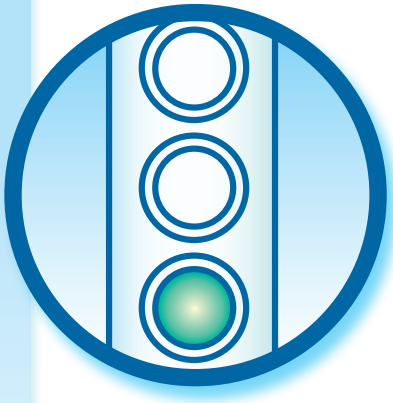
Liner Anatomy



LET'S BEGIN

The success of your separation, and more than likely the entire analysis, depends on how well your sample is transferred onto the column. As the vessel that holds the sample between injection and transfer onto the column, the GC inlet liner plays a critical role in that process. Different liners do different things, so don't risk compromising your data by using the wrong liner for your work. To correctly choose which liner is right for your application, let's consider different methods of sample introduction.

SPLIT INJECTIONS

Split injections are a fast, efficient way to transfer a portion of the sample onto the column for analysis. Split injection is often used for dirty samples or highly concentrated samples (e.g., fragrances, flavors, petroleum samples). Additionally, split injections are used to maintain narrow peak widths in gas analyses like purge-and-trap and static headspace analyses. A split ratio adjusts the amount transferred to the column, and that transfer happens so quickly that fast and efficient vaporization is necessary for accurate and precise results.

SPLITLESS INJECTIONS

Splitless injections are used for trace analyses (e.g., environmental, food safety samples). This technique involves an initial hold time where the split vent valve is closed and the sample is injected onto the column during that hold time. During the relatively slow introduction of the sample onto the column, peaks can broaden, so it's important to optimize the splitless run conditions, especially the initial oven temperature, in order to focus the analytes and get symmetrical, narrow peaks.

PROGRAMMABLE TEMPERATURE VAPORIZATION (PTV) AND LARGE VOLUME INJECTIONS (LVI)

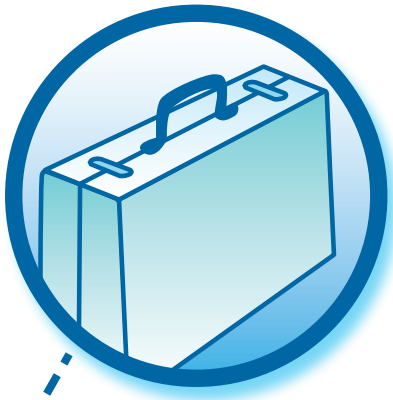
Unlike traditional hot split and hot splitless injections, PTV and LVI techniques commonly rely on lower initial inlet temperatures, which allow for solvent venting prior to transfer of the solutes onto the column. Rapid heating is then used to move the analytes onto the column, allowing them to be transferred as a sharp band and at the lowest possible temperature. PTV and LVI often provide a "gentle" means of sample transfer, which is advantageous for thermally labile compounds (e.g., explosives like nitroglycerin and PETN). In addition, these techniques can accommodate sample volumes of up to 100 times greater than those typically used in hot split or splitless injections; this can increase analytical sensitivity and decrease the amount of sample concentration that is required. Note that in large volume injections the use of a retention gap (typically a 2-3 m length of 0.53 mm deactivated capillary tubing without stationary phase) is necessary. For PTV, a retention gap is not required as long as the solvent is split off via the split vent.

COOL ON-COLUMN INJECTIONS

Typically, a true "cool on-column inlet" doesn't require a liner in the same sense that other injection techniques do. However, with a Gerstel PTV inlet and the specially designed on-column liner, a true "cool on-column" injection can be performed. Whether using a true cool on-column inlet or a modified PTV, this technique can dramatically mitigate molecular weight discrimination and analyte decomposition, but it requires the use of a retention gap to achieve proper analyte focusing, which produces narrow, symmetrical peak shapes.

DIRECT INJECTIONS

In direct injections, essentially the entire sample is transferred to the column via a hot liner through an actual connection between the fused silica column and the liner. This technique is sometimes used as an alternative to a splitless injection.



LINER PACKING

Liner packing and position improve sample vaporization and homogenization, and help prevent nonvolatile material from entering the column. The accuracy and precision of analyses of high molecular weight compounds in splitless, but especially in split mode, benefit from the use of packing material. Highly inert Restek Premium deactivation allows wool to be used with confidence!

PACKING MATERIAL AND POSITION

Glass wool is the most common packing material, and it does the job of assisting vaporization and capturing non-volatile compounds exceptionally well. Compared to many other designs, it is the most cost-effective alternative.

