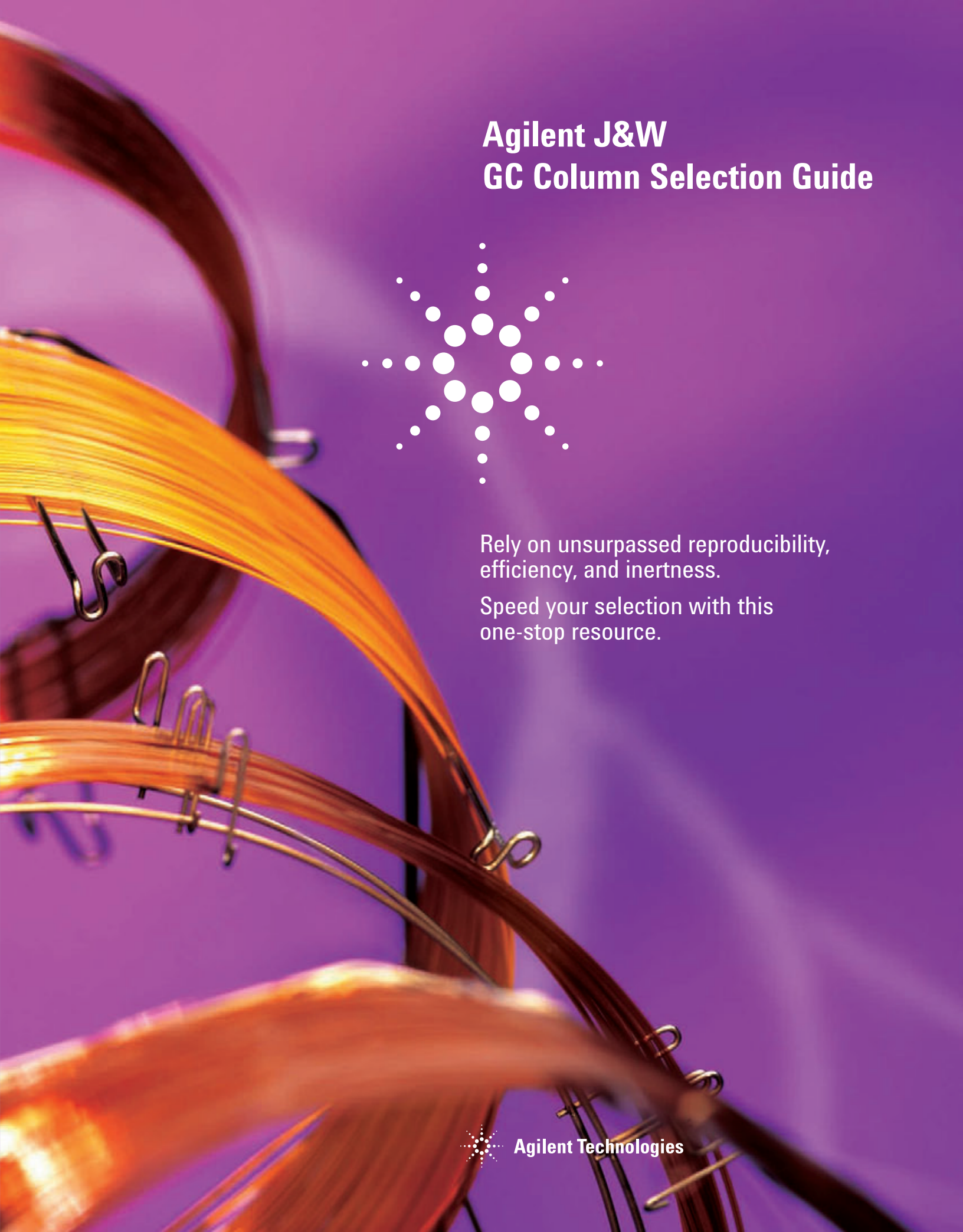

Agilent J&W GC Column Selection Guide

Rely on unsurpassed reproducibility, efficiency, and inertness.

Speed your selection with this one-stop resource.

Agilent Technologies

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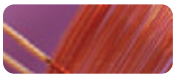

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The story behind Agilent J&W advanced GC Columns

In 2000, Agilent Technologies, the inventor of fused silica GC tubing, merged with J&W Scientific, the creator of the first GC stationary phase made from cross-linked siloxane polymers.

Now, thanks to this partnership, you can find both the renowned HP and DB column families under one name. All brought to you by Agilent Technologies – a company with over 40 years of gas chromatography experience.

The best low-bleed columns for sensitivity and performance.

Column bleed can decrease spectral integrity, reduce uptime, and shorten column life. But Agilent J&W columns have the widest range of low-bleed standard and stationary phases featuring superior inertness and high upper temperature limits – especially for ion trap MS users.

Better precision for better results.

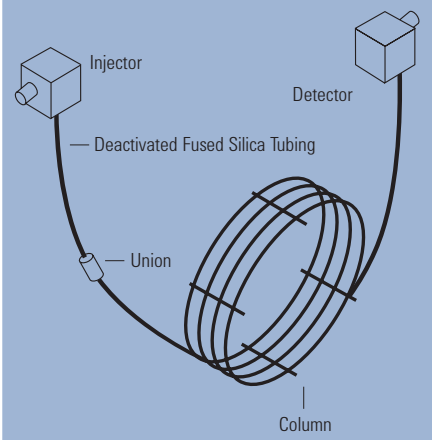
Agilent J&W columns adhere to tight retention factor (**k**) specifications, promoting consistent retention and separation. They also feature narrow retention indexes and a high number of theoretical plates per meter, ensuring narrow peaks and improving the resolution of closely eluting peaks.

The industry's tightest quality control specifications.

Agilent's stringent testing ensures reliable qualitative and quantitative results – even for your most challenging compounds. For example, we measure peak height ratios for both acids and bases to ensure top performance for the widest range of compounds. We also monitor peak symmetry and tailing for a broad scope of chemically active compounds.

As the world's leading provider of GC capillary columns, Agilent is uniquely positioned to offer you superior quality and unmatched service and support.

For additional column recommendations, chromatograms, and method parameters, go to **www.agilent.com/chem/myGCcolumns**.



Introduction to Basic Gas Chromatography

What is Gas Chromatography?

Chromatography is the separation of a mixture of compounds (solutes) into separate components, making it easier to identify (qualitate) and measure (quantitate) each component.

Gas Chromatography (GC) is one of several chromatographic techniques, and is appropriate for analyzing 10-20% of all known compounds. To be suitable for GC analysis, a compound must have sufficient volatility and thermal stability. If all or some of a compound's molecules are in the gas or vapor phase at 400-450°C or below, and they do not decompose at these temperatures, the compound can probably be analyzed by GC.

General GC Mechanics and Procedures

The first step in the GC process is to supply one or more high-purity gases to the GC. One of the gases (called the carrier gas) flows into the injector, through the column and into the detector. Next, a sample is introduced into the injector, which is usually heated to 150-250°C, causing the volatile sample solutes to vaporize. These vaporized solutes are subsequently transported into the column by the carrier gas, while the column is maintained in a temperature-controlled oven.

Solutes travel through the column at varying rates, which are primarily determined by their physical properties, as well as the temperature and composition of the column itself. The fastest-moving solute exits (elutes) the column first, followed by the remaining solutes in corresponding order. As each solute elutes, it enters the heated detector, where an electronic signal is generated based on the interaction of the solute with the detector. The size of the signal is recorded by a data system – such as Agilent's ChemStation software – and is plotted against elapsed time to produce a chromatogram.

Chromatogram Interpretation

Peak size corresponds to the amount of compound in the sample. As the compound's concentration increases, a larger peak is obtained. Retention time is the time it takes for a compound to travel through the column. If the column and all operating conditions are kept constant, a given compound will always have the same retention time.

Peak size and retention time are used to quantitate and qualitate a compound, respectively. However, it is important to note that the identity of a compound cannot be determined solely by its retention time. A known amount of an authentic, pure sample of the compound must first be analyzed to determine its retention time and peak size. This value can then be compared to the results from an unknown sample to determine whether the target compound is present (by comparing retention times) and in what quantity (by comparing peak size).

The ideal chromatogram has closely spaced peaks that do not overlap (co-elute). This is important for two reasons. First, co-elution makes it impossible to accurately measure the peaks. Second, if two peaks have the same retention time, neither can be accurately identified.

