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Simplified analysis

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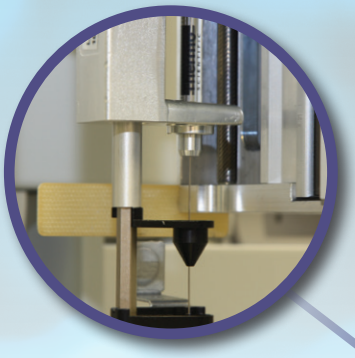
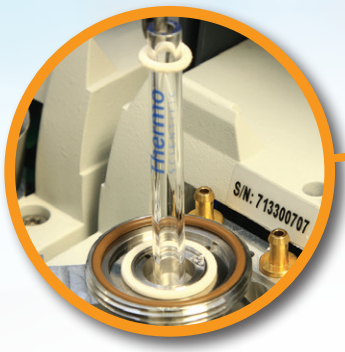
Product Selection Guide

Selection of the correct GC columns and accessories is critical to ensure optimum system performance. The selection guide below is designed to simplify this process

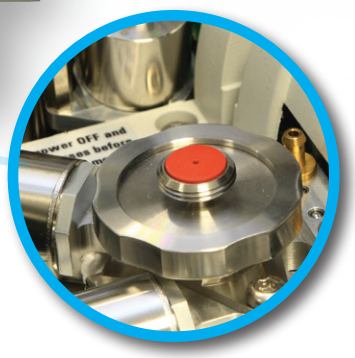


GC Syringes

Vials and Closures

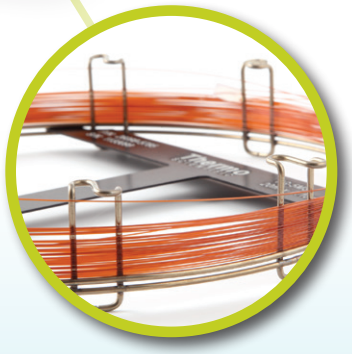


GC Liners



GC Septa

GC Ferrules



GC Columns

Thermo Scientific GC consumables are available for both Thermo Scientific and Agilent instruments.

Vials and Closures

Nature of Sample	Vial Type Recommended
Routine samples	Clear glass (with or without patch) as SureStop 9mm screw thread or 11mm crimp vial
Light sensitive samples	Amber glass (with or without patch) as SureStop 9mm screw thread or 11mm crimp vial
Low volume samples	Micro-Inserts or Microsampling and High Recovery vials with fixed inserts or reduced internal volume
Trace levels	Silanized glass and/or Certified Kits
Ultra Trace MS analysis	MSCERT kits: The first low particle, low background chromatography vials, pre-cleaned to provide unmatched consistency; tested and certified for up to 15 critical physical characteristics affecting vial performance for mass spectrometry

GC Septa

Material	Max Operating Temperature	Key Features
BTO	400 °C (330 °C for 17 mm size)	Low bleed
TR-Green	350 °C	Long lifetime
Marathon	350 °C	High mechanical durability
TR-Blue	200–250 °C	Easy to penetrate for routine applications

GC Liners

Injection Method	Injection Requirements	Liner Requirements
Split	Enables rapid vaporization and effective mixing of sample	• Typically open-ended • Large surface area and volume • Design to aid mixing • Low activity
Splitless 	Sample focused onto column – minimizes sample contact with catalytic metal components	• Typically tapered • Small volume to aid transfer • Low activity
PTV	Rapid heating and cooling, fast transfer to column-used for active compounds such as pesticides and large volume injections	• Small to aid sample transfer • Good thermal properties for rapid heating and cooling

GC Syringes

Syringe Selection by Needle Tip Style

Needle Tip Style	Features / Applications
Cone (Tapered tip)	Most versatile needle for autosampler use and resist coring of vial and inlet septa
Bevel (Sharp tip)	Typically used for manual injections. The tip shape helps reduce septa coring
Side Hole (Dome tip with a side hole for sample exit)	Usually used for headspace and large volume injections
Blunt End or 90° (flat top)	Used for injectors that do not contain an inlet septa such as Merlin MicroSeal™
Dual Gauge 	Narrow gauge part suitable for megabore on-column injection. Wider part suitable for autosampler use

Syringe Selection by Needle Gauge Size

- Gauge is a measure of the "thickness" of the needle
- The higher the gauge number, the thinner the needle e.g. a 23 gauge is thicker than a 26 gauge
- Suffix "s" e.g. 23s refers to a needle with a narrower internal diameter
- For on-column injection ensure that the column ID is greater than the needle gauge

GC Ferrules

Material	Uses	Advantages	Limitations
100% Graphite	FID, NPD, high temperature	• Easy-to-use stable seal • Higher temperature limit • Can be easily removed • Can be re-used	• Not for MS or oxygen-sensitive detectors • Soft, easily deformed or destroyed • Possible system contamination
85% Vespel / 15% Graphite	MS and oxygen-sensitive detectors	• Long lifetime • High temperature limit • MS compatible	• Cannot be re-used • Must be re-tightened after initial temperature cycles
SilTite™ Metal	MS and oxygen-sensitive detectors	• Long lifetime • High temperature limit • MS compatible	• Cannot be re-used - column must be cut to remove

GC Columns

Column Parameter	Parameters Affecting Resolution			Performance Changes
	Efficiency	Retention	Selectivity	
Column Length (m)	✔			Doubling column length increases resolution by ~ 40%
Internal Diameter (mm)	✔			The smaller the column ID, the greater the efficiency and better the resolution
Film Thickness (µm)		✔		The thicker the film, the greater the retention, e.g. ideal for highly volatile compounds. The thinner the film, the sharper the peaks and lower the bleed
Stationary Phase Chemistry			✔	Altering the stationary phase can affect elution order and help separate closely, or co-eluting peaks

Syringes

The syringe plays an important role in the GC system as it takes the sample from the vial and introduces it into the inlet. There is a lot of scope for error when selecting the correct syringe due to a wide range of inlets from different manufacturers and the wide range of autosampling devices available.

Once the correct syringe for the inlet and the autosampler has been selected, further parameters such as needle gauge and tip style need to be considered

Needle gauge selection

- Needle gauge is a measure of the “thickness” of the needle
- The higher the number, the thinner the needle e.g. 26 gauge is thinner than 23 gauge
- A suffix “s” e.g. 23s refers to a needle with a narrower internal diameter
- Use the thickest needle possible without breaking the column

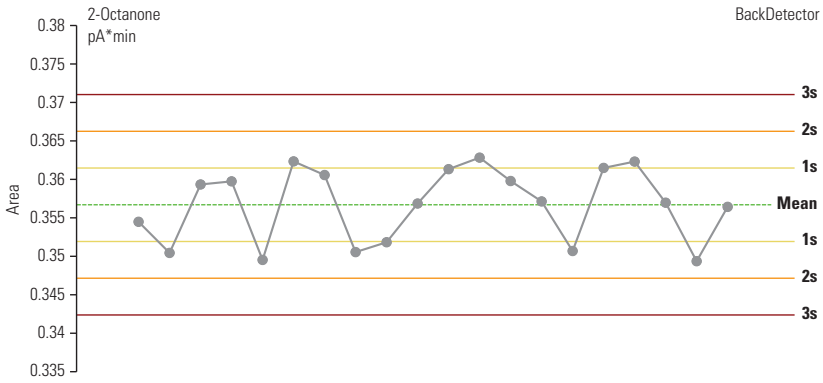
Needle type selection

Needle Tip Style	Features / Applications
Cone (Tapered tip) **# 1'C'** 	Most versatile needle for autosampler use resists coring of vial and inlet septa
Bevel (Sharp tip) **#2 'BV'** 	Typically used for manual injections. The tip shape helps reduce septa coring
Side Hole (Dome tip with a side hole for sample exit) **#5 'H'** 	Usually used for headspace and large volume injections
Blunt End or 90° (flat top) **#3 'LC'** 	Used for injectors that do not contain an inlet septa such as Merlin MicroSeal™
Dual Gauge 	Narrow gauge part suitable for megabore on-column injection. Wider part suitable for autosampler use

Syringe injection volume

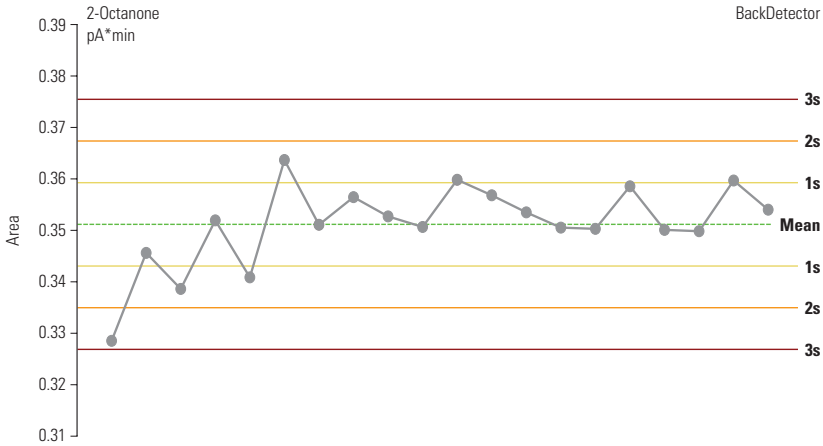
For optimum performance from a GC syringe, it is recommended that the injection volume be at least 10% of the volume of the syringe. To demonstrate, this, an injection volume of 1µL was replacated 20 times for different syringe volumes, using a 10ppm (10µg/mL) modified Grob mix in iso-octane. The graphs show the peak area for 2-Octanone.

