:** The issue under discussion here is whether to use the length of the column alone or the total length of the retention gap–column ensemble for plate-height calculations. But first I will take a look at the effect of a retention gap on retention times, because there are some trends that run counter to intuition. Along the way, some pressure and velocity parameters will be developed that are essential to modeling peak broadening in column segments.

Figure 2 illustrates some characteristics of the retention gap–column ensemble. A retention gap A with length  $L_1$  is joined to the analytical column C with length  $L_2$  by a zero dead-volume connector B. The ensemble has inlet pressure  $p_i$  and outlet pressure  $p_o$ , as well as midpoint pressure  $p_m$ . By definition,  $p_i > p_m > p_o$ . Also shown are the inlet, midpoint, and outlet carrier gas velocities, for which the velocities fall in the order  $u_i < u_m < u_o$ . Finally, both the retention gap and the analytical column have characteristic average carrier gas velocities  $\bar{u}_1$  and  $\bar{u}_2$ , respectively.

It is intuitive to state that adding a length of uncoated precolumn as a retention gap to the front of an analytical column, while keeping the average carrier gas velocity constant, at 40 cm/s in the present example, will increase the retention times of all of the peaks. However, this is not entirely correct. Peaks that have small retention factors do gain in retention time, but peaks with larger retention factors actually are eluted *earlier* with a retention gap than without one, as seen by compar-

**Table I: Metrics obtained from the peaks in Figure 1. (a) 25 m  $\times$  0.25 mm i.d.  $\times$  0.25 mm column. (b) Same column as (a) with a 5 m  $\times$  0.25 mm i.d. uncoated retention gap added to the beginning (peak 1 is an unretained peak)**

Peak	1		2		3		4	
Metric	a	b	a	b	a	b	a	b
Retention time ( $t_R$ , s)	62.5	75.0	375	369	688	663	713	687
	(= $t_M$ )							
Retention factor ( $k$ )	0.0	0.0	5.0	3.91	10.0	7.82	10.4	8.13
Width at half-height ( $w_{h/2}$ , s)	1.3	1.3	3.5	3.5	6.0	5.9	6.2	6.1
Measured plate count ( $N_{exp}$ )			64,000	62,000	73,000	70,000	74,000	70,000
Measured plate Height ( $H_{exp}$ , mm)			0.39	0.40	0.34	0.36	0.34	0.36
$L = 25$ m (column only)								
$L = 30$ m (column + retention gap)				0.48		0.43		0.43
Resolution ( $R_s$ )			Resolution between peaks 3 and 4				2.43	2.30

ing Figures 1a and 1b. To understand this effect, we will need to do some retention time calculations on the retention gap and the analytical column separately and then combine them to find retention times on the ensemble.

I can rearrange and combine equations 1 and 2 to express retention time in terms of the retention factor, the average linear velocity, and the column length:

$$t_R = \frac{L}{\bar{u}}(k + 1) \quad [6]$$

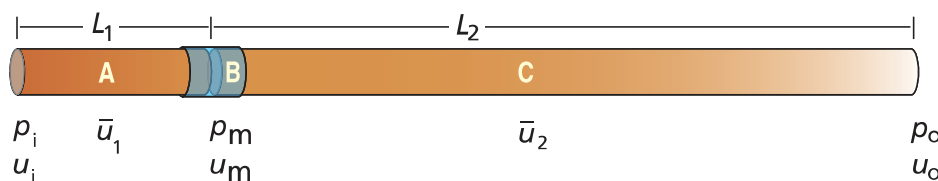
I can use equation 6 to calculate retention times on the retention gap and the analytical column separately if I know their lengths, average velocities, and the retention factors of the peaks in question. Then I can add the two times together to find the total retention time of the ensemble.

The lengths of the retention gap and column are known: 5 and 25 m, respectively. I also know the retention factors:  $k = 0.0$  on the retention gap, and  $k$  has the values from Table Ia for the analytical column. The problem now is to determine the average carrier gas velocity in the two parts of the ensemble separately. One part of the calculation of the velocities involves finding the pressures at the ensemble entrance  $p_i$  and also at the junction point  $p_m$ . The outlet pressure  $p_o$  remains at 1 atm. Although I could write equations and solve them for the pressure drops, most of this work already has been done for me by the GC manufacturers.

To set the inlet pressure of the ensemble, I went into the lab and used a gas chromatograph with electronic pressure control. I set the column length to 30 m, the inner diameter to 0.25 mm, the film thickness to 0, the average linear velocity to 40

**Table II: Pressures, velocities, and retention times for a column ensemble. (a) 25 m  $\times$  0.25 mm i.d.  $\times$  0.25 mm film analytical column alone. (b) 5 m  $\times$  0.25 mm i.d. uncoated retention gap and analytical column in series. Helium carrier gas at 40 cm/s, 100 °C**

	a	b
Inlet pressure ( $p_i$ , psig)	17.8	21.6
Midpoint pressure ( $p_m$ , psig)	--	18.98
Outlet pressure ( $p_o$ , psig)	14.7	14.7
Flow rate ( $F_c$ , mL/min)	1.98	2.17
Inlet velocity ( $u_i$ , cm/s)	30.4	29.8
Midpoint velocity ( $u_m$ , cm/s)	--	32.1
Outlet velocity ( $u_o$ , cm/s)	67.2	73.5
Retention gap average velocity ( $\bar{u}_1$ , cm/s)	--	30.9
Analytical column average velocity ( $\bar{u}_2$ , cm/s)	40	42.5
Ensemble average velocity ( $\bar{u}$ , cm/s)	--	40
Retention gap unretained peak time ( $t_{M1}$ , s)	--	16.2
Analytical column unretained peak time ( $t_{M2}$ , s)	62.5	58.8
Ensemble unretained peak time ( $t_{M}$ , s)	--	75



**Figure 2:** Retention gap and analytical column ensemble. A = retention gap, B = zero dead volume connection, and C = analytical column.

cm/s, the oven temperature to 100 °C, and the carrier gas to helium. Setting a film thickness of zero in this case will not affect the calculations because the 0.25-mm film has no significant effect on the pressure drop. The gas chromatograph selected an inlet pressure of 21.6 psig with an outlet pressure of 1 atm. This is slightly higher than the 17.8 psig needed to drive the carrier gas at 40 cm/s through the shorter analytical column alone, as would be expected.