Inside a Capillary Column

A capillary GC column is comprised of two major parts: tubing and stationary phase. A thin film (0.1 to 10.0 µm) of a high molecular weight, thermally stable polymer is coated onto the inner wall of small diameter (0.05 to 0.53 mm I.D.) tubing. This polymer coating is called the stationary phase. Gas flows through the tubing and is called the carrier gas or mobile phase.

Upon introduction into the column, solute molecules distribute between the stationary and mobile phases. The molecules in the mobile phase are carried down the column; the molecules in the stationary phase are temporarily immobile. As some of the molecules in the mobile phase move through the column, they eventually collide with and reenter the stationary phase. During this same time, some of the solute molecules also leave the stationary phase and enter the mobile phase. This occurs thousands of times for each solute molecule as it passes through the column.

All molecules corresponding to a specific compound travel through the column at nearly the same rate, and appear as a band of molecules (called the sample band). The rate at which each sample band moves through the column depends upon the structure of the compound, the chemical structure of the stationary phase, and the column temperature. The width of the sample band depends on the operating conditions and the dimension of the column.

To prevent peak co-elution, it is critical to have no overlap between adjacent sample bands as they exit the column. This can be accomplished by choosing columns and operating conditions that minimize the width of the sample band, while ensuring that each sample band travels at a different rate.

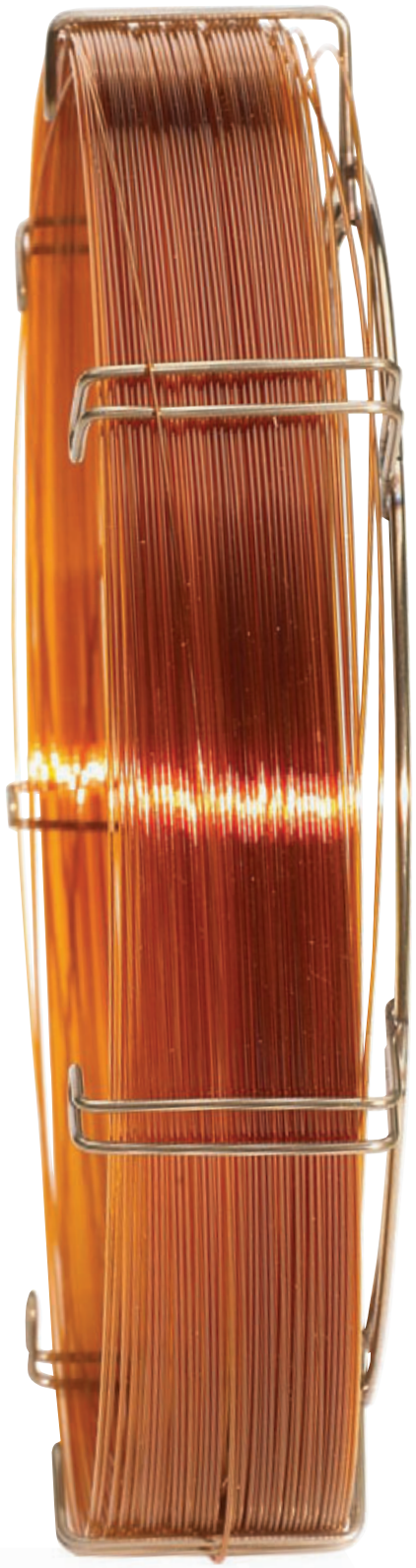
Terms and Conditions

Why bother with the basic arithmetic? There are a number of terms that are commonly used to describe various chromatographic and column characteristics, behaviors and conditions. An understanding of these terms is helpful for comparing column performance, quality, troubleshooting and interpreting your results.

Retention Time (t_R)

Retention time is the time it takes a solute to travel through the column. The retention time is assigned to the corresponding solute peak. The retention time is a measure of the amount of time a solute spends in a column. It is the sum of the time the molecule spent imbedded in the stationary and the time it spent traveling in the mobile phase.

The new Agilent 7890A Gas Chromatograph brings important new separation capabilities and productivity features to the industry leading Agilent GC platform. Learn more at **www.agilent.com/chem/7890A**.



Retention Time of an Unretained Compound (t_M)

Also known as the hold-up time, t_M or t_0 is the time for an unretained compound to travel through the column. Unretained solutes molecules do not enter the stationary phase, and they travel down the column at the same rate as the carrier gas. This is equivalent to the time a compound spends in the mobile phase. It is the same for all compounds in a single chromatographic run. The unretained peak time is obtained by injecting an unretained compound and determining the time it takes from injection to elution into the detector.

Retention Factor (k)

The Retention Factor is another measure of retention. It is the ratio of the amount of time a solute spends in the stationary phase and mobile phase (carrier gas). It is calculated using **Equation 1**. The retention factor is also known as the partition ratio or capacity factor. Since all solutes spend the same amount of time in the mobile phase, the retention factor is a measure of retention by the stationary phase. For example, a solute with a **k** value of 6 is twice as retained by the stationary phase (but not the column) as a solute with a **k** value of 3. The retention factor does not provide absolute retention information; it provides relative retention information. An unretained compound has k = 0.

$$k = \frac{t_R - t_M}{t_M} = \frac{t'_R}{t_M}$$

Equation 1

Retention Index (I)

Retention Index is a measure of the retention of a solute relative to the retention of normal alkanes (straight chain hydrocarbons) at a given temperature. **Equation 2a** is used to calculate retention indices for isothermal temperature conditions. For temperature program conditions, **Equation 2b** can be used.

The retention index for a normal alkane is its number of carbons multiplied by 100. For example, n-dodecane (n-$C_{12}H_{26}$) has **I** = 1200. If a solute has **I** = 1478 it elutes after n-C_{14} and before n-C_{15}, and it is closer to n-C_{15}. Retention indices normalize instrument variables so that retention data can be compared on different GC systems. Retention indices are also good for comparing retention characteristics for different columns.

$$I = 100_y + 100(z\text{-}y)\ \frac{\log t'_{R(x)} - \log t'_{R(y)}}{\log t'_{R(z)} - \log t'_{R(y)}}$$

Equation 2a

t_R = retention time
x = solute of interest
y = normal alkane with y number of carbon atoms eluting before solute x
z = normal alkane with z number of carbon atoms eluting after solute x
z – y = difference in carbon number between the two normal alkanes

$$I_T = 100\left(\frac{t_{R(x)} - t_{R(y)}}{t_{R(z)} - t_{R(y)}}\right) + y$$

Equation 2b

The Separation Factor is a measure of the time or distance between the maxima of two peaks. It is calculated using **Equation 3**. If $\alpha = 1$, the two peaks have the same retention time and co-elute.

$$\alpha = \frac{k_2}{k_1}$$

k_1 = retention factor of first peak
k_2 = retention factor of second peak

Equation 3

Number of Theoretical Plates (N)

Also known as column efficiency, the number of theoretical plates is a mathematical concept and can be calculated using **Equation 4**. A capillary column does not contain anything resembling physical distillation plates or other similar features. Theoretical plate numbers are an indirect measure of peak width for a peak at a specific retention time.

$$N = 5.545\left(\frac{t_R}{w_h}\right)^2$$

N = number of theoretical plates
t_R = retention time
w_h = peak width at half height (in units of time)

Equation 4

Columns with high plate numbers are considered to be more efficient, that is, have higher column efficiency, than columns with a lower plate count. A column with a high number of theoretical plates will have a narrower peak at a given retention time than a column with a lower N number.

High column efficiency is beneficial since less peak separation (meaning lower alpha, α) is required to completely resolve narrow peaks. On stationary phases where the alphas (α) are small, more efficient columns are needed. Column efficiency is a function of the column dimensions (diameter, length and film thickness), the type of carrier gas and its flow rate or average linear velocity, and the compound and its retention. For column comparison purposes, the number of theoretical plates per meter (N/m) is often used.

Theoretical plate numbers are only valid for a specific set of conditions. Specifically, isothermal temperature conditions are required because temperature programs result in highly inflated, inaccurate plate numbers. Also, the retention factor (k) of the test solute used to calculate plate numbers should be greater than 5. Less retained peaks result in inflated plate numbers. When comparing theoretical plate numbers between columns, the same temperature conditions and peak retention (k) are required for the comparison to be valid.

