Technical Note 20551

Gas Chromatography Liner Selection Guide

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Key Words
Liner, focus

Abstract
The liner serves an important function in allowing a sample which is injected in the liquid phase to pass into the gaseous phase and onto the GC column. Choosing the most suitable liner from the wide selection available can be confusing. However, with an understanding of how a liner performs its function this selection process can be simplified, ensuring peak shape and method robustness are optimized.

Introduction

When developing a new method, liner selection can be overlooked due to the number of other parameters that need to be considered. Selecting the wrong liner will lead to poor separation, which could be wrongly attributed to another part of the system and can result in lost troubleshooting time.

The role of the liner in a GC system is to form a vessel into which the sample can be injected and heated. This should enable rapid, uniform vaporization of the sample and efficient transfer onto the head of the GC column as a tight band. All this should occur without secondary interactions between the analyte and the wall of the liner. In general, if the sample does not transfer efficiently onto the column, peak tailing or splitting may be seen. This may not be the case for some injections such as PTV or splitless injections, where the transfer takes place over a longer time period. With these injection techniques the aim is to transfer each target analyte onto the column as a narrow band and not the entire sample.

Differences in the chemical and physical properties of samples, injection techniques, injection volume, gas flow rates, and inlet temperature necessitates a range of liners. This allows the appropriate liner to be chosen to enable the efficient transition of the sample from the liquid phase onto the column.

Detailed in this selection guide are the main types of liners with a description of their relative merits, as well as the process of selecting the correct liner for a particular application.

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Internal Diameter

The first parameter to consider when selecting a liner is the vapor volume which will be produced by the sample. When a sample is introduced into a heated liner its volume will increase greatly during vaporization. The amount of this expansion is determined by the solvent used, the temperature of the inlet and the pressure inside the liner.

The liner volume must be sufficient to accommodate the gaseous sample. If the diameter of the liner is too small the sample will expand beyond the capacity of the liner. This will result in sample loss both through the septum purge flow and split line and give disrupted sample transfer onto the column. This will likely be seen as peak tailing and poor peak area reproducibility.

If the diameter of the liner is too large there will be a large dead volume, which will increase the sample transfer time leading to peak tailing. The quartz wool packing in a FocusLiner™ (detailed below) helps prevent this diffusion.

The vapor volume for a sample can easily be calculated by following the calculation in appendix A. The table provides vapor volumes for common GC solvents at different temperatures and pressures.

Split and Splitless Liners

After ensuring the correct internal diameter has been selected for your liner the next thing to consider is what type of injection is going to be used. Thermo Scientific FOCUS and TRACE instruments recommend different liners for split and splitless injections. This is generally not required with the Thermo Scientific TRACE 1300/1310 and some other manufacturer's instruments, although specific split and splitless liners are available.

Split liners are typically open ended at the bottom (Figure 1) This enables the split flow to pass across the bottom of the liner removing a portion of the sample allowing a split injection to be performed. Consult your GC manual for correct column insertion distance.

Figure 1: Thermo Scientific Split Liner 5 mm x 105 mm

Splitless liners are typically tapered at the bottom (Figure 2) with the column inserted into the taper. This helps to funnel the sample onto the column and minimizes sample contact with reactive metal components in the inlet during the time the split flow is off during splitless injection. Consult the GC instrument manual for correct column insertion distances.

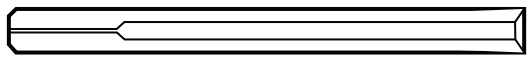


Figure 2: Thermo Scientific Splitless Liner 5 mm x 105 mm

Shown in Figure 3 is a comparison using a splitless and split liner in a splitless injection with a sample of alkanes. Notice how the peak shape and height of the early eluting (more volatile) compounds is severely affected when using the incorrect (split) liner. This is caused by poor sample transfer onto the column for the more volatile compounds. The taper in a splitless liner helps funnel the sample onto the column. If a split liner is installed this does not occur meaning sample transfer occurs over a longer time period resulting in peak tailing.

