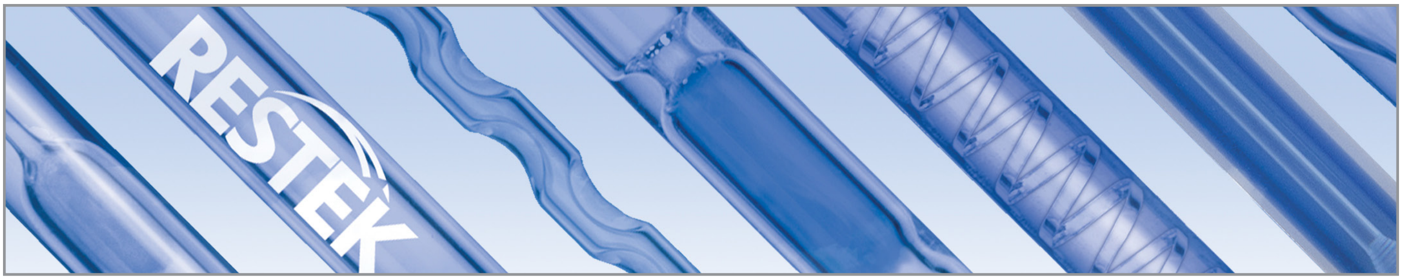

How to Choose a GC Inlet Liner

GC inlet liners are available in a multitude of styles. They differ in geometric design, volume and inner diameter, deactivation, and the presence or absence of some type of packing. However, with so many options to choose from, how do you determine which one is best for your analysis?

Generally, this question can be simplified based on your injection technique. In most cases, a Restek Topaz Precision liner with wool for split injection, or a Topaz single taper liner with wool for splitless injection, will produce excellent results. For direct injections, the placement of the drilled hole is the only decision you need to make, with most applications finding the hole drilled at the top of the liner to be effective. For gaseous samples, an inlet liner with a narrow inner diameter is recommended to ensure a tight sample band. Finally, for PTV injections, a narrow inner diameter liner would also be used, but one that contains baffles or dimples and is compatible with the inlet.

While these recommendations provide a good starting point, the unique needs of your application may require a specific feature to be successful. Therefore, it's helpful to learn about the different liner options available to understand how they can affect your analysis.

Geometry

The simplest liners are straight tubes with or without packing. However, many inlet liners are designed with special geometries. These principally serve two purposes: to enhance 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 (Figure 1).

Figure 1: Restek Topaz Precision liner with wool for Agilent GCs. (cat.# 23305).

Protect the Sample
Some samples are prone to degradation inside of the inlet, especially when in contact with hot metal surfaces. To help limit these effects, some liners feature tapered geometry that's designed specifically to minimize the sample's contact with the injection port (Figures 2 to 5). This is especially important with splitless injections where the sample remains within the inlet for a relatively long time.

Figure 2: Restek Topaz single taper liner for Agilent GCs. (cat.# 23302)

Figure 3: Restek Topaz double taper liner for Agilent GCs. (cat.# 23308)

Additionally, some liners combine features to enhance vaporization while also protecting the sample:

Figure 4: Restek Topaz single taper liner with wool for Agilent GCs. (cat.# 23303)

Figure 5: Restek Topaz cyclo double taper liner for Agilent GCs. (cat.# 23310)

Volume and Inner Diameter
Sample expansion volume and linear velocity should be considered when choosing the dimensions of your inlet liner.

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 Table I for some common liner physical and effective volumes and Table II for an example of the solvent expansion calculator's results.

Table I: Common liner physical and effective volumes.

		Appx. Liner Volume (µL)	
Liner Description	**Inlet Type**	**Physical**	**Effective***
3 mm Intermediate-Volume Liner	Split/Splitless	520	260
3 mm Intermediate-Volume Liner for Shimadzu GCs	Split/Splitless	520	260
4 mm ID Straight Liner for Agilent GC	Split/Splitless	990	495
2 mm ID Straight Liner for Agilent GC	Split/Splitless	250	125
5 mm ID Straight Liner for Thermo TRACE GC	Split/Splitless	2060	1030
3.5 mm ID Straight Liner for Shimadzu 2010 GC	Split/Splitless	914	457
4 mm ID Single Taper Liner for Agilent GC	Split/Splitless	900	450
5 mm ID Single Taper Liner for Thermo TRACE GC	Split/Splitless	2000	1000
3.5 mm ID Single Taper Liner for Shimadzu 2010 GC	Split/Splitless	740	370
Double Taper Liner for Agilent GC	Split/Splitless	800	400
Cyclo Liner for Agilent GC	Split/Splitless	820	410
4 mm ID Low Pressure Drop Liner for Agilent GC	Split/Splitless	850	425
1.5 mm ID Baffled Liner for Agilent GC	PTV	150	75

* Effective volume is ≈ $^1/_2$ the physical volume.