Height Equivalent to a Theoretical Plate (H)

Another measure of column efficiency is the height equivalent to a theoretical plate denoted as H. It is calculated using **Equation 5** and usually reported in millimeters. The shorter each theoretical plate, the more plates are "contained" in any length of column. This, of course, translates to more plates per meter and higher column efficiency.

$$H = \frac{L}{N}$$

L = length of column (mm)
N = number of theoretical plates

Equation 5

Utilization of Theoretical Efficiency (UTE%)

Coating Efficiency (CE%) is a historical term that compares the measured column efficiency and its theoretical maximum efficiency. It is calculated using **Equation 6**.

$$UTE\% = \left(\frac{H_{actual}}{H_{theoretical}} \right) x\ 100$$

Equation 6

Historically, $H_{theoretical}$ was usually so heavily impacted by heterogeneities in the stationary phase film that extra-column contributions to H_{actual} could be ignored (such as injection anomalies, insufficient or misdirected make up gas, mechanical and electronic lag times). Because of improvements to coating efficiency this is no longer the case and H_{actual} is usually more heavily impacted by extra-column contributions than the column itself. Column contributions to H_{actual} become more meaningful with increasing film thickness or polarity, both of which affect stationary phase diffusion. Many authorities prefer the term "utilization of theoretical efficiency," UTE, which take the above factors into account. Typically, UTEs are 85 to 100% for non-polar stationary phases and 60 to 80% for polar phases.

Resolution (R_S)

It is not surprising that the higher the resolution, the less the overlap between two peaks. Separation is only the distance or time between two peak maxima (alpha, α). Resolution takes into consideration both alpha (α) and the width of the peaks. It is calculated using either form of **Equation 7**. Baseline resolution usually occurs at resolution number 1.50; however, there is no visible baseline between the two peaks. Numbers greater than 1.50 indicate there is baseline between the peaks and numbers less than 1.50 indicate there is some degree of co-elution.

$$R = 1.18 \left(\frac{t_{R2} - t_{R1}}{w_{h_1} + w_{h_2}} \right)$$

$$R = 2 \left(\frac{t_{R2} - t_{R1}}{w_{b_1} + w_{b_2}} \right)$$

t_{R1} = retention time of first peak
t_{R2} = retention time of second peak
w_{h1} = peak width at half height (in units of time) of the first peak
w_{h2} = peak width at half height (in units of time) of the second peak
w_{b1} = peak width at base (in units of time) of the first peak
w_{b2} = peak width at base (in units of time) of the second peak

Equation 7

Phase Ratio (β)

A column's Phase Ratio, β, is a dimensionless value calculated using **Equation 8**. If the same stationary phase and column temperature (program or isothermal) are maintained, the change in the phase ratio can be used to calculate the change in a solute's retention. This relationship is expressed by **Equation 9**. The Distribution Constant (K_c) is the ratio of the solute concentration in the stationary phase and mobile phases. The distribution constant is fixed for the same stationary phase, column temperature and solute.

$$\beta = \frac{r}{2d_f}$$

r = column radius (micrometers, µm)
d_f = film thickness (micrometers, µm)

Equation 8

Thus, for a stationary phase and column temperature, the amount and direction of any change in retention upon a change in column diameter or film thickness can be determined. **Equation 9** shows that an increase in the phase ratio results in a corresponding decrease in retention (k) since K_c is a constant. Conversely, a decrease in the phase ratio results in a corresponding increase in retention (k).

$$\frac{c_S}{c_M} = K_c$$

$$K_c = k\beta = k\left(\frac{r}{2d_f}\right)$$

c_S = solute concentration in the stationary phase
c_M = solute concentration in the mobile phase

Equation 9

Equation 8 shows that the phase ratio decreases with a decrease in diameter or an increase in film thickness. Either of these column changes results in an increase in solute retention. The phase ratio increases with an increase in diameter or a decrease in film thickness. Either of these column changes results in a decrease in solute retention. Sometimes it is desirable to change column diameter or film thickness to obtain a specific effect (increased efficiency), without changing retention. This can be accomplished by proportionate changes in both column diameter and film thickness.

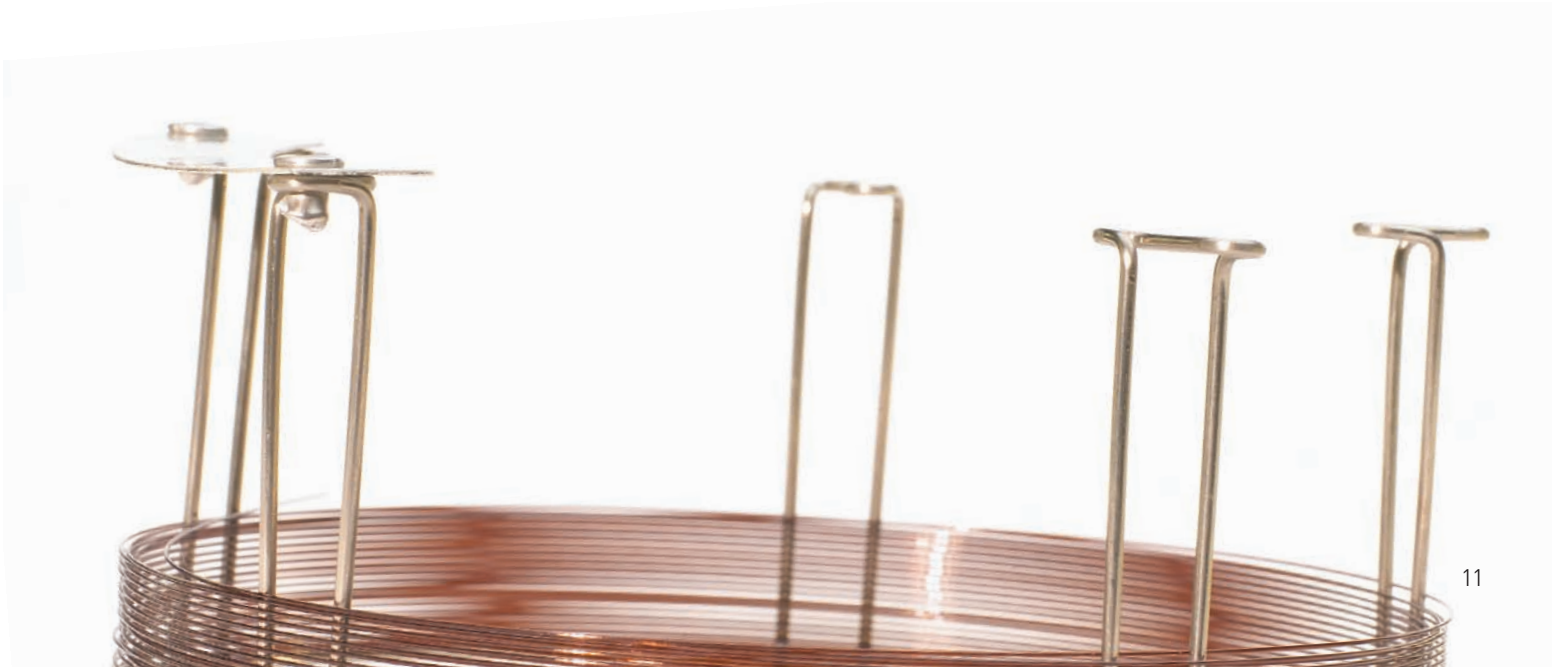
Column Selection Principles

How to narrow your choices, save time, and reduce trial and error.

Selecting the right capillary column for your application can be an uncertain (and sometimes difficult) task. If possible, you should begin by consulting sample applications provided by GC manufacturers and suppliers – or described in published Application Notes.

In addition, the following pages will help you...

- Choose a stationary phase – your most critical decision – based on factors such as selectivity, polarity, and phenyl content.
- Understand how column diameter influences factors like efficiency, solute retention, head pressure, and carrier gas flow rates.
- Determine which column length will affect solute retention, column head pressure, column bleed – and cost.
- Appreciate the difference between thin-film and thick-film columns with regard to capacity, inertness, bleed, and upper temperature limit.