5µL syringe



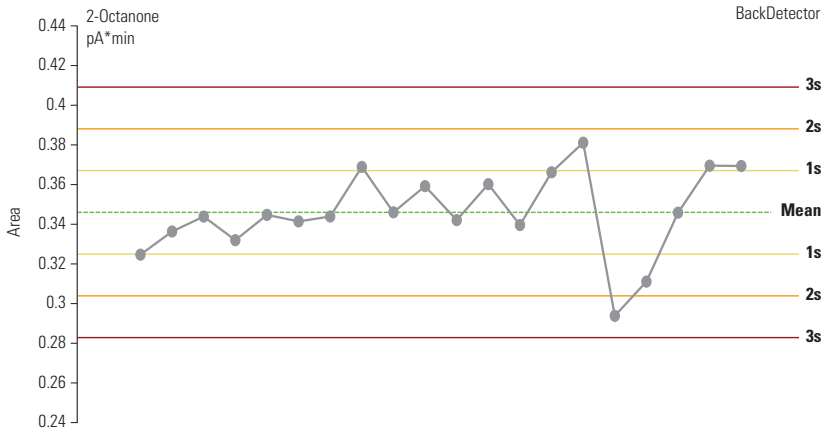
Analyte	2-Octanone	1-Octanone	2,6-DMP	2,6-DMA	Naphthalene	Dodecane	Tridecane
Mean (pA/min)	0.357	0.376	0.378	0.405	0.431	0.540	0.427
Stdev	0.005	0.005	0.005	0.006	0.007	0.008	0.007
RSD (%)	1.339	1.336	1.452	1.403	1.655	1.429	1.727
Max area (pA/min)	0.363	0.384	0.385	0.413	0.444	0.550	0.440
Min area (pA/min)	0.349	0.368	0.369	0.397	0.420	0.528	0.416
Max % deviation	3.711	4.115	4.115	3.735	5.286	4.062	5.545

10µL syringe



Analyte	2-Octanone	1-Octanone	2,6-DMP	2,6-DMA	Naphthalene	Dodecane	Tridecane
Mean (pA/min)	0.351	0.371	0.373	0.402	0.424	0.534	0.419
Stdev	0.008	0.009	0.009	0.009	0.010	0.012	0.010
RSD (%)	2.306	2.334	2.532	2.230	2.410	2.235	2.425
Max area (pA/min)	0.364	0.383	0.386	0.414	0.437	0.551	0.433
Min area (pA/min)	0.329	0.345	0.345	0.376	0.394	0.500	0.390
Max % deviation	9.664	10.045	10.46	9.397	9.919	9.346	9.930

25µL syringe



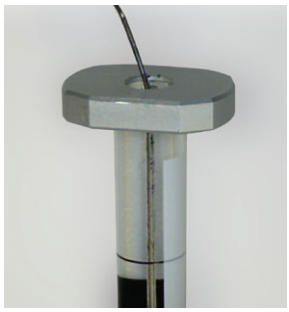
Analyte	2-Octanone	1-Octanone	2,6-DMP	2,6-DMA	Naphthalene	Dodecane	Tridecane
Mean (pA/min)	0.346	0.340	0.367	0.395	0.415	0.525	0.411
Stdev	0.021	0.022	0.022	0.023	0.024	0.031	0.024
RSD (%)	6.083	6.577	5.986	5.842	5.892	5.885	5.850
Max area (pA/min)	0.381	0.379	0.405	0.434	0.457	0.578	0.451
Min area (pA/min)	0.294	0.287	0.312	0.337	0.353	0.447	0.350
Max % deviation	22.902	24.244	22.950	22.462	22.607	22.682	22.459

Syringe care and maintenance

Syringe lifetimes can be significantly improved by adhering to the maintenance procedures and good practice guidelines shown below:

- Wash syringes daily with a solvent the intended samples are soluble in, such as methanol or acetonitrile
- After using a syringe, always rinse with 3 to 5 volumes of solvent
- Avoid operating the plunger when the syringe is dry
- Never fully submerge the syringe in solvent as adhesives can be damaged
- Do not replace the plunger in a non-gas tight syringe as the plunger and barrel are manufactured together so that they match. Gas-tight syringe plungers can be replaced

Examples of syringes at end-of-use



Insoluble particulates in the samples can block syringes after repeated use, as shown here.

Effective rinsing of the syringe between injections is critical as is submission of particulate free sample solutions – pre filtration of samples can be performed.

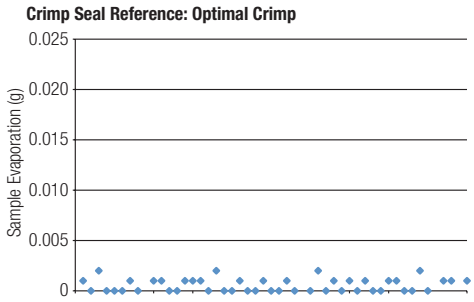
AVCS Closures and SureStop Vials

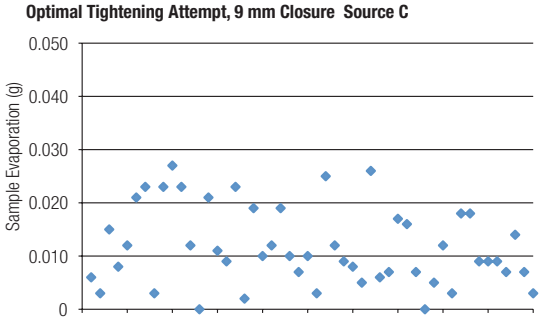
Thermo Scientific™ AVCS Closures and SureStop™ Vials – The next generation of sample handling

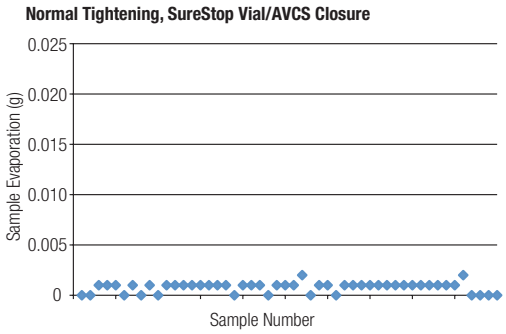
A study of the effects of the typical operator response to evaporative sample loss and septum dislodging during the use of 9 mm screw thread and 11 mm crimp vials and closures was conducted. Sample losses were measured for both overtightened vials and for vials perceived to be optimally tightened and these were compared to losses from new vials designed to provide a definite sealing point.

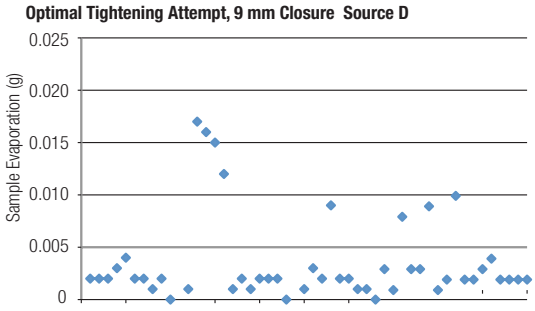
Test conditions

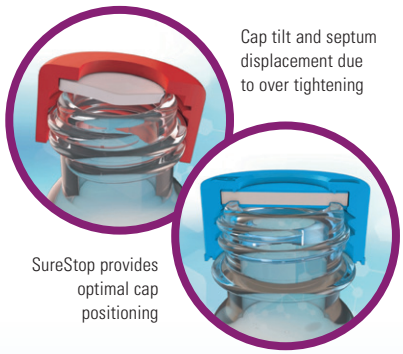
- 1.3 mL of pure methanol was added to each vial (always 50 in total)
- All vials were incubated at a temperature of 40 °C for 72 hours
- After 72 hours the final weight was taken and subtracted from the initial 40 °C temperature weight to yield the sample loss in grams







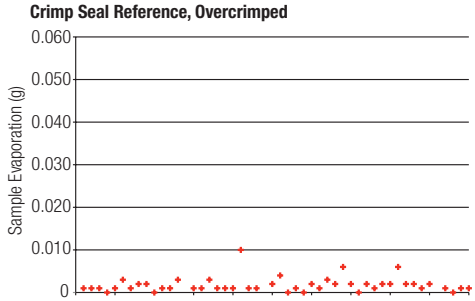


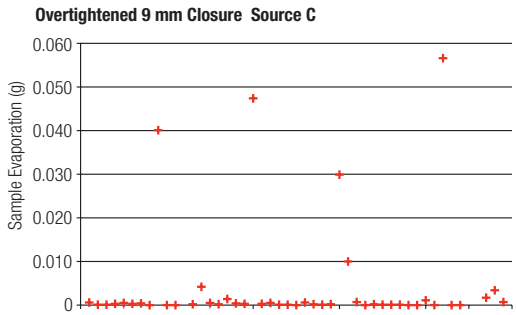


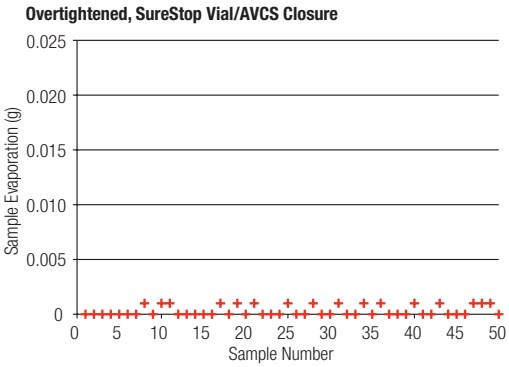
Are you currently using crimp caps?