Wool often is placed near the bottom of the liner, especially when using an autosampler for splitless injections; without it, the relatively long sample residence time allows solvent vapor expansion to carry the solute out the top of the liner along with the solvent. When the sample is deposited onto the wool at the bottom of the liner, all but the most volatile solutes are left to vaporize in the wool while the solvent alone expands up into the liner's volume.

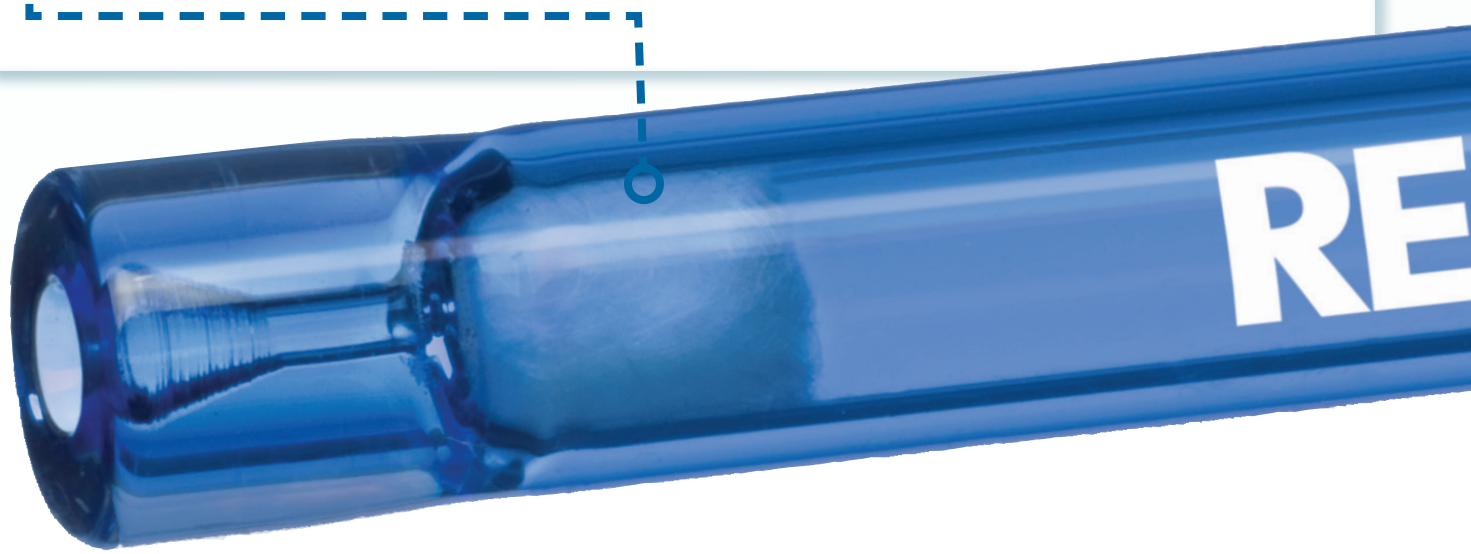
RESTEK PREMIUM PRECISION® LINER with WOOL

Wool positions near the middle and top of the liner are common in split injections, again especially with auto-sampler injections. This is because the residence time of the sample in the inlet is very short, so it is beneficial to stop the sample in a hotter region of the inlet to assist in vaporization. Wool increases the heat capacity of the liner, which maintains the temperature during evaporation and results in better reproducibility. Additionally, if the position is high enough for the syringe needle to enter the wool and make the injection, the wool will wipe the needle tip upon removal. This will result in even greater injection-to-injection precision, which is why Restek's Precision® liners have wool relatively high in the liner, braced by two sets of dimples to maintain the original position. Note that good needle maintenance is critical for these injections as a burred needle can still pull the packing out of position, eliminating its effectiveness.

BUT SOMETIMES WOOL JUST WON'T DO

As wool deactivation technology improves, more and more applications should be able to take advantage of its benefits. However, some applications are problematic with even trace amounts of wool activity. In those cases, a liner like a cyclo double taper does a very good job producing accurate and reproducible results, especially in splitless injections where packing activity is most critical.

RESTEK PREMIUM CYCLO DOUBLE TAPER LINER



RESTEK PREMIUM DEACTIVATION

Liners and their packing materials need to provide highly inert pathways to guard against sample adsorption (reversible or irreversible) and sample degradation.