Column Selection Principles

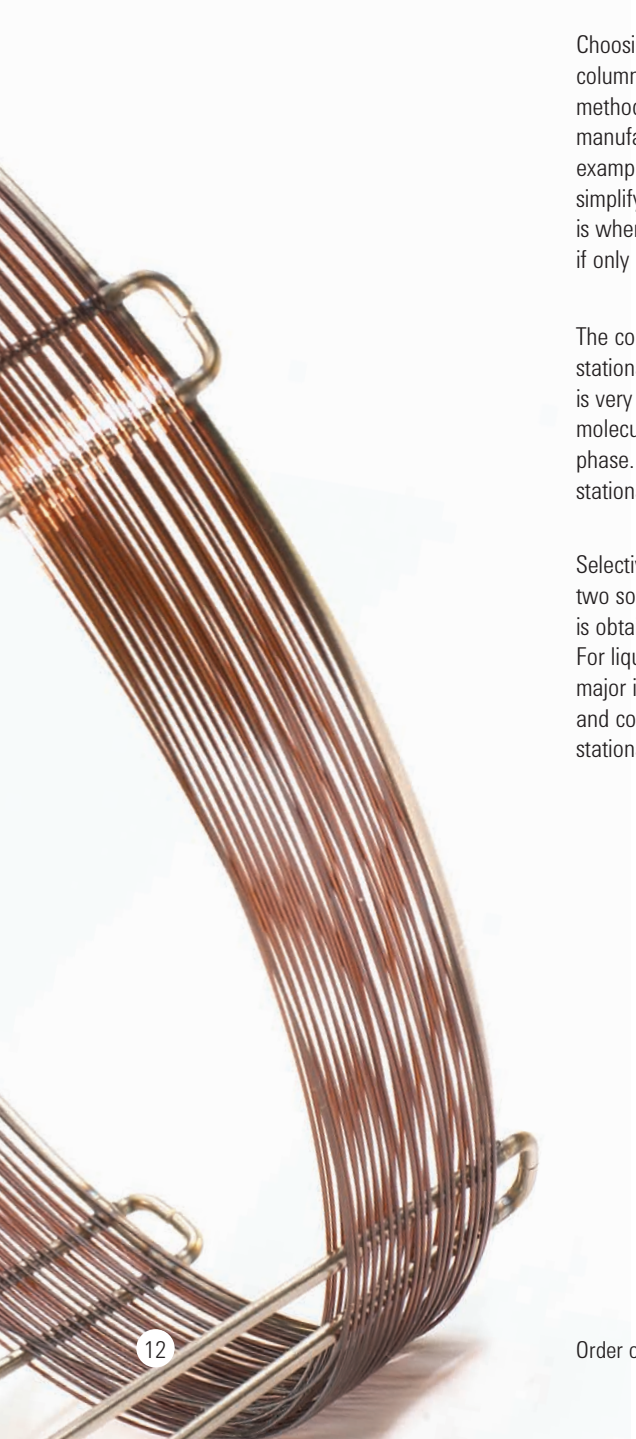
Selecting the best capillary column for an analysis can be an uncertain and sometimes difficult task. While there are no foolproof techniques, shortcuts, tricks or secrets to column selection, there are some guidelines and concepts that simplify the process. There are four major column parameters to consider: stationary phase, diameter, length, and film thickness.

Selecting Stationary Phases

Choosing the best stationary phase is the most important decision when selecting a capillary column. Unfortunately, it is also the most difficult and ambiguous decision. The most reliable method is to consult the large collection of example applications provided by column manufacturers and suppliers, GC manufacturers and in published literature. While an exact example application may not be available, enough information can usually be obtained to simplify the decision or reduce the number of potential columns. The most difficult situation is when no previous information is available. Stationary phase selection is much easier even if only one chromatogram is available for all or most of the sample compounds.

The concepts of stationary phase selectivity and polarity are very useful when selecting stationary phases. Synonymous use of the terms polarity and selectivity is not accurate, but it is very common. Selectivity is determined by the physicochemical interactions of the solute molecules with the stationary phase. Polarity is determined by the structure of the stationary phase. Polarity does have an effect on separation; however, it is only one of the many stationary phase properties that influence peak separation (see the next section on polarity).

Selectivity can be thought of as the ability of the stationary phase to differentiate between two solute molecules by differences in their chemical or physical properties. Separation is obtained if the interactions between the stationary phase and solutes are different. For liquid or gum stationary phase (polysiloxanes and polyethylene glycols), there are three major interactions: dispersion, dipole, and hydrogen bonding. The following is a simplified and condensed explanation of the interactions for polysiloxane and polyethylene glycol stationary phases.

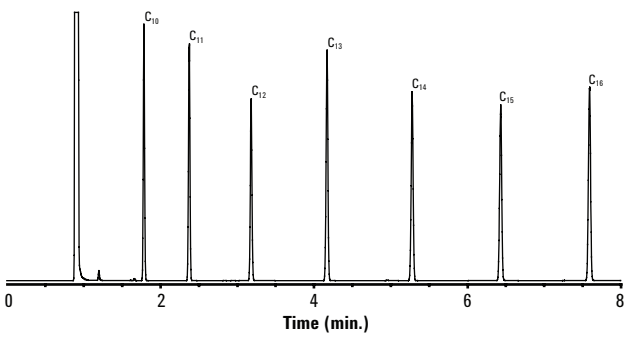


Dispersion is the dominant interaction for all polysiloxane and polyethylene glycol stationary phases. Dispersion can be simplified into the concept of volatility. Simply stated, the more volatile a solute, the faster it elutes from the column (i.e., shorter retention time). However, this order can be altered by the effect of solute and stationary phase polarities, and the other interactions. Solute boiling points are sometimes used as a measure of compound volatility. That is, compounds elute in the order of their increasing boiling points. Unfortunately, boiling points cannot be universally applied to the dispersion interactions. Boiling points are fairly valid when dealing with compounds with similar structures, functional groups or homologous series (**Figure 1**). When dealing with compounds with mixed functional groups, the boiling points simplification often fails (**Figure 2**). If compound boiling points differ by more than 30°C, they usually can be separated by most stationary phases (there are exceptions). If compound boiling points differ by less than 10°C, the boiling point simplification becomes less certain and more likely to be in error (except for compounds in a homologous series).

Figure 1: Boiling Point Elution Order for Homologous Series

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: Helium at 30 cm/sec
Oven: 60°C for 1 min, 60-180°C at 20°/min

	Boiling Point (°C)
1. n-Decane (C_{10})	174
2. n-Undecane (C_{11})	196
3. n-Dodecane (C_{12})	216
4. n-Tridecane (C_{13})	234
5. n-Tetradecane (C_{14})	253
6. n-Pentadecane (C_{15})	268
7. n-Hexadecane (C_{16})	287

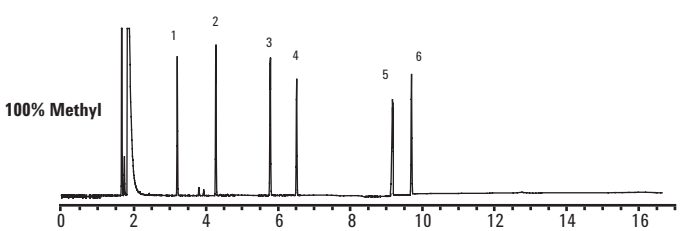


Homologous series of hydrocarbons. The solutes elute in order of their increasing boiling points; however, the peaks are not spaced in proportion to their respective boiling points.

Figure 2: Deviation from Boiling Point Order

Column: **DB-1, 30 m x 0.25 mm I.D., 0.25 µm**

	Boiling Points °C
1. Toluene	111
2. Hexanol	157
3. Phenol	182
4. Decane (C_{10})	174
5. Naphthalene	219
6. Dodecane (C_{12})	216



Solutes outside of the homologous series do not elute in the boiling point order.

If the stationary phase is capable of dipole interaction, it enhances its power to separate solutes whose dipole moments are different. Only some stationary phases are able to exploit this interaction. Polyethylene glycols, and cyanopropyl and trifluoropropyl substituted polysiloxanes readily undergo the dipole interactions; methyl or phenyl substituted groups do not undergo a dipole interaction (**Table 1**). The amount of peak separation for solutes with different dipoles often changes if a stationary phase with a different interaction is used (**Figure 3**). If the dipole difference between compounds is small, a greater amount of the appropriate group is needed (e.g., a 50% cyanopropylphenyl-methyl polysiloxane instead of a 14% cyanopropylphenyl-methyl polysiloxane). It is difficult to accurately predict the magnitude of the separation change for all of the peaks. Empirical results have shown that dipole interaction stationary phases are well suited for samples containing compounds that have base or central structures to which different groups are attached in various positions. Examples include substituted aromatics, halocarbons, pesticides and drugs.