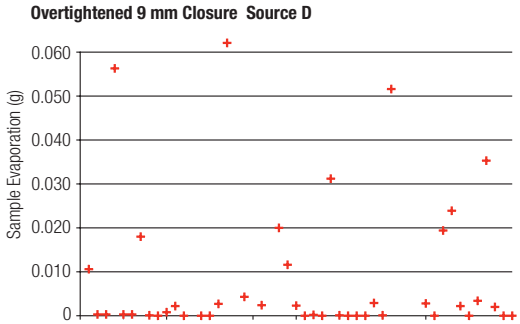
Changing to AVCS closures and SureStop vials will provide the following benefits:

- The hassle of crimping is removed; crimping and de-capping tools are not required. Screw thread closures are easier to attach and remove reducing time required for sample prep. Additionally, there can be repetitive stress issues related to high volume crimping that will be alleviated with screw thread vials
- AVCS closures and SureStop vials offer identical performance to crimp caps (based on solvent loss studies), which make SureStop products a viable alternative for GC use
- AVCS and SureStop provides a "like crimped" product tightness and reliable quantification even for low boiling compounds; you remove user-to-user vial/closure sealing variably that results from user subjectivity of when they "think" the vial is properly sealed









Virtuoso Vial Identification System

Providing the next generation in sample security

From sample entry to final reports, everything an analytical lab does revolves around ensuring accurate data and reliable results. Chromatography vial sample identification can be complicated, because once the sample is in the vial, there is no easy way to identify it. Current methods, like hand written or adhesive labels, can be illegible or time consuming, and no accurate, reliable and efficient system for vial sample identification existed…until now.

The Thermo Scientific™ Virtuoso™ Vial Identification System is the most innovative device for ensuring sample identity and sample security ever developed. By providing a fast, accurate, detailed and reproducible system for producing customized sample information directly onto a vial, Virtuoso has revolutionized vial identification.

Load a single vial, or up to 10 with the included multi-vial sleeve

File management made easy
Virtuoso's network connectivity allows you to transfer label information from your files

Add text and barcodes
Virtuoso comes loaded with templates to make accurate labeling quick and easy, or easily create your own custom format

Input data instantly from the touch screen interface, or via the Pi Gateway Software interface

Start-to-finish in 5 seconds
Fully labeled vial completed in just 5 seconds

Septa

The inlet septa is a key component of sample introduction into a GC system. The purpose of the septa is to provide a barrier that is readily penetrated by the injector needle, while maintaining internal pressure without any contamination of the analysis.

Septa is available in a range of different materials and sizes according to system inlet specifications. They are generally made of high-temperature, low bleed silicone rubber compositions.

Septa is available according to recommended upper temperature limits. Lower temperature materials are generally softer, seal better and can withstand a greater number of injections than higher temperature materials. If septa are used above the recommended temperature limit, they can leak or decompose in the inlet. This can lead to sample losses as the air-tight seal is lost, leading to lower column flow and decreased column lifetime.

Septa is available packaged into both glass jars and individual blister packs

Why septa should be replaced regularly:

- Avoid system leaks
- Reduce sample loss
- Avoid decomposition of septa in system inlet
- Prolong column lifetime

BTO septa after 200+ injections

Septa materials

System Requirement	Recommended Material	Secondary Alternative
Low Bleed	BTO	TR-Green
Long Lifetime	Marathon	TR-Green
High Temperature	BTO	Marathon or TR-Green
Cost-Effective, Low Temperature	TR-Blue	N/A

BTO (Bleed and Temperature Optimized)

- Low bleed, high temperature material
- Optimized for use with GC-MS systems
- Maximum injection port temperature 400°C
- Packaged in both glass jars and individual blister packs for enhanced cleanliness

Marathon

- Long injection lifetime, pre-pierced for minimal coring
- Maximum injection port temperature 350°C
- Up to 400 injections per septa
- Packaged in both glass jars and individual blister packs for enhanced cleanliness

TR-Green

- Long injection life
- Reduced injection port adhesion
- Maximum injection port temperature 350°C
- Packaged in both glass jars and individual blister packs for enhanced cleanliness

TR-Blue

- Ideal for non-demanding, routine applications
- Easy to penetrate
- Maximum injection port temperature 200-250°C
- Packaged into glass jars

Liners

The liner serves an important purpose in the GC system. It allows a sample which is injected in the liquid phase to pass into the gaseous phase and onto the GC column. The elevated temperature used in the inlet vaporizes the liquid sample into a vapor for transfer onto the head of the GC column. There is a significant volume change during this phase transition and the volume of the resulting vapor must be able to be contained within the volume of the liner. If the expansion volume is too large, sample can be lost, leading to poor reproducibility and sensitivity, and backflash can lead to sample carryover in the system.

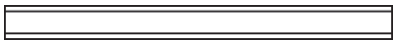
Liner selection is a key aspect for optimum GC system performance. Key considerations in correct selection are:

- Liner ID and geometry
- Type of injection
- Liner packing materials
- Liner treatment or deactivation

Why liners should be replaced regularly

- Maintain consistent reproducibility
- Avoid peak shape degradation
- Avoid sample decomposition
- Avoid ghost peaks

Liner ID and geometry



A split/straight liner 4mm ID × 78.5 mm length has a volume of 986 µL.
A number of factors reduce the effective volume of the liner:

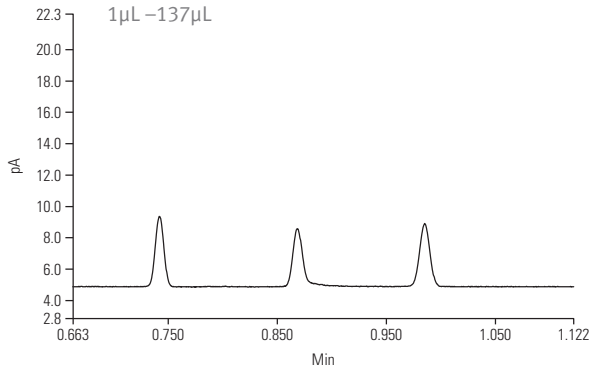
- Tapers, baffles and other liner features
- Packing materials
- Carrier gas

As a rule, the vapor cloud formed by the sample should not exceed half of the total volume of the liner. The expansion volume of solvents limits the injection volume. Solvents with low densities and high molar mass are more desirable – they increase the volume of solvent which can be injected and lower detection limits.

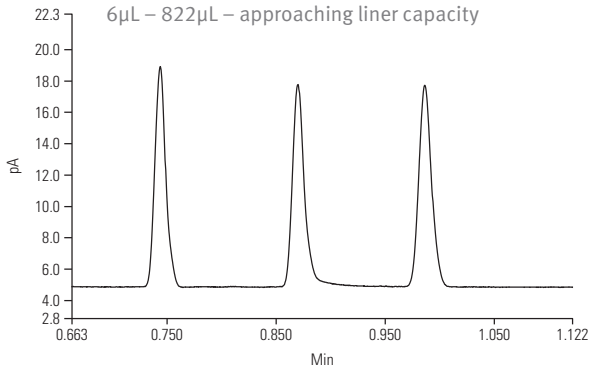
To show the effects of solvents on injection volume, different solvents were injected onto a straight liner:

Iso-octane

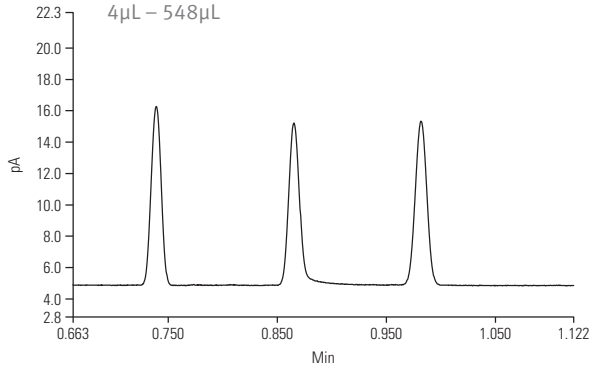
1µL –137µL



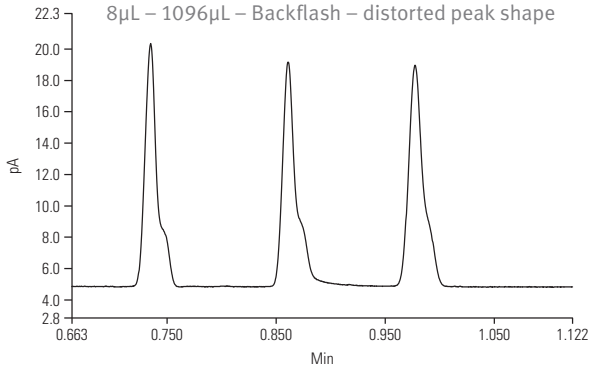
6µL – 822µL – approaching liner capacity