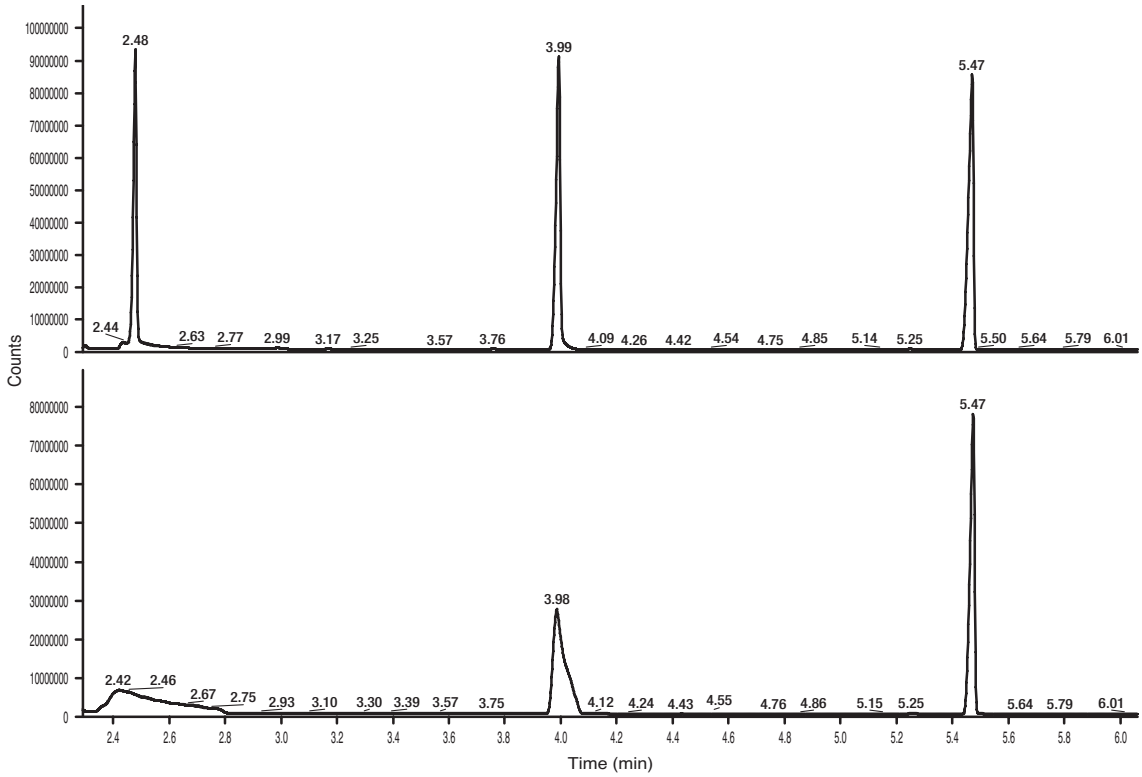


Figure 3: The effect of using the wrong liner in splitless mode (n-alkanes). Top chromatogram, splitless (correct) liner, bottom chromatogram split (incorrect) liner

Packed Liners

Once the liner for the appropriate injection technique has been selected the final consideration is whether to use a packed or unpacked liner.

Liners are available packed with deactivated quartz wool, named FocusLiner, or without a packing material. FocusLiners are available with and without tapers for split and splitless injections. It is recommended to use a FocusLiner for most methods as this will give good peak shapes and injection reproducibility with little low or high boiling point discrimination.

The first part of the vaporization process involves the liquid sample forming an aerosol, this then becomes gaseous due to the high temperature of the injector. If the aerosol reaches the column before becoming gaseous, poor sample transfer will occur. When a sample is injected into a FocusLiner the sample is deposited onto the quartz wool packing, this increases the surface area for vaporization and ensures the sample is fully vaporized before it reaches the column. This improved vaporization gives more reproducible injections with little boiling point discrimination.

The position of the quartz wool in the liner can also help improve sample transfer. The wool can be positioned such that the needle enters the packing and injects inside it, or so the tip of the needle stops above the packing and injects onto it (see Figure 4). The advantage of injecting inside the packing is that the needle tip is wiped as the needle is removed, thus any droplets formed on the needle are removed, improving injection reproducibility.