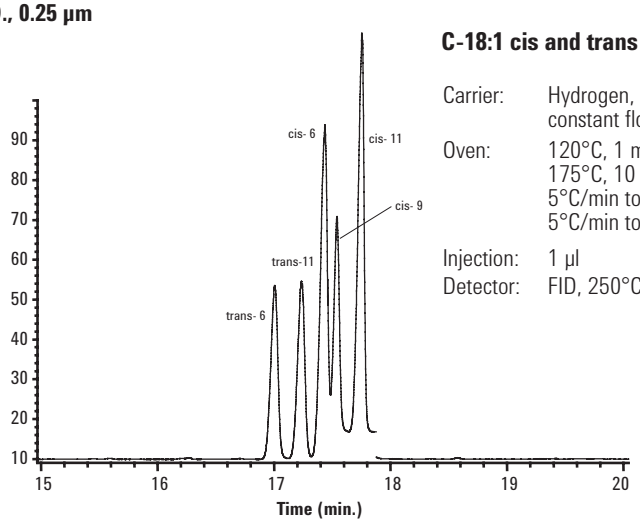
Table 1: Stationary Phase Interactions

Functional Group	Dispersion	Dipole	Hydrogen Bonding
Methyl	Strong	None	None
Phenyl	Strong	None to Weak	Weak
Cyanopropyl	Strong	Very Strong	Moderate
Trifluoropropyl	Strong	Moderate	Weak
PEG	Strong	Strong	Moderate

Figure 3: Dipole Interactions

Column: HP-88, 30 m x 0.25 mm I.D., 0.25 µm

Molecular weight and boiling points are virtually identical for these fatty acid methyl ester (FAME) isomers, with only the dipole interactions due to the hydrogen isomeric positions on the molecules being different. Only strong dipole interactions in the stationary phase can provide chromatographic separation for these types of compounds.



C-18:1 cis and trans isomers on HP-88.

Carrier:	Hydrogen, 2 mL/min constant flow
Oven:	120°C, 1 min, 10°C/min to 175°C, 10 min 5°C/min to 210°C, 5 min 5°C/min to 230°C, 5 min
Injection:	1 µl
Detector:	FID, 250°C

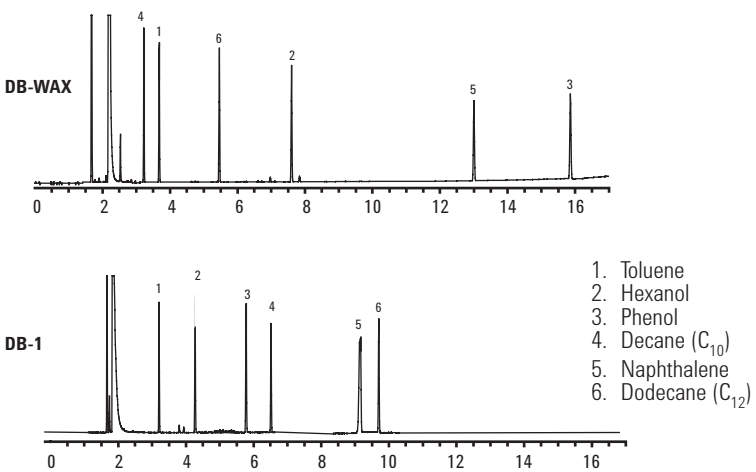
The hydrogen bonding interaction occurs if there is hydrogen bonding between the solute molecules and the stationary phase. **Table 2** lists the types of compounds that can form hydrogen bonds along with their relative bonding strengths. It is the difference in the strength of the hydrogen bonding that is critical. The same stationary phases that undergo dipole interactions also undergo hydrogen bonding interactions. The amount of peak separation for solutes whose hydrogen bonding potentials differ often changes if a stationary phase with a different amount of hydrogen bonding interaction is used (**Figure 4**). If the hydrogen bonding difference between compounds is small, a great amount of the appropriate group is needed (e.g., a polyethylene glycol instead of a 14% cyanopropylphenyl-methyl polysiloxane). It is difficult to accurately predict the magnitude of the separation change for all of the peaks. Sometimes the desired separation is obtained, but another set of peaks now co-elute with the new stationary phase.

Table 2: Relative Hydrogen Bonding Strengths

Strength	Compounds
Strong	Alcohols, carboxylic acids, amines
Moderate	Aldehydes, esters, ketones
Weak to None	Hydrocarbons, halocarbons, ethers

Figure 4: Hydrogen Bonding Interactions

Column: 15 m x 0.25 mm I.D., 0.25 µm



DB-1 does not undergo hydrogen bonding interactions. The change in the elution order of hexanol and phenol with DB-WAX is a combination of the dipole and hydrogen bonding interaction.

Agilent Gold Standard Syringes increase septum life while decreasing inlet contamination. Learn more at **www.agilent.com/chem/syringes**.

Another stationary phase characteristic that may affect retention in a predictable manner is the phenyl content. In general, the higher the phenyl content of the stationary phase, the higher the retention of aromatic solutes relative to aliphatic solutes. This does not mean that aromatic solutes are more retained (e.g., higher **k**) by high phenyl content stationary phases, but that aromatic solutes are more retained relative to aliphatic solutes. **Figure 5** shows an example of this retention behavior.

Polarity

Stationary phase polarity is determined by the polarity of the substituted groups and their relative amounts. **Table 3** lists a variety of stationary phases in order of their increasing polarity. Polarity is often erroneously used to select columns or to determine separation characteristics. Stationary phase polarity is only one of many factors that affect retention and separation.

While polarity is not directly related to selectivity, it has pronounced affect on compound retention, thus separation. For compounds of similar volatility, greater retention is obtained for solutes with polarities similar to the stationary phase. In other words, polar compounds are more strongly retained by a polar stationary phase than a less polar stationary phase, and vice versa. This affect can be seen in **Figure 6**. The changes in retention and elution order can be largely attributed to the changes in stationary phase polarity. Changes in the amount of phenyl substitution, and dipole and hydrogen bonding interactions also contribute to the changes; however, it is difficult to assess the magnitude of their individual contributions.

In addition to retention, stationary phase polarity influences other column characteristics. There is a general trend between stationary phase polarity and column lifetime, temperature limits, bleed and efficiency. Column life, temperature limits and efficiency tend to be higher for more non-polar stationary phases. These are general trends and not absolute certainties. Low bleed stationary phases sometimes go against this trend.

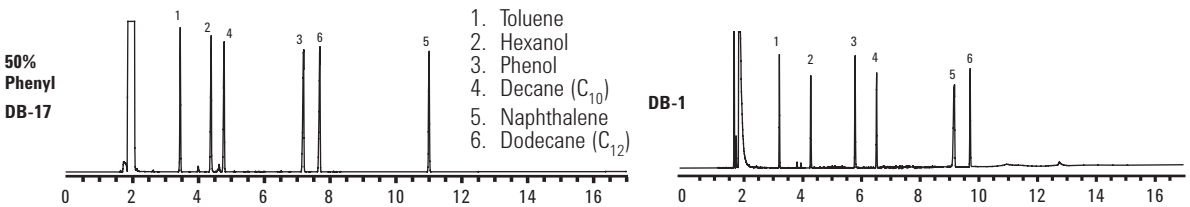
Table 3: Stationary Phase Polarity

Non Polarity									Mid
DB-1 HP-1 DB-1ms HP-1ms DB-2887 DB-Petro DB-PONA DB-HT Sim Dis DB-1ht Ultra 1	DB-5 HP-5 DB-5ms HP-5ms HP-5ms Semivol DB-5.625 DB-5ht Ultra 2 HP-PASS DB-EVDX	DB-XLB	DB-35 DB-35ms HP-35	HP-Chiral 10β HP-Chiral 20β	DB-17 DB-17ms DB-608 HP-50+ DB-17ht	DB-TPH	DB-502.2 HP-VOC	DB-VRX	DB-1301 DB-624 HP-Fast Residual Solvent

Separation and efficiency have to be considered together and not as separate column attributes. Each contributes to peak resolution. When the stationary phase provides adequate resolution between peaks, higher efficiency is not needed. Shorter or larger diameter columns and less than optimal GC conditions can be used in these situations. When resolution is not adequate, there is a need for higher column efficiency.