Table II: Example solvent expansion calculator results.

	Solvent Vapor Expansion Examples	
Parameter	**Example 1**	**Example 2**
Solvent	Hexane	Water
Inlet Pressure (psi)	15.8	15.8
Inlet Temperature (°C)	250	250
Expansion Volume (µL)	159	1145

Where a 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.

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 compounds introduced via purge-and-trap or static headspace techniques, or when narrow-bore (0.18 mm, 0.15 mm, or 0.10 mm ID) columns are used. Note that while narrow ID liners do provide the advantages of faster sample transfer and reduced residence time in the inlet, their low volume means less sample can be injected without the risk of backflash. Larger volume liners have more capacity, but use lower flow rates that can lead to band broadening and analyte degradation in the inlet. Intermediate-volume liners (e.g., cat.# 27231 and 27232) can provide more balanced performance and allow more sample to be injected while preserving chromatographic performance, particularly when paired with narrow-bore columns.

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's Topaz inlet liners offer exceptional inertness—assuring accurate transfer of analytes to the column—good response, and highly symmetrical peaks. These liners go through a state-of-the art deactivation process that renders the liner and wool inert to a wide variety of sensitive analytes.

As noted in the Packing Material and Position section below, 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 the benefits wool has to offer without many of the concerns about liner activity, it's important to use pure and highly inert wool. Restek's Topaz inlet 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 Topaz liners are deactivated in situ, after packing, providing exceptional inertness and product reproducibility.

Packing

Liner packing and position helps improve sample vaporization and homogenization and prevents 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.

Packing Material and Position

Glass (quartz) wool is the most common packing material for inlet liners. It does the job of assisting vaporization and capturing nonvolatile compounds exceptionally well; and, compared to other packing designs, it's also the most cost-effective option.

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.

Wool positions near the middle and top of the liner are common in split injections, especially with autosampler injections. This is because the residence time of the sample in the inlet is very short, so it's 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 (Figure 6). Note that good needle maintenance is critical for these injections as a burred needle can pull the wool out of position, eliminating its effectiveness.

Figure 6: Restek Topaz Precision liner with wool for Agilent GCs. (cat.# 23305)

Wool Alternatives
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 (Figure 7) does a very good job producing accurate and reproducible results, especially in splitless injections where packing activity is most critical.

Figure 7: Restek Topaz cyclo double taper liner for Agilent GCs. (cat.# 23310)

Injection Type
Now that we've covered the different styles of liner anatomy and their effects on analyses, the last step is to consider the injection type. Here, you will see how each of these styles come together—and in some cases, combine—to help support the injection type being used.

Split Injections
Split injections are used when the compounds of interest in your sample are of relatively high concentration or when it's not necessary to achieve low limits of detection. Split injections are characterized by high flow rates through the inlet, with some flow (and sample) going to the GC column, and some flow (and sample) going out the split vent. Given these higher flow rates, the sample spends a minimal amount of time within the inlet. So, to efficiently and reproducibly get a representative amount of sample onto the analytical column, the inlet must vaporize and mix the sample quickly.

Based on its ability to enhance vaporization and mixing of the sample, we recommend starting with a Topaz Precision split liner with wool (Figure 8). This liner contains deactivated glass wool that is placed in the same location within every liner and held there by dimples on the inside of the liner. The wool enhances vaporization and mixing of the sample by increasing surface area, and it also wipes the syringe needle during injection to increase repeatability. With Topaz inlet liners the wool is deactivated in situ, making for a very inert liner, which will work well for most split injection applications.