4µL – 548µL

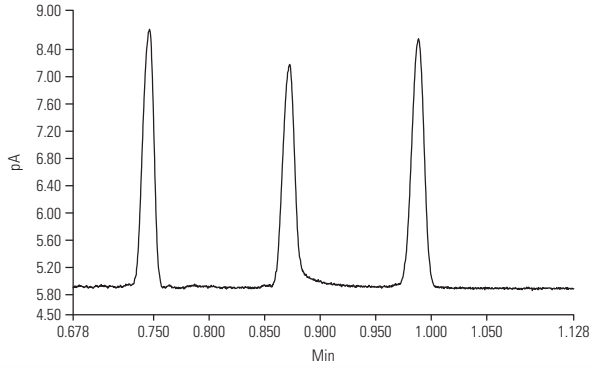


8µL – 1096µL – Backflash – distorted peak shape

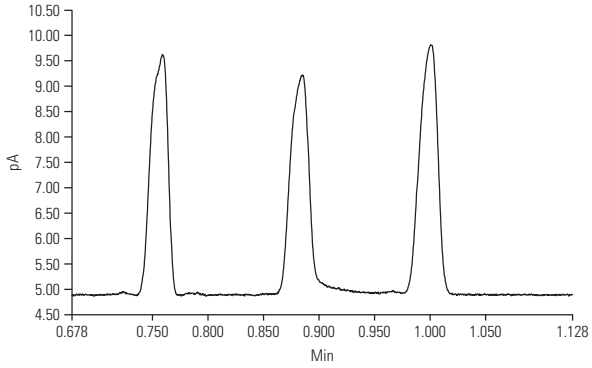


Dichloromethane

1µL – 353µL: - good peak shape, vapor cloud is below half of total liner volume.

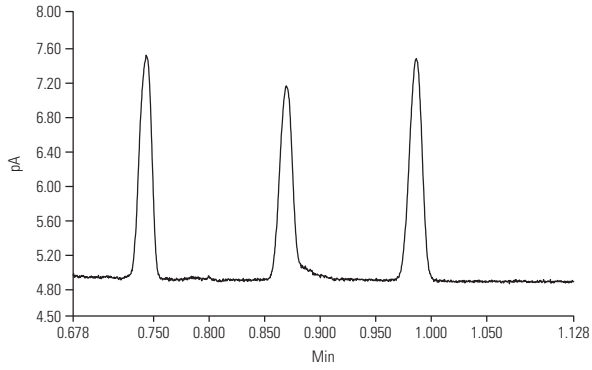


2µL – 706µL: - distorted peak shape, vapor cloud is well above half of liner volume (493µL)

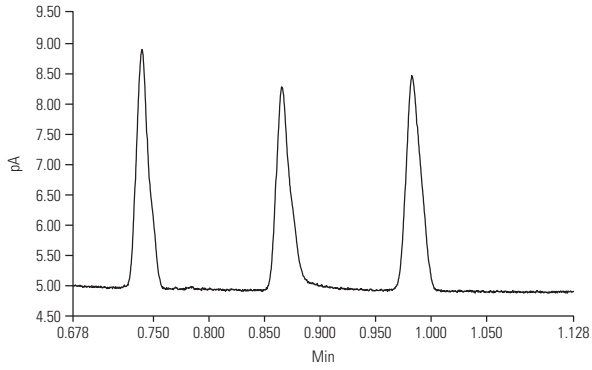


Acetonitrile

1µL – 432µL: - peak shape is ok, but vapor cloud is on the limit of half total liner volume.



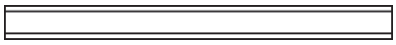
2µL – 864µL: - distorted peak shape, vapor cloud is well above half of liner volume (493µL)



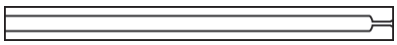
Type of injection

The type of injection is a key consideration in selecting the correct liner.

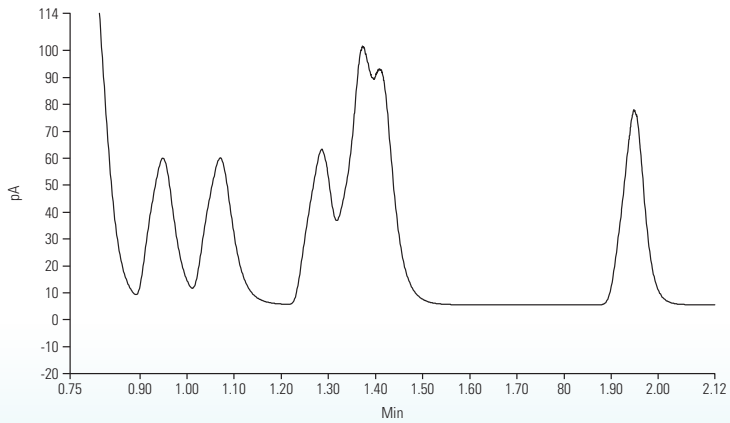
Split liners are typically open-ended at the bottom to enable the split flow to pass across the bottom of the liner, removing a portion of the sample. This allows a split injection to be performed.



Splitless liners are typically tapered at the bottom 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.

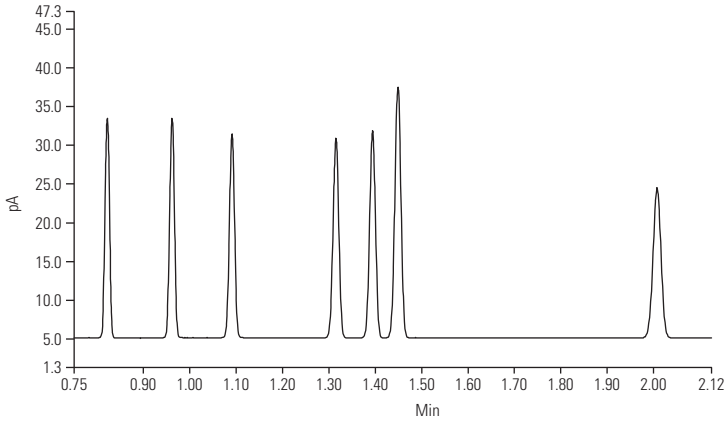


Incorrect liner choice



Inlet Mode	Split 50:1 – Split/Splitless FocusLiner with single taper (P/N 453A1315)
Septum Purge Flow	5.000 [ml/min]
Inlet Temp.	250 [°C]
Column	TG-5SilMS GC Column 15 m × 0.25 mm × 0.25 µm (P/N 26096-1300)
Column Flow	1.500 [ml/min]
Oven Temp.	130.0 [°C] - Isothermal
Detector	FID
Data Collection Rate	50 [Hz]
Oxidizer gas Flow - Air	350.0 [ml/min]
Makeup gas Flow - N2	35.0 [ml/min]
Fuel Gas Flow - H2	35.0 [ml/min]
Detector Temp.	300 [°C]

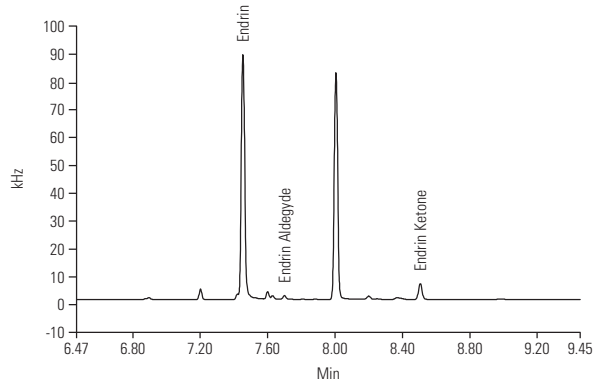
Correct liner choice

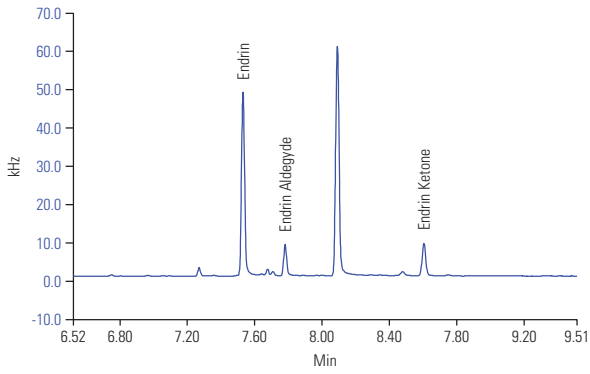


Inlet Mode	Split 50:1 – Split/Splitless FocusLiner - (P/N 453A1255)
Septum Purge Flow	5.000 [ml/min]
Inlet Temp.	250 [°C]
Column	TG-5SilMS GC Column - 15m x 0.25mm x 0.25µm - (P/N 26096-1300)
Column Flow	1.500 [ml/min]
Oven Temp.	130.0 [°C] - Isothermal
Detector	FID
Data CollecHon Rate	50 [Hz]
Oxidizer gas Flow - Air	350.0 [ml/min]
Makeup gas Flow - N_2	35.0 [ml/min]
Fuel Gas Flow - H_2	35.0 [ml/min]
Detector Temp.	300 [°C]

Liner packing

Both chromatograms show the 50th injection of an Endrin/DDT standard. The left chromatogram is an empty deactivated liner and the right chromatogram is from a packed deactivated liner.