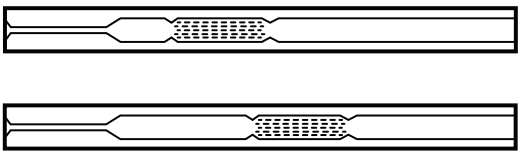


Figure 4: Example of Thermo Scientific Splitless FocusLiners 5 x 105 mm, note the different positions of the quartz wool packing

If the samples being analyzed contain solid particles the quartz wool will trap these particles and stop them contaminating or blocking the column. However any particles trapped in the liner may be seen as carryover in subsequent injections.

To prevent the quartz wool packing moving when the needle is inserted, Thermo Scientific FocusLiners hold the packing in place using baffles. This gives more reproducible injections over the lifetime of the liner.

While FocusLiners are less active than manually packed liners they may not be suitable for the analysis of very active compounds. CarboFrit liners may be more appropriate (see below) for these compounds.

Unpacked Liners

Unpacked liners are cheaper than FocusLiners and can be cleaned for repeated use. Cleaning of liners can lead to increased activity within the liner, which can cause their performance to deteriorate and is generally not recommended.

Unpacked liners tend to exhibit more low and high boiling point discrimination. This may be seen as low injection reproducibility.

An unpacked liner may show advantages over a FocusLiner when analyzing very active samples, such as some pesticides. The quartz wool packing may show an increase in activity for such compounds giving rise to breakdown products.

Other Liner Styles

Tapered Liners

Tapered liners have a constriction at the end of the liner. Tapered liners are available for TRACE 1300/1310 instrument and other manufacturer's instruments (many of these instruments do not require different liners for split and splitless injections). The tapers can be at one or both ends (see Figures 5 and 6). The advantage of a taper at the bottom is to prevent contact with the inlet base seal. This helps reduce activity for active compounds. A double taper (top and bottom) helps to contain the vapor cloud preventing loss of sample from the top of the liner and out through the purge flow.

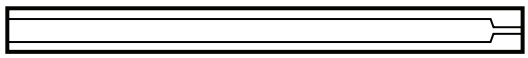


Figure 5: Thermo Scientific liner for TRACE 1300/1310 and Agilent Split/Splitless inlet, Single Taper 4 x 78.5 mm internal dimension (P/N 453A1345)

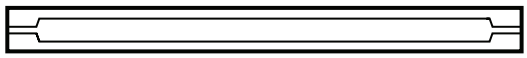


Figure 6: Thermo Scientific liner for TRACE 1300/1310 and Agilent Split/Splitless inlet, Double Taper 4 x 78.5 mm internal dimension (P/N 453A1355)

Both types of tapered liner will reduce high boiling point discrimination, but low boiling point discrimination can still occur. Using a FocusLiner will reduce both high and low boiling point discrimination.

Siltek coated liners

Siltek liners are suitable for use with very active compounds such as pesticides. They provide an even more highly inert surface than the normal deactivation process. These can be be particularly useful for the analysis of very labile compounds e.g. endrin. These liners are available in both split and splitless formats.

CarboFrit Liners

Carbofrit liners offer the same advantages as FocusLiners, but with higher inertness and higher temperature stability. They also have a Siltek coating so may be used with highly labile compounds.

Baffled PTV Liners

For the PTV inlet, baffled liners are available. The baffles create a turbulent flow improving sample mixing in the inlet improving injection reproducibility. These may not be suitable for samples with high boiling points as incomplete vaporization can occur.

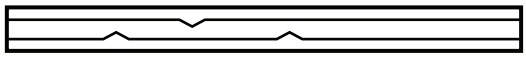


Figure 7: Thermo Scientific PTV liner with 3 baffles 1 x 120 mm internal dimensions (P/N 45352062)

PTV Silcosteel Liner for On-Column (OC)

These liners allow simile OC injections to be performed. The column (0.53 mm internal diameter) is inserted into the liner until it reaches a constriction within the liner, the syringe is guided into the column by the liner where the sample is injected. The sample does not contact the liner and the entire sample enters the column.

These liners are typically used when performing simulated distillation analysis.