Many chromatographic problems, such as poor response and missing or tailing peaks, are caused by activity in the inlet liner. These effects complicate quantification and can be particularly problematic for sensitive analytes. Restek Premium inlet liners from Restek offer exceptional inertness, assuring accurate transfer of analytes to the column, good response, and highly symmetrical peaks. A state-of-the art deactivation process renders the liner and wool inert to a wide variety of sensitive analytes.

As noted in the Liner Packing section, for many applications glass wool is an essential component to achieving the most precise and accurate results; however, it has also traditionally been a source of physically and chemically active sites that can have unwanted interactions with the sample.

To confidently take advantage of all of the benefits that wool has to offer without many of the concerns about liner activity, it's important to use pure and highly inert wool. Restek's Premium liners are packed with fused quartz wool that is much purer than the commonly used borosilicate glass wool. Handling the wool after deactivation can introduce activity as well, so Premium liners are deactivated after packing, providing exceptional inertness and product reproducibility.

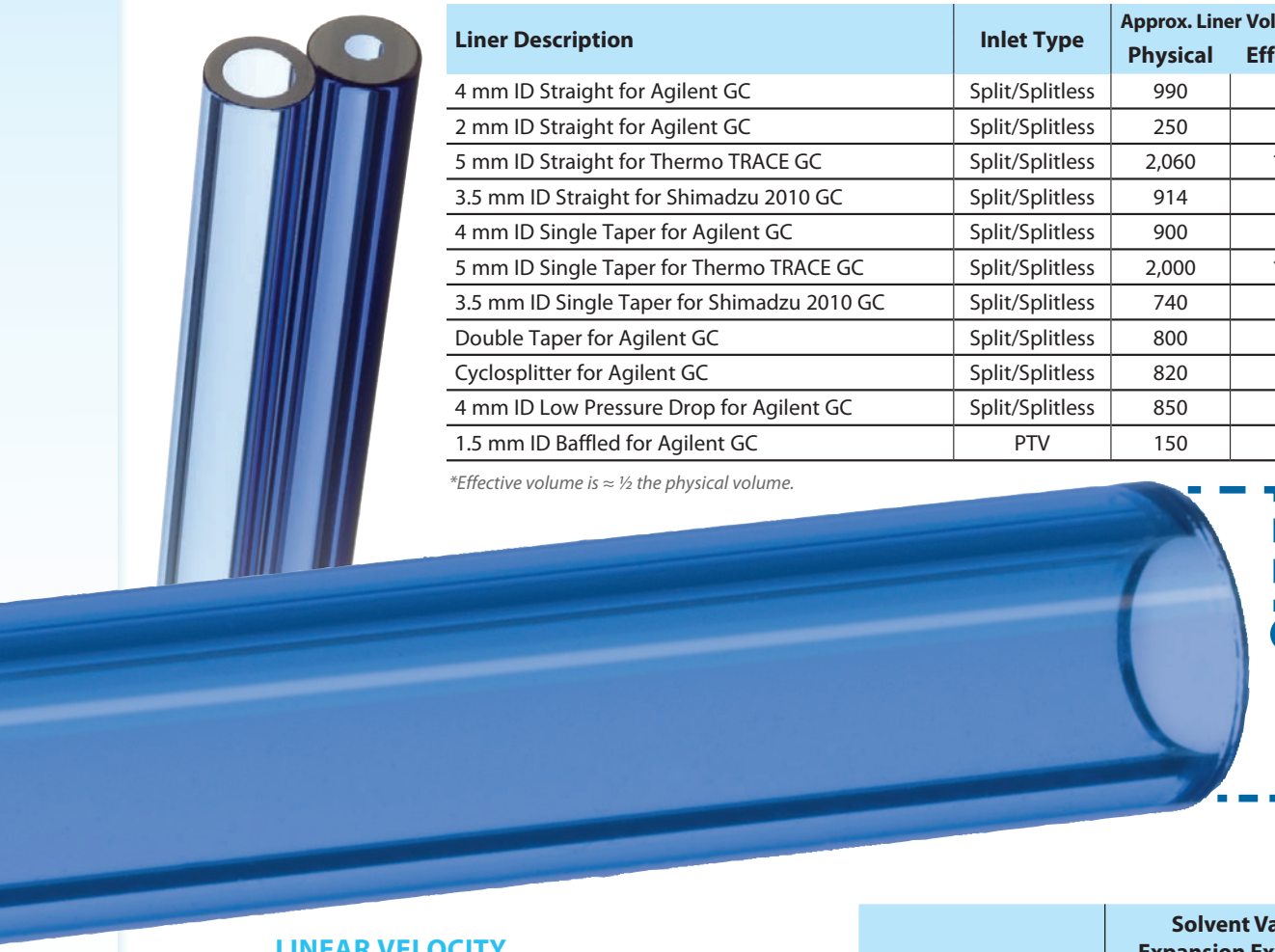
TECH TIP: Correct installation of Restek Premium inlet liners is quick and easy. Simply orient the liner so the column installs toward the "R" on the Restek logo.