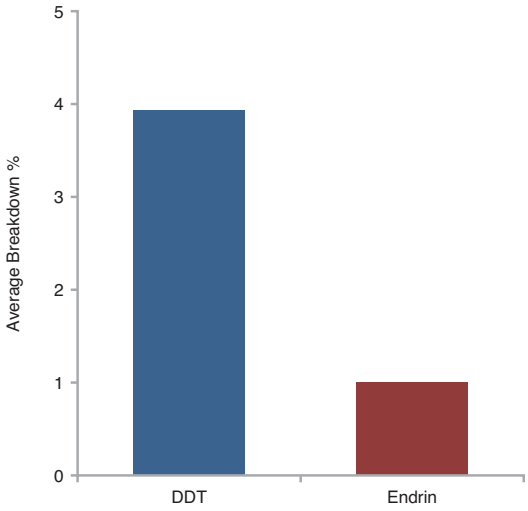




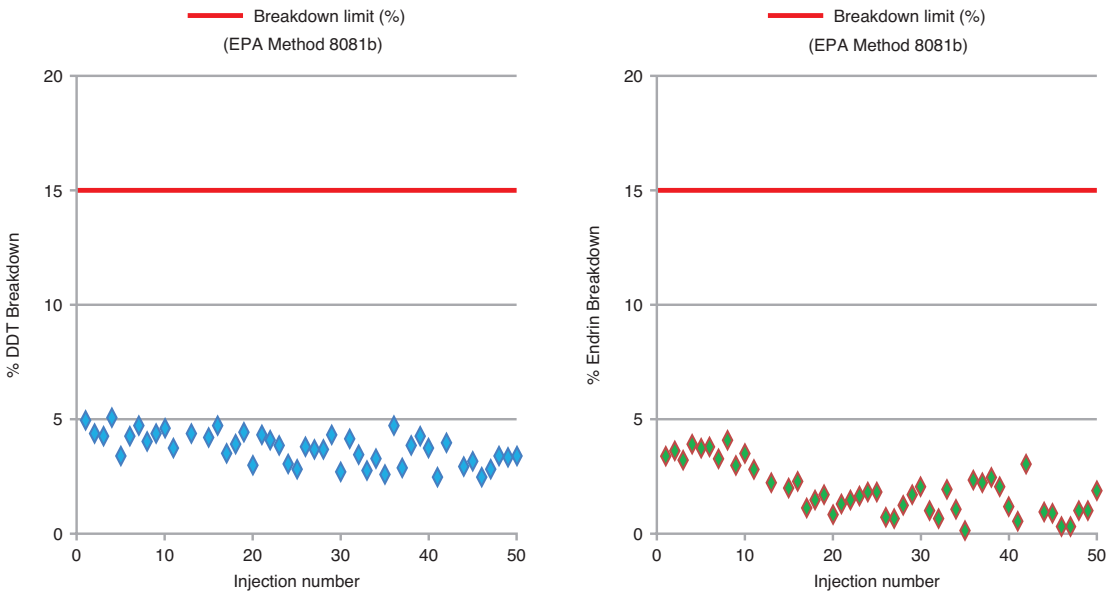
Active sites on inlet liners can adsorb sample components and cause peak tailing. This can lead to a loss of sensitivity and reproducibility. Active sites can also cause certain classes of compounds to degrade.

Liner deactivation

Thermo Scientific™ LinerGOLD™ GC liners provide enhanced inertness for a wide range of compounds. Using a unique, state-of-the-art deactivation process, they provide enhanced transfer of the sample to the GC column, leading to increased accuracy and precision in analysis. This enables lower detection limits for active compounds.



Endrin and DDT breakdown test results showing the lot-to-lot reproducibility and low levels of inertness of LinerGOLD



Compound degradation after 50 injections – LinerGOLD exhibits minimal breakdown

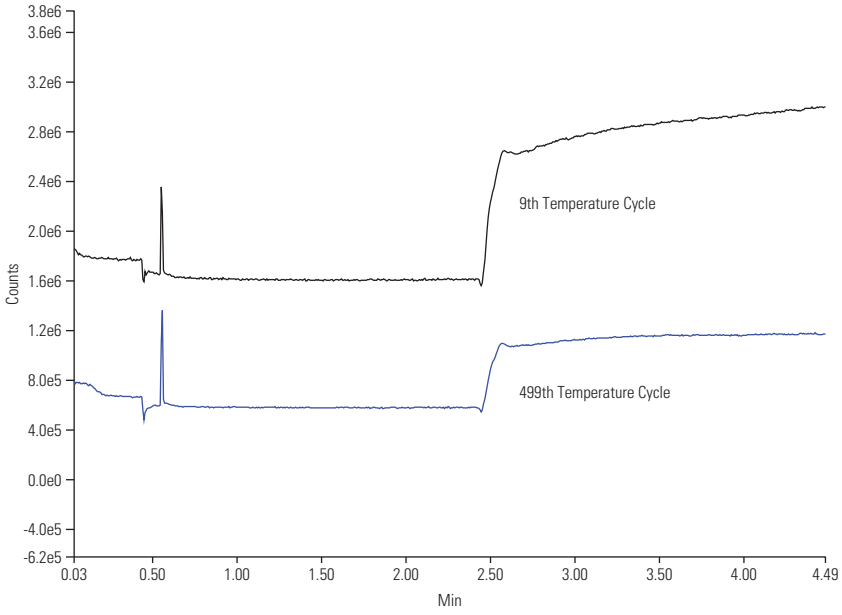
Connectors

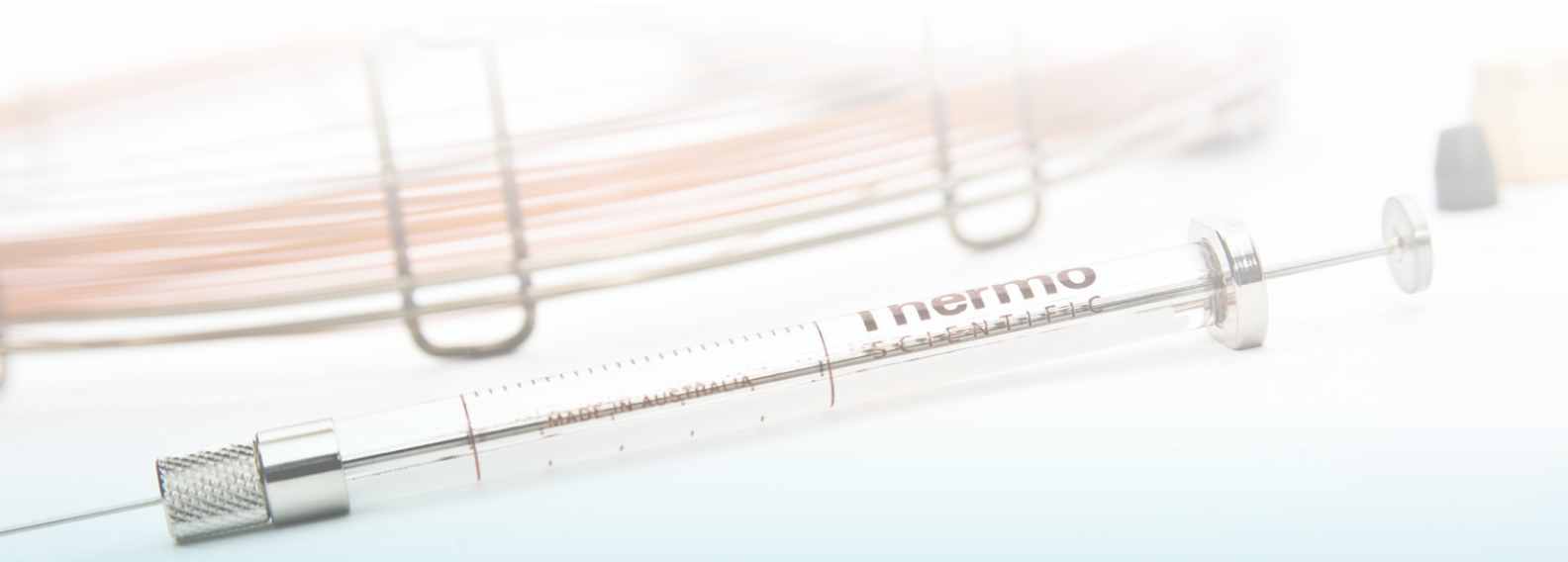
SilTite µ-Union

The SilTite µ-Union is a connector for GC capillary columns, giving zero dead volume. The product has low thermal mass – it is only 9mm in length and has a mass <0.5g. It is available in kits to connect columns from 0.1mm ID to 0.53mm ID.