Summary

When selecting a liner the first factors to consider are:

- Vapor volume
- Injection method, split or splitless

As a general rule using a FocusLiner will give the greatest injection reproducibility and symmetrical peak shape, improving sensitivity, these liners should be used as a first choice.

If highly active compounds are used straight liners may give a reduced number of breakdown products, however if poor peak shape is observed consider the use of Siltek coated or CarboFrit liners.

The appendices contains a vapor volume calculation and a quick liner selection table suitable for use with Thermo Scientific TRACE and FOCUS and Agilent instruments.

Appendix A

Calculating Vapor Volume

The vapor volume produced by a solvent is dependent on the temperature, pressure and volume of solvent injected. To calculate the vapor volume produced by a sample use the ideal gas equation:

$$\text{Vapor Volume (mL)} = \frac{(V \times D / MW) \times R \times T}{P_a + P_i} \times 1\,000\,000$$

Where:

- V = sample volume (mL)
- D = solvent density (g/mL @20 °C)
- MW = molecular weight of the solvent (Da)
- R = Boltzman gas constant (8.314462)
- T = inlet temperature (° K)
- P_a = atmospheric pressure (Pa)
- P_i = inlet pressure (Pa)

For a 1 µL injection of hexane at 300 °C and 66KPa the formula would be as follows:

$$\text{Vapor volume(mL)} = \frac{(0.001 \times 0.659/86) \times 8.314462 \times 573}{101325 + 66000} \times 1\,000\,000$$

$$(= 0.22)$$

Shown in Figure 8 are vapor volumes for a 1 µL injection of common GC solvents at typical flow rates and inlet temperatures. These can be compared with liner volumes given in Figure 9 to assess the correct liner for an application.

Solvent	Inlet Pressure (KPa)	Inlet Temperature (°C)				
		100	150	200	250	300
Water (B.P. = 100 °C)	66	-	1.17	1.30	1.44	1.58
	83	-	1.06	1.18	1.31	1.43
	105	-	0.95	1.06	1.17	1.28
Methanol (B.P. = 65 °C)	66	-	0.52	0.58	0.64	0.70
	83	-	0.47	0.53	0.58	0.64
	105	-	0.42	0.47	0.52	0.57
Acetonitrile (B.P. = 82 °C)	66	-	0.40	0.45	0.50	0.55
	83	-	0.37	0.41	0.45	0.50
	105	-	0.33	0.37	0.40	0.44
DCM (B.P. = 40 °C)	66	0.29	0.33	0.37	0.41	0.44
	83	0.26	0.30	0.33	0.37	0.40
	105	0.23	0.27	0.30	0.33	0.36
Ethyl Acetate (B.P. = 77 °C)	66	-	0.21	0.24	0.27	0.29
	83	-	0.20	0.22	0.24	0.26
	105	-	0.17	0.19	0.22	0.24
Toluene (B.P. = 111 °C)	66	-	0.20	0.22	0.24	0.27
	83	-	0.18	0.20	0.22	0.24
	105	-	0.16	0.18	0.20	0.22
Pentane (B.P. = 36 °C)	66	0.16	0.18	0.20	0.23	0.25
	83	0.15	0.17	0.19	0.21	0.22
	105	0.13	0.15	0.17	0.18	0.20
Hexane (B.P. = 69 °C)	66	-	0.16	0.18	0.20	0.22
	83	-	0.15	0.16	0.18	0.20
	105	-	0.13	0.15	0.16	0.18