Figure 5: Phenyl Content Retention

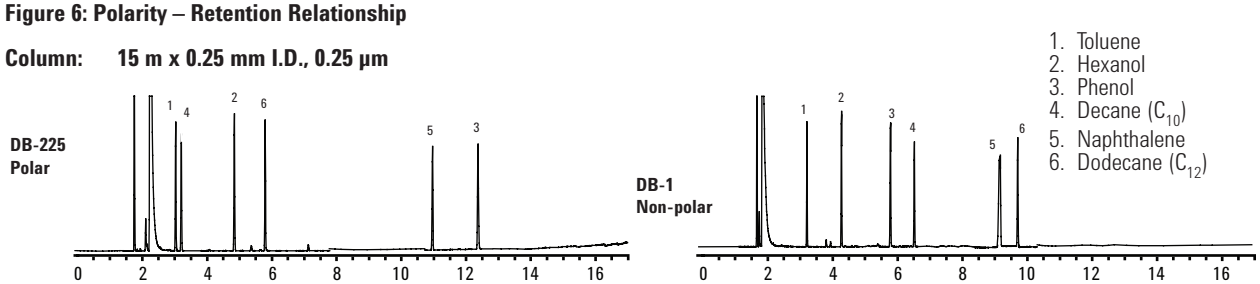
Column: 15 m x 0.25 mm I.D., 0.25 µm



The aromatics increase in retention relative to the hydrocarbons for the DB-17 columns. DB-17 contains 50% phenyl substitution. DB-1 contains no phenyl substitution.

Figure 6: Polarity – Retention Relationship

Column: 15 m x 0.25 mm I.D., 0.25 µm



The alcohols (polar) increase in retention relative to hydrocarbon (non-polar) for the DB-225 column. DB-225 is more polar than DB-1.

Polarity						High Polarity			
DB-1701 DB-1701P CycloSil-β Cyclodex-β	DB-ALC2	DB-225 DB-225 ms HP Blood Alcohol	DB-ALC1	DB-Dioxin	DB-200	DB-210	DB-23	HP-88	DB-WAX DB-WAXetr HP-INNOWax DB-FFAP HP-FFAP DB-WaxFF

Gas-Solid or PLOT Columns

PLOT (Porous Layer Open Tubular) columns are intended for the separation of very volatile solutes (primarily gases) without the need for cryogenic or sub-ambient cooling of the oven. Separations that would require column temperatures below 35°C, even with thick film liquid stationary phase can be obtained at temperatures above 35°C with PLOT columns.

Gas-solid or PLOT column stationary phases are physically different than polysiloxanes and polyethylene glycols. Gas-solid stationary phase are small, porous particles. The particles are stuck to the inner wall of the capillary tubing using a binder or similar means. Solutes are separated based on differences in their adsorption properties. Since the particles are porous, size and shape differentiation occurs also.

GS-Alumina columns are well suited for the separation of C_1-C_{10} hydrocarbons and small aromatics. The KCl version of the GS-Alumina column changes the retention order for some of the hydrocarbons. The HP-PLOT Q column provides slightly better separation for C_1-C_3 hydrocarbons, but C_4 and higher hydrocarbons are better separated with a GS-Alumina column. HP-PLOT Q exhibits extremely long retention times and very broad peaks for C_6 and higher hydrocarbons and aromatics. HP-PLOT Q separates sulfur gases from each other and form most light hydrocarbons. HP-PLOT Molesieve is used to separate many noble and permanent gases. GS-GasPro columns combine many of the features of the various other PLOT columns. Light hydrocarbons, inorganic gases and solvents are some of the samples suitable for GS-GasPro.

Primary Selectivity Interactions in PLOT Phases

Dispersive

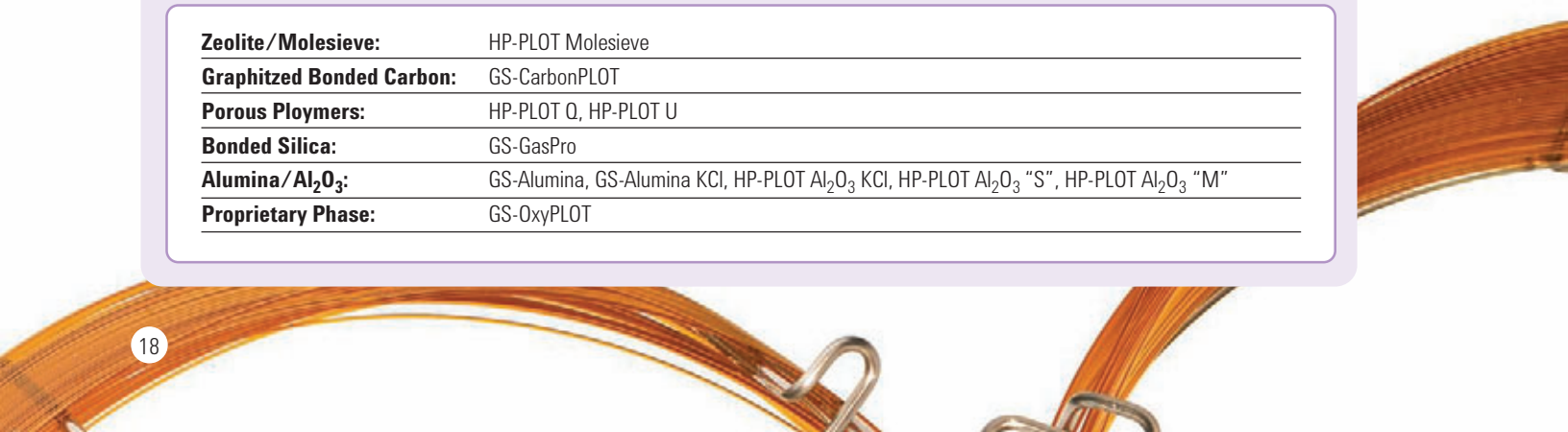
Shape/Size	⟷	**Ionic Surface**
Zeolites		Alumina/Al2O3 GS-OxyPLOT

Dispersive

Shape/Size	⟷	**Ionic Surface**
Bonded Graphitized Carbon Molecular Sieves	**Porous Polymers**	Bonded Silica

PLOT Column Examples

Zeolite/Molesieve:	HP-PLOT Molesieve
Graphitzed Bonded Carbon:	GS-CarbonPLOT
Porous Ploymers:	HP-PLOT Q, HP-PLOT U
Bonded Silica:	GS-GasPro
Alumina/Al_2O_3:	GS-Alumina, GS-Alumina KCl, HP-PLOT Al_2O_3 KCl, HP-PLOT Al_2O_3 "S", HP-PLOT Al_2O_3 "M"
Proprietary Phase:	GS-OxyPLOT



Stationary Phase Selection Summary

1. If no information or ideas about which stationary phase to use is available, start with a DB-1 or DB-5.

2. Low bleed ("ms") columns are usually more inert and have higher temperature limits.

3. Use the least polar stationary phase that provides satisfactory resolution and analysis times. Non-polar stationary phases have superior lifetimes compared to polar phases.

4. Use a stationary phase with a polarity similar to that of the solutes. This approach works more times than not; however, the best stationary phase is not always found using this technique.

5. If poorly separated solutes possess different dipoles or hydrogen bonding strengths, change to a stationary phase with a different amount (not necessarily more) of the dipole or hydrogen bonding interaction. Other co-elutions may occur upon changing the stationary phase, thus the new stationary phase may not provide better overall resolution.

6. If possible, avoid using a stationary phase that contains a functionality that generates a large response with a selective detector. For example, cyanopropyl containing stationary phases exhibit a disproportionately large baseline rise (due to column bleed) with NPDs.

7. A DB-1 or DB-5, DB-1701, DB-17, and DB-WAX cover the widest range of selectivities with the smallest number columns.

8. PLOT columns are used for the analysis of gaseous samples at above ambient column temperatures.

Table 4:
Column Efficiency vs. Diameter

Column ID Diameter (mm)	Theoretical Plates/Meter
0.10	12,500
0.18	6,600
0.20	5,940
0.25	4,750
0.32	3,710
0.45	2,640
0.53	2,240

Maximum efficiency for a solute with k=5

Column Diameter

Column diameter has an influence over five parameters of primary concern. They are efficiency, retention, pressure, carrier gas flow rate, and capacity.