- Zero dead volume – giving optimized peak shapes
- FingerTite technology – easy to install and leak-free
- Highly inert and robust

To demonstrate how the SilTite µ-Union is leak-free, the device was cycled 500 times in an oven from 100°C to 280°C. The graphs below show no leaks during the 9th and 499th cycle.



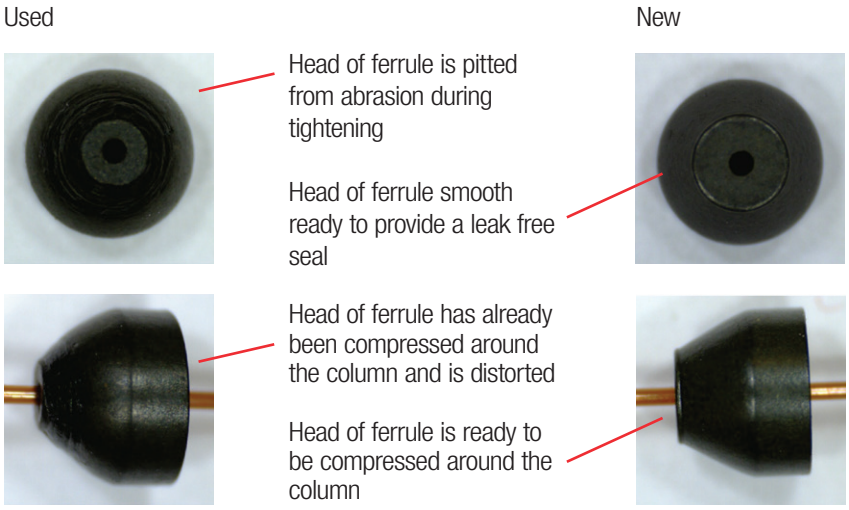


Ferrules

The purpose of the ferrule is to seal the connection of the column or liner to the GC system. Using the wrong ferrule or a poor-quality ferrule to seal your column can result in inconsistent and unreliable chromatography. Leaks caused by incorrect ferrules allow air and contaminants to enter the system, causing interferences with the column and detector. To ensure optimum system performance, the ferrule should be replaced every time the column is replaced and when performing column maintenance.

Material	Uses	Advantages	Limitations
100% Graphite	FID, NPD	• Easy-to-use stable seal • Higher temperature limit • Can be easily removed • Can be re-used	• Not for MS or oxygen-sensitive detectors • Soft, easily deformed or destroyed Possible system contamination
85% Vespel/15% Graphite	MS and oxygen-sensitive detectors	• Long lifetime • High temperature limit • MS compatible	• Cannot be re-used • Must be re-tightened after initial temperature cycle
SilTite Metal	MS and oxygen-sensitive detectors	• Long lifetime • High temperature limit • MS compatible	• Cannot be re-used

When to change a ferrule



Minimizing problems associated with ferrules

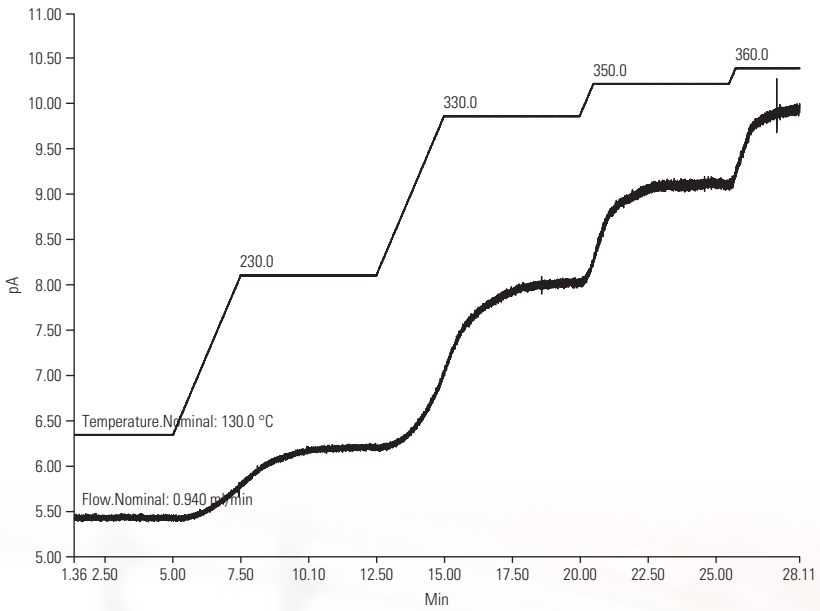
- Don't overtighten them
- Ensure ferrule is clean prior to use and avoid any contamination before and during use
- Bake out ferrule prior to use
- Change ferrule when new column is installed or injector/detector parts are installed
- Use the correct ferrule for the column size being installed

GC Columns

The GC column is the device that carries out the separation. In order to optimize the separation, there are a number of parameters that can be changed:

- Column length
- Column inner diameter (I.D.)
- Film thickness
- Phase chemistry

A GC column is generally specified with two maximum operating temperatures, the isothermal limit at which the column may be run continuously and a programmed maximum where the column reaches a maximum for a limited time period only. There is also a minimum temperature below which a column will perform poorly. Over time, if a column is run continuously at the upper limit of temperature, column bleed will be observed. This is the normal background signal caused by stationary phase degradation and increases with increasing film thickness and column dimensions. It is therefore important to minimize bleed effects by minimizing the use of columns at upper limits of temperature.



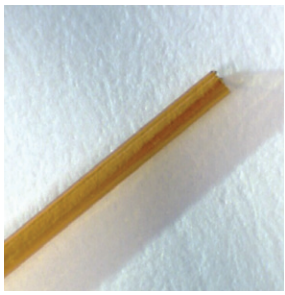
Maximum temperature limits for a typical GC column

As the column reaches its isothermal limit, there is an increase in the bleed levels observed. This bleed further increases as the programmed maximum operating temperature is reached.

Temperature range (°C)	Bleed increase (pA/°C)
130–230	0.008
230–330	0.018
330–350	0.055
350–360	0.090

The positioning of the ends of the column in the injector and in the detector is critical for optimum performance and the quality of the cut ends of the column may also affect performance. If in doubt use a magnifier to check the cut ends of column for a clean square cut.

Snapped column – high level of increased activity due to higher exposure of active silica



Cut with rough ceramic edge – increased activity due to higher exposure to active silica

Single flick – increased activity due to higher exposure to active silica

Good cut – low exposure to active, optimal cross sectional shape leading to even loading onto column

The positioning of the ends of the column in the injector and in the detector is critical for optimum performance and the quality of the cut ends of the column may also affect performance. If in doubt use a magnifier to check the cut ends of column for a clean square cut.

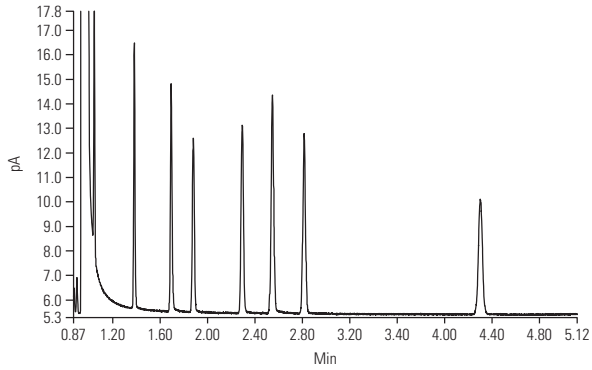
Altering GC column performance

A number of parameters can be changed to adjust GC column performance

Column Parameter	Parameters Affecting Resolution			Performance Changes
	Efficiency	Retention	Selectivity	
Column Length (m)	✔			Doubling column length increases resolution by ~ 40%
Internal Diameter (mm)	✔			The smaller the column I.D., the greater the efficiency and better the resolution
Film Thickness (µm)		✔		The thicker the film, the greater the retention e.g. ideal for highly volatile compounds. The thinner the film, the sharper the peaks and lower the bleed
Stationary Phase Chemistry			✔	Altering the stationary phase can affect elution order and help separate closely, or co-eluting peaks