Calculating the midpoint pressure of a column ensemble is beyond the capability of a standard lab gas chromatograph, but the relationships required to perform the calculations are found in GC textbooks (2,3). I derived the carrier gas velocities at the inlet, midpoint, and outlet as well as the average gas velocities in the retention gap and the analytical column, all of which are listed in Table II. These calculations are more complex than will fit in the available space here, so I have placed them in an on-line supplement to this article for interested readers to review. Others might wish to use this material as a soporific. The supplement is located on the internet at <http://www.chromatographyonline.com>.

The carrier gas expands during its passage through the column, but the rate of expansion is not proportional to the distance along the column. Rather, the gas expands more toward the end of the column than the beginning. As a result, although the *average* gas velocity from entrance to exit is 40 cm/s in both cases, the average velocity across the analytical column, where peaks are retained, is higher (42.5 cm/s) when it is preceded by a retention gap than when the retention gap is absent. This nonlinear carrier gas expansion causes peaks to traverse the analytical column portion in less time with the retention gap attached. For this particular example, peaks with  $k > 3.5$  end up being

eluted sooner than on the analytical column alone, as shown in the retention times in Table Ib for the peaks in Figure 1b, with the retention gap attached. This retention gap effect on retention time varies considerably with different column and retention gap lengths and diameters.

**Peak shapes:** To calculate the composite effect of the retention gap and analytical columns' peak broadening, we can add the peak variances  $\sigma^2$  from each section taken separately:

$$\sigma^2 = \sigma_1^2 + \sigma_2^2 \quad [7]$$

The subscripts 1 and 2 refer to the retention gap and analytical columns, respectively. The theoretical variance of a peak is a function of the column length, the plate height, and the retention time:

$$\sigma^2 = \frac{H \cdot t_R^2}{L} \quad [8]$$

To find the theoretical variance of a peak on the retention gap and on the analytical column then, we must know its retention time and theoretical plate height on both. With that information, we can compare the variances contributed by the retention gap and the column to better understand the effects of the retention gap and to

decide how best to measure the plate height.

To find the individual plate heights for the retention gap and the analytical column, we need to access some more theory. The Golay equation and its modifications that account for the columns' pressure drops give a fairly accurate assessment, but this derivation and the calculations also are too lengthy to include in print. They have been placed in the second part of the supplement to this discussion, located at <http://www.chromatographyonline.com>.

Table III shows the theoretical peak dispersion for each peak (in seconds) attributable to the individual sections and to the overall column or ensemble both without and with a retention gap. The retention gap contribution is the same for all peaks. This makes sense because they are not retained there and should experience only gas-phase broadening, which is assumed to be the same for all peaks. For the unretained peak, about 40% of the ensemble dispersion is due to the retention gap and 60% to the analytical column. The retention gap affects the second peak slightly, but it does not have any kind of significant affect on the last two peaks' theoretical shapes at all.

**To include or not to include:** The degree of band broadening that occurs on the analytical column, as measured by the cal-

**Table III: Theoretical peak dispersion. (a) 25 m × 0.25 mm i.d. × 0.25 mm column. (b) Same column as (a) with a 5 m × 0.25 mm i.d. uncoated retention gap added to the beginning (peak 1 is an unretained peak)**

Metric	Peak	1		2		3		4	
	Location	a	b	a	b	a	b	a	b
Dispersion ( $\sigma$ , s)	Retention Gap		.10		.10		.10		.10
	Analytical Column	0.141	0.166	1.24	1.23	2.35	2.29	2.43	2.38
	Ensemble		0.194		1.24		2.29		2.38

culated peak dispersions, is similar with and without the retention gap. For the later-eluted peaks 3 and 4, less broadening occurs on the analytical column with the retention gap in place. Peak 4, for example, has a dispersion of 2.43 s from the analytical column alone, while adding the retention gap decreases the dispersion from the analytical column to 2.38 s. These differences are due to the slight shift of the later peaks to earlier retention times, as described in equation 8, and not to a real performance shift.

Overall, the earlier retention times and slightly smaller variances with the retention gap in place cause a net decrease in the resolution between peaks 3 and 4, as shown in Table I. The theoretical plate count is not impacted in any meaningful way, however. The resolution loss is not significant and is likely to be less than the error associated with the theoretical calculations used to derive it and less than the accuracy of chromatogram measurements performed to determine it.

Table I clearly shows that including the retention gap length in the calculations increases the apparent plate heights, yet the number of theoretical plates and the peak widths do not change appreciably. Therefore, the retention gap length should not be included when determining analytical column plate heights.

## Conclusion

This has been a long journey through a theoretical quagmire in quest of an answer to the question of how best to calculate observed theoretical plate heights when a retention gap is used. For the particular example chosen here, peaks with a retention factor of five or greater do not show a significant contribution to their shape from the retention gap. Theoretical plate numbers do not change, and only a negligible resolution loss might occur. Therefore, it seems valid to conclude that the length of a retention gap as long as 5 m can be ignored when measuring analytical column performance.

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For an ongoing discussion of GC issues with John Hinshaw and other chromatographers, visit the Chromatography Forum discussion group at <http://www.chromforum.com>.

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