VOLUME AND INNER DIAMETER

Sample expansion volume and linear velocity should be considered when choosing liner dimensions.

SAMPLE EXPANSION VOLUME

When a liquid sample is vaporized inside an inlet liner, its volume expands considerably. Care should be taken to ensure the expanded volume of the injected sample does not exceed the effective volume of the liner. Use Restek's solvent expansion calculator *(www.restek.com/calculators)* to determine the expansion volume of your solvent under your conditions. See below for some common liner physical and effective volumes, as well as an example of the solvent expansion calculator's results.



Liner Description	Inlet Type	Approx. Liner Volume (µL)	
		Physical	Effective*
4 mm ID Straight for Agilent GC	Split/Splitless	990	495
2 mm ID Straight for Agilent GC	Split/Splitless	250	125
5 mm ID Straight for Thermo TRACE GC	Split/Splitless	2,060	1,030
3.5 mm ID Straight for Shimadzu 2010 GC	Split/Splitless	914	457
4 mm ID Single Taper for Agilent GC	Split/Splitless	900	450
5 mm ID Single Taper for Thermo TRACE GC	Split/Splitless	2,000	1,000
3.5 mm ID Single Taper for Shimadzu 2010 GC	Split/Splitless	740	370
Double Taper for Agilent GC	Split/Splitless	800	400
Cyclosplitter for Agilent GC	Split/Splitless	820	410
4 mm ID Low Pressure Drop for Agilent GC	Split/Splitless	850	425
1.5 mm ID Baffled for Agilent GC	PTV	150	75

**Effective volume is ≈ ½ the physical volume.*

LINEAR VELOCITY

Choosing a liner with a narrow inner diameter will give a faster linear velocity (for a given flow rate). In turn, this will move the sample onto the column quickly, reducing the injection band width, improving efficiency, and helping keep peak widths narrow. This is particularly important for very volatile components introduced via purge-and-trap or static headspace techniques, or when 0.18 mm, 0.15 mm, or 0.10 mm ID columns are used.

Parameter	Solvent Vapor Expansion Examples	
	Example 1	Example 2
Solvent	Hexane	Water
Inlet Pressue (psi)	15.8	15.8
Inlet Temperature (°C)	250	250
Expansion Volume (µL)	159	1,145

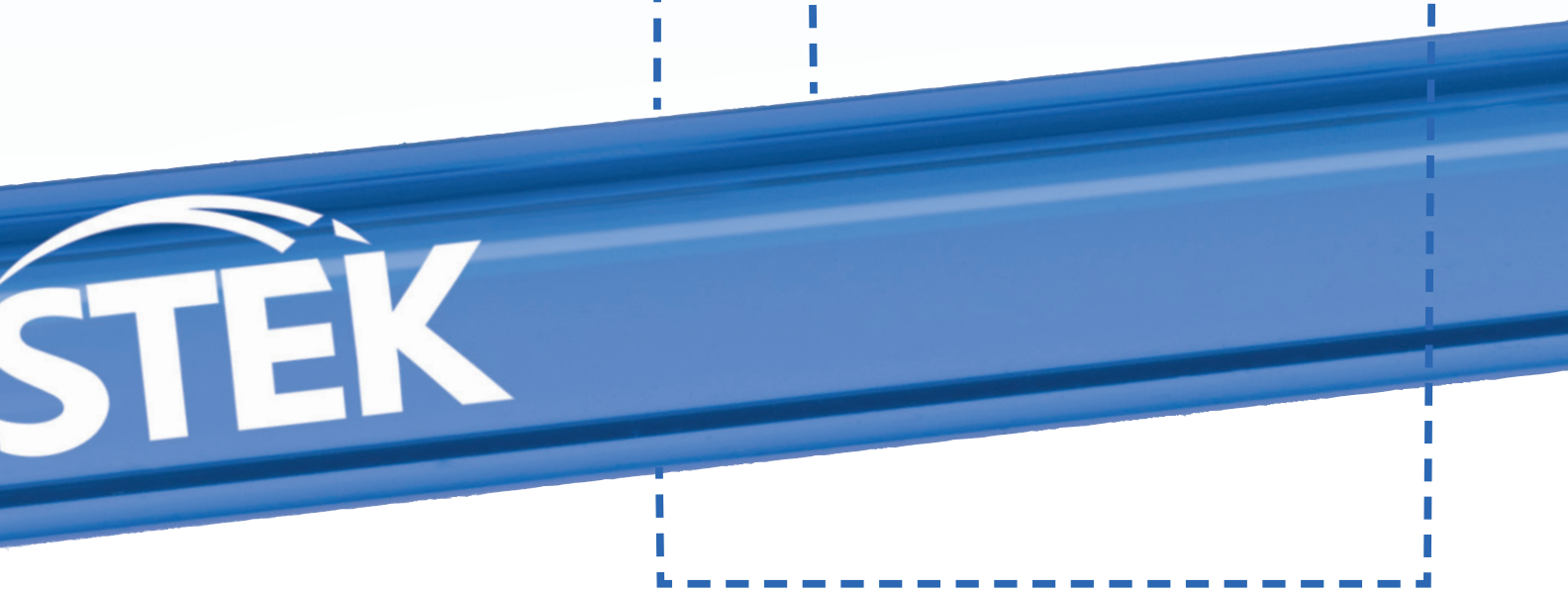
Where 15.8 psi head pressure creates a column flow of 1.5 mL/min for a 30 m, 0.25 mm ID column in an oven at 40 °C.