Figure 8: Restek Topaz Precision liner with wool for Agilent GCs. (cat.# 23305)

Splitless Injections

Splitless injections are used when the compounds of interest in your sample are present at lower levels. With this technique, the split vent is closed at the start of the injection and all the flow passing through the inlet is directed through the column for a programmed period, sometimes known as “purge valve time” or “splitless hold time.” The split vent is then opened to flush out any remaining vaporized solvent. In a proper splitless injection, 99% of your compounds of interest will have been transferred onto the GC column.

With splitless injection, we recommend first trying the Topaz single taper liner with wool (Figure 9). The single taper at the bottom of the liner limits the interaction of the analytes of interest with the metal inlet seal and helps direct or focus the sample to the head of the column. The wool catches the injected sample, assisting in vaporization, while also trapping nonvolatile “dirt” that can contaminate the expensive GC column. With Topaz liners, the wool is deactivated in situ, creating a very inert liner, which is often needed when the compounds of interest are found at trace levels within the sample. This liner is a good starting point for the majority of splitless injections.

Figure 9: Restek Topaz single taper liner with wool for Agilent GCs. (cat.# 23303)

Direct Injections

Direct injections are typically used when the compounds of interest in your sample are at trace levels and no contact between the sample and the wool or the inlet bottom seal can be tolerated due to the potential for compound loss through degradation or adsorption. With a direct injection, the sample is injected into a hot inlet allowing the entire sample to be vaporized into the GC column, which is sealed directly to the inlet liner.

A Topaz Uniliner inlet liner is designed with an internal “press-fit” connection at the bottom of the liner, which seals the GC column to the liner so there is no contact between the sample and the metal seal on the bottom of the inlet. Topaz Uniliner inlet liners are made in two configurations. One has a small hole drilled near the top of the liner (Figure 10) while the other variation has a hole drilled near the bottom but above the liner/column seal (Figure 11). If your analytes of interest are semivolatile compounds, or if they could be affected by a tailing solvent peak, use a Topaz Uniliner inlet liner with the hole drilled near the bottom. For aqueous injections or when your compounds of interest elute away from the solvent peak, choose the configuration with the hole drilled near the top.

Figure 10: Restek Topaz Uniliner inlet liner with hole near top for Agilent GCs. (cat.# 23311)

Figure 11: Restek Topaz Uniliner inlet liner with hole near bottom for Agilent GCs. (cat.# 23306)

Gas samples via sample loop injection
Injecting a gaseous sample is fundamentally different than injecting a liquid sample. With a liquid sample, the inlet needs to vaporize the sample so it can be introduced onto the column. For a gas sample, the inlet only needs to move the sample efficiently onto the column.

The best inlet liner for gaseous samples has a small inner diameter (ID) to transfer the gaseous sample to the column in the tightest sample band possible. A Topaz straight liner with a 1.0 mm ID is recommended for the injection of gaseous samples (Figure 12).

Figure 12: Restek Topaz straight liner (1 mm) for Agilent GCs. (cat.# 23333)

Programmable Temperature Vaporization (PTV) Injections
The principle of a PTV inlet is that a sample is injected into a cold inlet. The inlet is then programmed to increase in temperature, often vaporizing the solvent to vent and then increasing in temperature to vaporize the compounds of interest and introduce them onto the column.

There are several manufacturers that offer PTV inlets, and liners for these inlets will vary depending upon the geometry of the inlet. Certain features that almost all PTV liners have include a small inner diameter and baffles or dimples on the inner surface of the liner. These baffles/dimples increase the inner surface area of the liner, providing more space for the sample to adhere to as well as enhancing the heat transfer from the inlet to the sample as the temperature of the inlet increases. When choosing a PTV liner, look for your specific inlet manufacturer, then select a Topaz liner with a small inner diameter that contains at least one baffle or dimple.

Liner Maintenance
Samples can take their toll on the system, so we recommend changing inlet liners 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.

Topaz
INLET LINERS

Restek's Topaz GC Inlet Liners

Restek's Topaz GC inlet liners feature revolutionary technology and inertness to deliver the next level of True Blue Performance:

- **Deactivation**—unbelievably low breakdown for accurate and precise low-level GC analyses.
- **Reproducibility**—unbeatable manufacturing controls and QC testing for superior reliability across compound classes.
- **Productivity**—unparalleled cleanliness for maximized GC uptime and lab throughput.

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