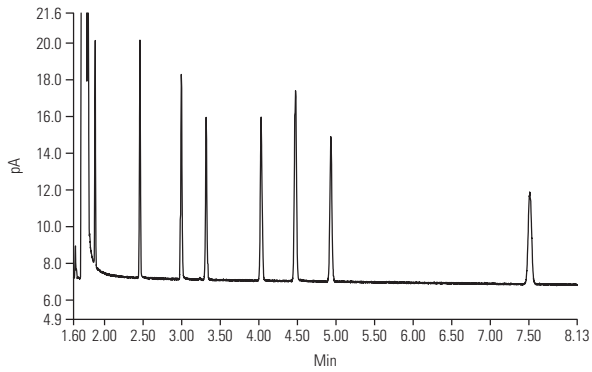
Column length

15m × 0.25mm × 0.25µm



Number	Peak Name	Retention Time	Width (50%)	Plates (USP)	Resolution (EP)	Asymmetry (EP)
1	2-Octanone	1.382	0.013	62319	n.a.	1.05
2	1-Octanol	1.693	0.016	60054	12.8	1.1
3	2,6-Dimethylphenol	1.88	0.017	58996	6.63	1.03
4	2,6-Dimethylaniline	2.292	0.022	64391	12.42	1.05
5	Naphthalene	2.545	0.024	59516	6.53	1.05
6	Dodecane	2.814	0.024	72950	6.58	0.98
7	Tridecane	4.299	0.037	63768	28.45	1.03

30m × 0.25mm × 0.25µm

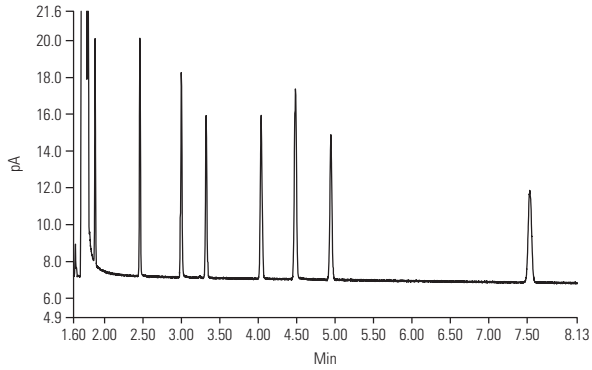


Number	Peak Name	Retention Time	Width (50%)	Plates (USP)	Resolution (EP)	Asymmetry (EP)
1	2-Octanone	2.459	0.015	149537	n.a.	1.04
2	1-Octanol	2.995	0.019	139528	18.84	1.04
3	2,6-Dimethylphenol	3.318	0.021	143916	9.74	1.02
4	2,6-Dimethylaniline	4.031	0.025	129791	18.33	1.02
5	Naphthalene	4.474	0.028	139598	9.74	1
6	Dodecane	4.934	0.03	141836	9.22	1
7	Tridecane	7.513	0.048	146205	38.69	1.02

Doubling the column length has increased the resolution between all peaks.

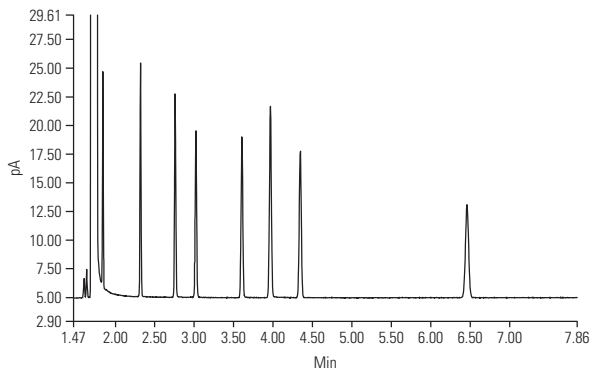
Column I.D.

30m × 0.25mm × 0.25µm



Number	Peak Name	Retention Time	Width (50%)	Plates (USP)	Resolution (EP)	Asymmetry (EP)
1	2-Octanone	2.459	0.015	149537	n.a.	1.04
2	1-Octanol	2.995	0.019	139528	18.84	1.04
3	2,6-Dimethylphenol	3.318	0.021	143916	9.74	1.02
4	2,6-Dimethylaniline	4.031	0.025	129791	18.33	1.02
5	Naphthalene	4.474	0.028	139598	9.74	1
6	Dodecane	4.934	0.03	141836	9.22	1
7	Tridecane	7.513	0.048	146205	38.69	1.02

30m × 0.32mm x 0.25µm

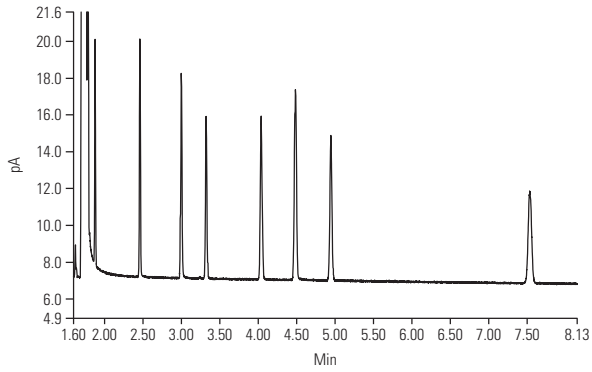


Number	Peak Name	Retention Time	Width (50%)	Plates (USP)	Resolution (EP)	Asymmetry (EP)
1	2-Octanone	2.319	0.014	144224	n.a.	1.03
2	1-Octanol	2.756	0.018	132707	16.11	1.05
3	2,6-Dimethylphenol	3.02	0.02	127661	8.35	1
4	2,6-Dimethylaniline	3.604	0.024	119119	15.63	0.99
5	Naphthalene	3.967	0.027	117526	8.32	0.99
6	Dodecane	4.347	0.029	122153	8.02	1.01
7	Tridecane	6.46	0.045	109119	33.75	1.02

Reducing column I.D. has given greater resolution between peaks

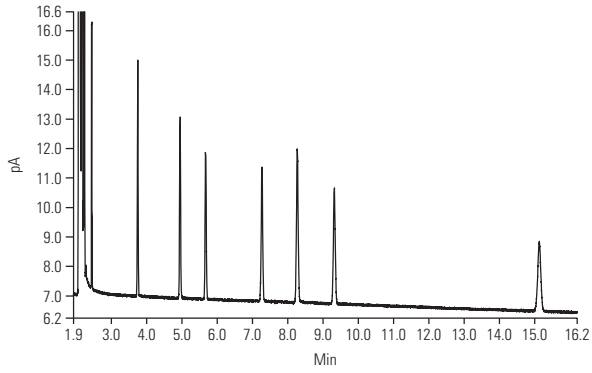
Film thickness

30m × 0.25mm × 0.25µm



Number	Peak Name	Retention Time	Width (50%)	Plates (USP)	Resolution (EP)	Asymmetry (EP)
1	2-Octanone	2.459	0.015	149537	n.a.	1.04
2	1-Octanol	2.995	0.019	139528	18.84	1.04
3	2,6-Dimethylphenol	3.318	0.021	143916	9.74	1.02
4	2,6-Dimethylaniline	4.031	0.025	129791	18.33	1.02
5	Naphthalene	4.474	0.028	139598	9.74	1
6	Dodecane	4.934	0.03	141836	9.22	1
7	Tridecane	7.513	0.048	146205	38.69	1.02

30m × 0.25mm × 0.5µm

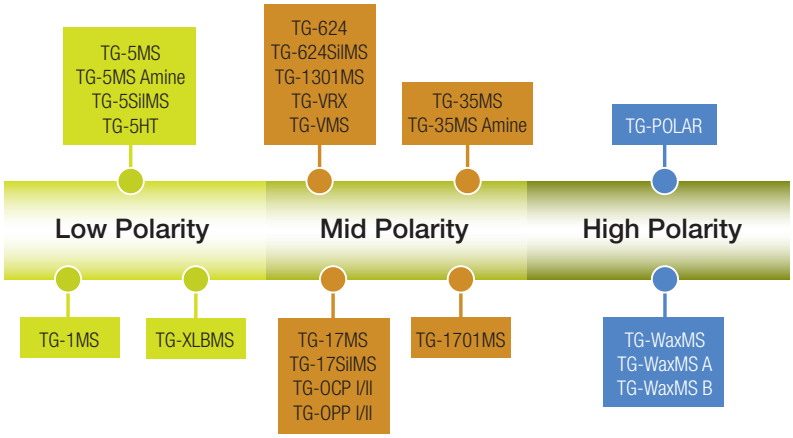


Number	Peak Name	Retention Time	Width (50%)	Plates (USP)	Resolution (EP)	Asymmetry (EP)
1	2-Octanone	3.742	0.023	145715	n.a.	1.01
2	1-Octanol	4.945	0.031	136225	26.13	1.03
3	2,6-Dimethylphenol	5.67	0.036	119006	12.72	1.02
4	2,6-Dimethylaniline	7.274	0.047	137243	22.69	0.99
5	Naphthalene	8.278	0.054	90705	11.71	1
6	Dodecane	9.327	0.058	144516	11.03	1.03
7	Tridecane	15.149	0.095	81203	44.93	0.95

Increasing film thickness has lead to greater retention of compounds

Phase chemistry

- When selecting an appropriate phase chemistry, use the principle 'like dissolves like'
- More polar analytes will require a more polar phase

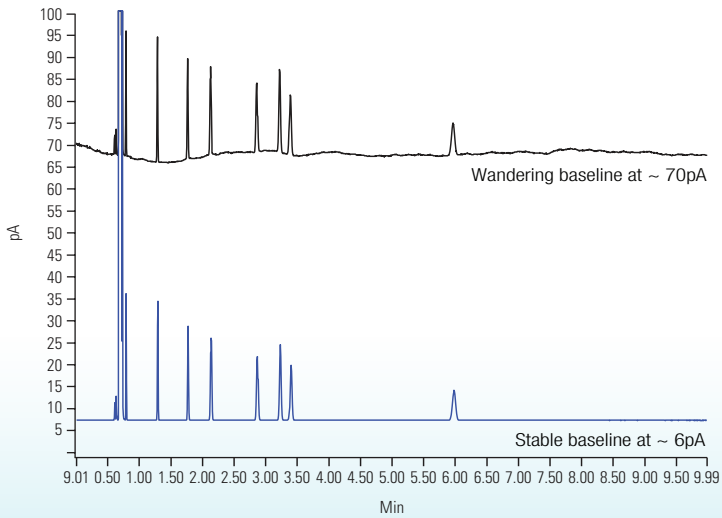


- The skill is knowing the degree of polarity required to avoid long retention times whilst still obtaining a satisfactory separation
- Separating compounds of intermediate polarity or mixed polarity and functionality requires knowledge of the retentivity and selectivity of each phase.