Column efficiency (N/m) is inversely proportional to column diameter. The efficiencies listed in **Table 4** show that smaller diameter columns have higher theoretical plates per meter. Resolution is a square root function of the theoretical plate number. Therefore, doubling column efficiency theoretically increases resolution only by 1.41 times (the square root of 2), but closer to 1.2-1.3 times in real practice. Smaller diameter columns are used when peak separation is small and high column efficiency (i.e., narrow peaks) is needed. **Figure 7** shows the difference in resolution for two different diameter columns.

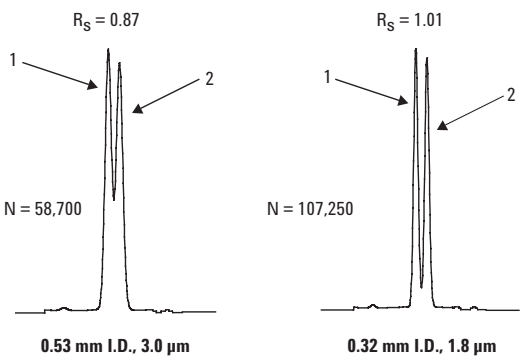
Solute retention is inversely proportional to column diameter, for isothermal temperature conditions. For temperature program conditions, the change is 1/3-1/2 of the isothermal value. Column diameters are rarely selected based on retention. Figure 7 shows the difference in retention for two different diameter columns.

Column head pressure is approximately an inverse squared function of the column radius. For example, a 0.25 mm I.D. column requires about 1.7 times the head pressure of a 0.32 mm I.D. column of the same length (also, carrier gas and temperature). Column head pressures increase or decrease dramatically with changes in column diameter. Column diameters of 0.18 mm I.D. or larger are used for standard GC analysis due to the very high pressures needed for smaller diameter columns. Wider diameter columns, especially shorter ones (e.g., 15 m x 0.32 mm I.D.), are impractical for use in GC/MS systems. The vacuum at the exit of the column greatly reduces the required head pressure, and it is difficult to maintain or control very low head pressures.

Figure 7: Column Diameter – Comparison of Resolution and Retention

Column: DB-624, 30 m

1. 1,3-Dichlorobenzene
2. 1,4-Dichlorobenzene



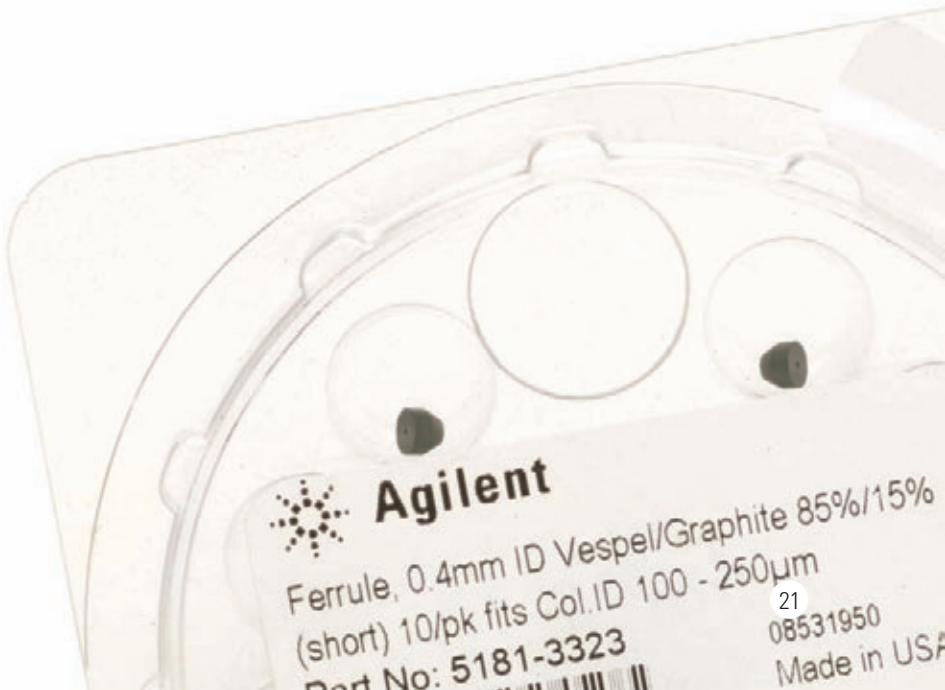
0.53 mm I.D., 3.0 µm **0.32 mm I.D., 1.8 µm**

At constant pressure, **carrier gas flow rates** increase as column diameters increase. For applications or hardware requiring high flow rates, larger diameter columns are normally used. Headspace and purge & trap systems require higher carrier gas flow rates for proper operation. 0.45 or 0.53 mm I.D. columns are used with these systems so that the higher flow rates can be used. Special considerations must be taken if small diameter columns are used in these types of systems. This includes the use of cryogenic interfaces or ovens, or interfacing through split injectors. Added complexity and /or cost, or sample loss, are involved with these techniques. For applications or hardware requiring low carrier gas flow rates, smaller diameter columns are normally used. GC/MS is the typical system requiring low carrier gas flow rates, and therefore, 0.25 mm I.D. and smaller I.D. columns are used in these applications.

Column capacity increases as the column diameter increases. The actual column capacity also depends on the stationary phase, solute and film thickness. **Table 5** lists typical capacity ranges for a variety of column diameters.

Table 5: Column Capacity in ng

Film Thickness (µm)	Column Inside Diameter (mm)			
	0.18-0.20	**0.25**	**0.32**	**0.53**
0.10	20-35	25-50	35-75	50-100
0.25	35-75	50-100	75-125	100-250
0.50	75-150	100-200	125-250	250-500
1.00	150-250	200-300	250-500	500-1000
3.00		400-600	500-800	1000-2000
5.00		1000-1500	1200-2000	2000-3000



Agilent capillary ferrules are packaged in novel dial packs which deliver one clean ferrule at a time. Learn more at **www.agilent.com/chem/ferrules**.

Column Diameter Selection Summary

1. Use **0.18-0.25 mm I.D. columns** when higher column efficiencies are needed. 0.18 mm I.D. columns are especially well suited for GC/MS systems with low pumping capacities. Smaller diameter columns have the lowest capacities and require the highest head pressures.

2. Use **0.32 mm I.D. columns** when higher sample capacity is needed. They often provide better resolution of earlier eluting solutes for splitless injections or large injection volumes (>2 µL) than 0.25 mm I.D. columns.

3. Use **0.45 mm I.D. columns** when only a Megabore direct injector is available and higher column efficiency is desired. Well suited for high carrier gas flow rate situations such as with purge & trap, headspace samplers, and valve injection applications.

4. Use **0.53 mm I.D. columns** when only a Megabore direct injector is available. Well suited for high carrier gas flow rate situations such as with purge & trap and headspace samplers. 0.53 mm I.D. columns have the highest sample capacities at constant d_f.

Column Length

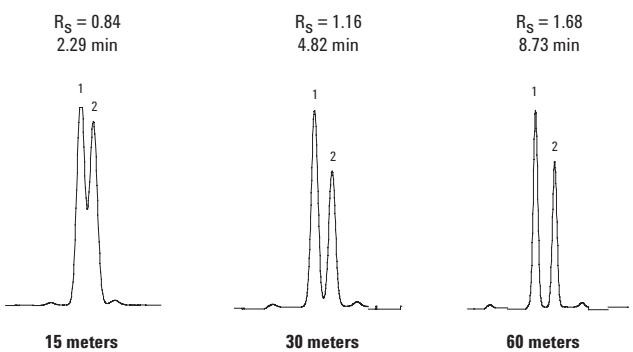
Column length influences three parameters of major concern. They are efficiency, retention (analysis time) and carrier gas pressure.

Column efficiency (N) is proportional to column length. Resolution is a square root function of the theoretical plate number. For example, doubling column length (thus efficiency) theoretically increases resolution by only 1.41 times (closer to 1.2-1.3 times in practice). Longer columns are used when peak separation is small and high column efficiency (i.e., narrow peaks) is needed. **Figure 8** shows the difference in resolution for three different lengths.

Figure 8: Column Length –
Comparison of Resolution and Retention

Column: **DB-624**
15 m x 0.53 mm I.D., 0.3 µm
30 m x 0.53 mm I.D., 0.3 µm
30 m x 0.53 mm I.D., 0.3 µm

1. 1,3-Dichlorobenzene
2. 1,4-Dichlorobenzene



Solute retention is proportional to column length for isothermal temperature conditions. For temperature program conditions, the change is 1/3-1/2 of the isothermal value. When efficiency is increased by lengthening the column, there is a significant increase in analysis time. **Figure 8** shows the difference in retention for three different lengths.