Figure 8: Solvent Vapor Volumes for GC solvents in mL under various conditions

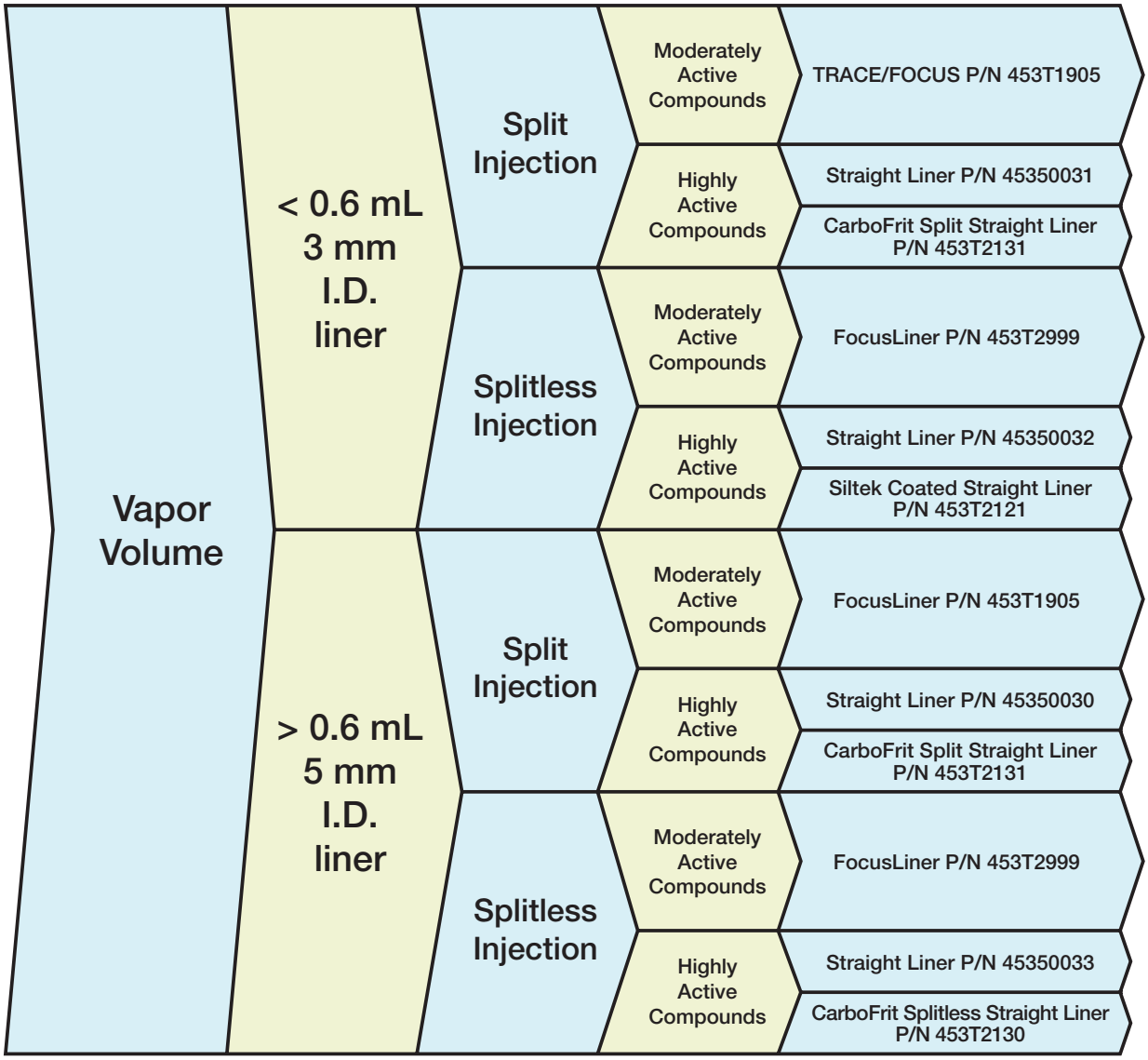
Approximate liner volume (baffles and tapers not taken account for)	
TRACE and FOCUS 5 mm I.D. x 105 mm liner =	1.60 mL
TRACE and FOCUS 3 mm I.D. x 105 mm liner =	0.74 mL
TRACE 1300/1310 and Agilent 4 mm I.D. x 78.5 mm =	0.98 mL
TRACE 1300/1310 and Agilent 2.3 mm I.D. x 78.5 mm =	0.32 mL
As a general rule do not exceed 80% of total liner volume	

Figure 9: Approximate liner volumes for Thermo Scientific and Agilent liners

Appendix B

Quick Liner Selection Table for Thermo Scientific TRACE and FOCUS instruments

To select a liner for a Thermo Scientific TRACE or FOCUS instrument using a SSL injector use the flow chart below:



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TN20551_E07/12S