Gas Filters

The purpose of a gas filter is to remove instrument damaging impurities from the carrier gas.

To demonstrate the benefits of using a gas filter, a comparison was made between chromatograms where the carrier gas and make-up were fitted with triple gas filters and where gas filters were not fitted. The triple filter is designed to remove moisture, oxygen and hydrocarbons.



System Maintenance

GLD Pro Gas Leak Detector

Specifically designed for use with gas chromatography instruments. The GLD Pro detects minute leaks of any gas with a thermal conductivity different from air.

LED Light Response Range

Gas	Minimum Detectable Leak Rate (atm cc / sec)
Helium	1.0×10^{-5}
Hydrogen**	1.0×10^{-5}
Nitrogen	1.4×10^{-3}
Argon	1.0×10^{-4}
Carbon Dioxide	1.0×10^{-4}

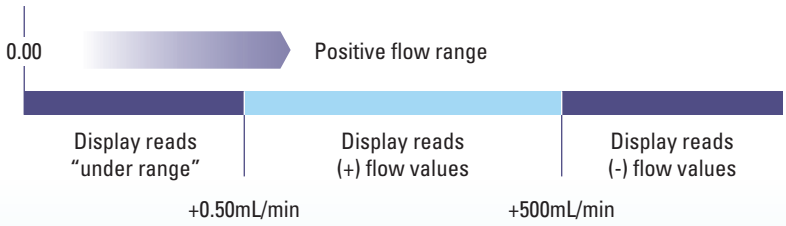
**CAUTION: This unit is designed to detect TRACE AMOUNTS of hydrogen and rising from a small leak in a non flammable environment, e.g., laboratory room air, etc. This unit is rated for use in a non flammable atmosphere where the sample gas may become sufficiently high in concentration to become explosive.

GFM Pro Gas Flowmeter

Specifically designed for use with gas chromatography instruments. The probe is applied directly to the gas flow stream and the measured rate presented on the LCD screen.

Flow Range Display

Flow Range	Display Resolution (mL/min)
0.50-9.99	0.01
10.0-99.9	0.1
100-500	1



GC and GC-MS Instruments

Our gas chromatography and mass spectrometry instruments offer solutions to food, environmental, pharmaceutical laboratories and industrial customers. Our instruments stimulate to advance scientific knowledge, enable drug discovery and to improve manufacturing processes. Using our GC and GC-MS you can expect the best results and highest level of productivity to keep your research or processes moving smoothly.

TRACE 1300 Series GC

- User-installable injectors and detectors
- Easy adoption of standard GC methods
- Unmatched detector sensitivity in trace analysis
- Increased robustness of injector technology
- Shorter sample cycle time

For routine GC and GC-MS laboratories that need flexibility for a wide range of applications, the Thermo Scientific™ TRACE™ 1300 Series GC Gas Chromatograph is the latest technology to simplify workflow and increase analytical performance.

The TRACE 1300 Series offers the most versatile GC platform in the market, with unique instant connect modularity for ground-breaking ease of use and performance, setting a new era in GC technology. GC users now have the unique ability to easily configure the system themselves, to increase throughput or for a rapid exchange of configurations, with the added benefit of continuous operation since modules can be swapped and routine maintenance performed offline to fit laboratory's schedule.

Visit **www.thermofisher.com/trace1300**

TriPlus RSH Autosampler

- Reliable GC and GC-MS automation
- Liquid injection/headspace/SPME, all-in-one unattended sequence
- Enhanced productivity and powerful versatility in sample preparation

The Thermo Scientific™ TriPlus™ RSH Autosampler offers scalable flexibility from simple liquid injection to extended sample preparation. An innovative Automated Tool Change (ATC) station addresses sampling demand and selects the most suitable syringe during a sequence. Up to 6 different syringes can be programmed in a sequence for extended sample preparation capabilities and different sampling modes (liquid, HS, SPME). Unsurpassed sample handling flexibility combined with high sample capacity, places no limits even to more stringent productivity requirements. Multiple sample trays increase unattended operation up to 972 x 2mL vials. The unique Bottom Vial Sensing feature secured syringe depth positioning in your vial for the last µL sample. Even nanovolume injections through the use of plunger-in-needle syringes can be programmed in a flexible sequence. All these, combined with large volume injections deliver unsurpassed sample handling flexibility.

Visit **www.thermofisher.com/triplusrsh**

GC and GC-MS Instruments

ISQ Series Single Quadrupole GC-MS

- Unique Full Source Removal™ capability delivers maximum uptime and unstoppable productivity
- ExtractaBrite™ solid, inert ion source provides robust operations and low detection limits
- Versatile and flexible for a broad range of applications

The Thermo Scientific™ ISQ™ Series single quadrupole GC-MS system features time-proven technology developed with the accumulation of almost 50 years of mass spectrometry innovation, offering an affordable and robust solution. This GC-MS series offers operational simplicity, proven dependability, and unstoppable productivity.

The ISQ QD GC-MS offers quality design, MS operational simplicity, and proven dependability for QA/QC and low-to medium-throughput production environments, as well as in teaching and academic facilities.

For analytically-demanding, high-throughput laboratories, requiring utmost sensitivity and unstoppable productivity, the ISQ LT GC-MS does not need to be vented to exchange the source, and it boasts the lowest detection limits and unlimited flexibility.

Visit **www.thermofisher.com/isq**

TSQ Duo Triple Quadrupole GC-MS/MS

- AutoSRM: provides automated method development and method maintenance software
- SIM Bridge: assists transitioning from SIM to SRM methods
- Portable methods: use existing methods or develop master methods on the TSQ 8000 Evo in the core lab and run them on the TSQ Duo system in field labs
- Chromeleon CDS software: MS control and data processing
- Timed Acquisition upgrade: when your methods grow in analyte number
- Excellent performance in Full Scan mode, with NIST MS Library searchable spectra
- User-installable modules: can be changed in less than two minutes

This GC-MS/MS is like no other. The Thermo Scientific™ TSQ™ Duo GC-MS/MS system is tailored to chromatographers and single quadrupole GC-MS users who need easy access to powerful new MS/MS workflows and who need to satisfy current method requirements. The system provides excellent performance in both single and triple quadrupole modes that is easily achievable, even for less experienced users. The TSQ Duo is the only cost-sensitive instrument featuring efficient, simply intelligent software workflows made possible by Thermo Scientific™ Dionex™ Chromeleon™ Chromatography Data System (CDS) software.

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Q Exactive GC Orbitrap GC-MS/MS

Bring the power of the first-ever combination of high-resolution gas chromatography (GC) and high-resolution/accurate-mass (HR/AM) Orbitrap mass spectrometry to your laboratory. The Thermo Scientific™ Q Exactive™ GC Orbitrap™ GC-MS/MS system provides comprehensive characterization of samples in a single analysis for the highest confidence in compound discovery, identification, and quantitation. Q Exactive GC offers the quantitative power of a GC triple quadrupole MS combined with the high performance, full scan HR/AM capabilities that are only possible with Orbitrap MS technology.

Visit **www.thermofisher.com/qexactivegc**

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A range of Thermo Scientific™ capabilities for air, food and beverage, environmental, forensic and pharmaceutical applications. Simplify analysis and minimize regulatory risks.

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Reproducible and clean sample extractions

Syringe Filters
Reliable elimination of particles and micro organisms

Virtuoso™ Vials
The highest level of sample integrity and sample information possible

Virtuoso™ Vial Identification System

HPLC/UHPLC Columns

Sample Preparation

Sample Handling

Separation and Detection

Data Management

Vanquish™ UHPLC Systems
Built for every biopharma workflow

GC Columns

TRACE™ 1300 Series GC
Simplify workflow and increase analytical performance

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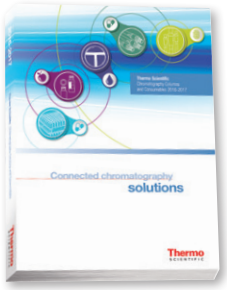

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