LINER MAINTENANCE

Samples can take their toll on the system, so inlet liners need to be changed regularly to avoid the following problems.

- Sample degradation resulting in poor response.
- Sample adsorption resulting in poor peak shape and reduced response.
- Sample discrimination that could result in the loss of certain analytes (e.g., high molecular weight compounds).
- Peak area irreproducibility.
- Extraneous peaks or unwanted sample interactions from contamination or cored septum particles.

Just like any consumable, it's good practice to thermally condition your liners for a short period of time to prepare them for use. Make a few blank injections with the analytical method or raise the inlet temperature slightly above (e.g., +10 °C) the operational setpoint, if the system will tolerate it, to ensure the removal of contaminants.



GEOMETRY

The simplest liners are straight tubes with or without packing. However, many inlet liners are designed with special geometries. They principally serve two purposes: to aid vaporization and to protect the sample, especially during splitless injections.

ENHANCE VAPORIZATION

To minimize discrimination (between high and low boiling point compounds or nonpolar and polar analytes), some liners are packed with glass wool or are designed with complex flow paths to aid vaporization.

RESTEK PREMIUM PRECISION® LINER with WOOL

TECH TIP: Did you know drilled Uniliner® inlet liners allow direct injections on EPC-equipped GCs? While complete sample transfer can be achieved under properly set splitless conditions, a drilled Uniliner® inlet liner can help ensure that transfer through a leak-free seal with the column. That seal also prevents sample contact with the bottom of the injection port.

Use the drilled Uniliner® inlet liner with the hole near the bottom for analyses where compounds of interest could be affected by a tailing solvent peak. Use the drilled Uniliner® inlet liner with the hole near the top for chlorinated pesticides analyses, aqueous injections, and analyses in which the compounds of interest elute well after the solvent peak.

DRILLED UNLINER® with HOLE near BOTTOM

PROTECT THE SAMPLE

Some samples are prone to degradation inside of the inlet, especially when in contact with hot metal surfaces. Several liners are designed specifically to minimize contact with the injection port. This is especially important with splitless injections where the sample stays in the inlet for a relatively long time.

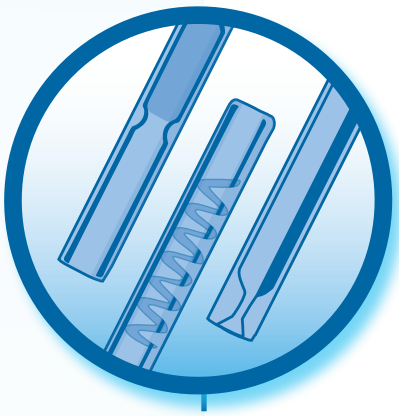
RESTEK PREMIUM SINGLE TAPER LINER

RESTEK PREMIUM DOUBLE TAPER LINER

SOME LINERS COMBINE BOTH FEATURES!

RESTEK PREMIUM SINGLE TAPER LINER with WOOL

RESTEK PREMIUM CYCLO DOUBLE TAPER LINER



GET MORE!

Want to learn more about liners and see data demonstrating many of the concepts discussed in this brochure? Visit **www.restek.com/liners** to see the following resources, and many more!

- Form and Function: Understanding the Complex World of GC Inlet Liners (webinars)
- PTV On-Column Liner Gives You Two Inlets in One
- Rethinking the Use of Wool With Splitless GC

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