Column head pressure is nearly proportional to column length. Pressure is usually not an issue unless the column has a very small or large diameter. Long, small diameter columns require extremely high head pressures, and short, wide diameter columns require very low head pressures. Neither situation is very practical and may be a limiting factor. Choice of carrier gas will also have an impact on column pressure.

Column bleed increases as column length increases. Longer columns have more stationary phase, thus more degradation products are produced. The increase in bleed with longer columns is not large and should not be a deterrent to using a longer column when one is necessary.

Column cost is directly related to column length. Doubling column length nearly doubles the price of the column. When efficiency is increased by lengthening the column, there is a significant increase in column cost. When considered in conjunction with the increase in analysis time, lengthening the column should be the last reasonable option for increasing efficiency.

Shorter columns cost more per meter than longer columns. Cutting longer columns into shorter lengths seems like a good method to save money, but it is not recommended. The quality of the smaller pieces cannot be guaranteed and may not be the same as the original, intact column. Theoretically, each piece should provide satisfactory and consistent results. In practice, this does not always occur. The probability of individual piece variation is higher when shorter pieces are cut from the original column. Greater variability between individual pieces is observed as column length, film thickness and stationary phase polarity increases, and column diameter decreases. Finally, there is the increased chance of tubing breakage when rewinding the shorter columns on other cages. Technically, cutting a column into shorter pieces voids the performance warranty.

Column Length Selection Summary

1. Start with **25-30 meter columns** when the best length is unknown.

2. **10-15 meter columns** are well suited for samples containing very well separated solutes or very few solutes. Shorter lengths are used for very small diameter columns to reduce head pressures.

3. **50-60 meter columns** should be used when resolution is not possible by other means (smaller diameter, different stationary phase, change in column temperature). Best suited for complex samples containing a large number of solutes. Long columns have long analysis times and higher cost.

Column Film Thickness

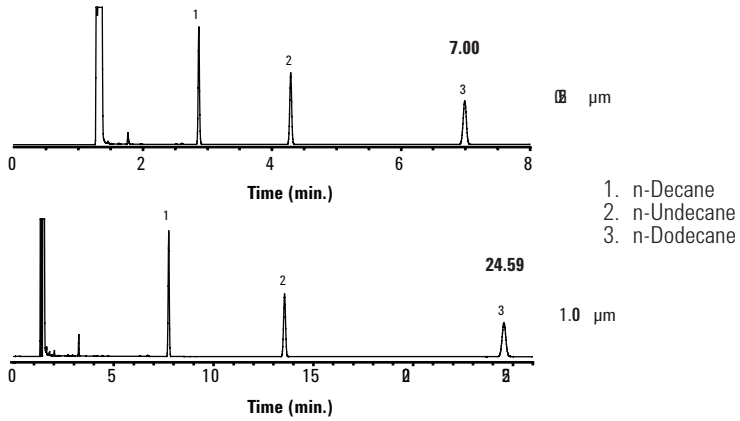
Column film thickness influences five major parameters: retention, resolution, bleed, inertness and capacity.

For isothermal conditions, solution retention is directly proportional to film thickness. For temperature program conditions, the change is 1/3-1/2 of the isothermal value. Thicker film columns are used to obtain higher retention for very volatile solutes. Volatile solutes normally requiring cryogenic (subambient) cooling with standard film thickness columns can be sufficiently retained at temperatures above 30°C. Changing to a thicker film column has a net effect of providing equal or greater retention at a higher column temperature. Thicker film columns are typically used for volatile compounds like solvents and select gases. Thinner film columns are used to reduce the retention of highly retained solutes. Highly retained solutes can be eluted faster or at a lower temperature. Changing to a thinner film column has the net effect of providing equal or less retention at a lower column temperature. Thinner film columns are typically used for high boiling or molecular weight compounds. **Figure 9** shows the difference in retention for two different film thicknesses.

Solutes with **k** values less than 2 are very difficult to resolve due to insufficient retention by the column. Changing to a thicker film column results in better resolution since solute retention is increased. The resolution improvement depends on the solute **k** value for the original column. For solutes with **k** values of about 5 or less, increasing their retention results in improved resolution. For solute peaks with values of 5-10, increasing their retention provides a small to moderate increase in resolution. For peaks with **k** values above 10, increasing their retention often results in no resolution improvement and sometimes a loss of resolution. Increasing film thickness to improve the resolution of early eluting peaks may result in a resolution loss for later eluting peaks.

Figure 9: Column Film Thickness – Comparison of Resolution and Retention

Column: **DB-1, 30 m x 0.32 mm I.D.**
Carrier: **Helium at 38 cm/sec**
Oven: **100 °C isothermal**



1. n-Decane
2. n-Undecane
3. n-Dodecane

For a given stationary phase, column bleed increases as film thickness increases. Since thicker film columns are more retentive, later eluting peaks may shift into a region of much higher column bleed when increasing film thickness. The upper temperature limits of thick film columns may be lower due to their higher bleed levels.

Thicker film columns are more inert. There is more stationary phase to shield the solutes from the tubing surface. Peak tailing for active compounds can often be reduced or eliminated with a thicker film column.

Thicker film columns have higher solute capacities. When one solute is present in significantly higher amounts, the resulting broad peak may interfere or co-elute with an adjacent peak. Changing to a thicker film column may reduce peak broadening, thus co-eluting. **Table 5** lists typical capacity ranges for a variety of film thickness.

Agilent's Capillary Flow Technology devices can be used for backflush applications to shorten cycle times, reduce column maintenance, and improve data quality.

Column Film Thickness Selection Summary

1. For **0.18-0.32 mm I.D. columns**, a film thickness of 0.18-0.25 µm is average or standard (i.e., not thin or thick) and used for most analyses.

2. For **0.45-0.53 mm I.D. columns**, a film thickness of 0.8-1.5 µm is average or standard (i.e., not thin or thick) and used for most analyses.

3. **Thick film columns** are used to retain and resolve volatile solutes (e.g., light solvents, gases). Thick columns are more inert and have higher capacities. Thick film columns exhibit higher column bleed and decreased upper temperature limits.

4. **Thin film columns** are used to minimize the retention of high boiling, high molecular weight solutes (e.g., steroids, triglycerides). Thin film columns are less inert, have lower capacities and exhibit lower column bleed.

Method Guides

GC Columns Stationary Phase Applications Guide

Agilent Phase	Application	Composition	Polarity	Approximate Temp Range (°C)	Similar Phases
General Applications					
HP-1ms, DB-1ms, HP-1, DB-1	Amines, hydrocarbons, pesticides, PCBs, phenols, sulfur compounds, flavors and fragrances	100% Dimethylpolysiloxane	Non-polar	From -60 to 325/350	BP-1, SPB-1, CP-Sil 5, Rtx-1, OV-1, SE-30, 007-1, ZB-1
HP-5ms, DB-5, HP-5	Semivolatiles, alkaloids, drugs, FAMEs, halogenated compounds, pesticides, herbicides	5% Phenyl 95% dimethylpolysiloxane	Non-polar	From -60 to 325/350	SPB-5, XTI-5, Mtx-5, CP-Sil 8CB, SE-54, Rtx-5, BPX-5, MDN-5, Rtx-5ms, BP-5, ZB-5
DB-5ms	Semivolatiles, alkaloids, drugs, FAMEs, halogenated compounds, pesticides, herbicides	5% Phenyl 95% dimethyl arylene siloxane	Non-polar	From -60 to 325/350	Rtx-5ms, PTE-5, CP-Sil 8 CB Low Bleed/MS, BPX-5, AT-5ms, ZB-5ms
DB-1301	Aroclors, alcohols, pesticides, VOCs	6% Cyanopropyl-phenyl 94% dimethyl polysiloxane	Mid-polar	From -20 to 280/300	Rtx-1301, PE-1301
DB-35, HP-35	CLP-pesticides, aroclors, pharmaceuticals, drugs of abuse	35% Phenyl 65% dimethyl polysiloxane	Mid-polar	From 40 to 300/320	Rtx-35, SPB-35, AT-35, Sup-Herb, MDN-35, BPX-35
DB-35ms	CLP-pesticides, aroclors, pharmaceuticals, drugs of abuse	35% Phenyl 65% dimethyl arylene siloxane	Mid-polar	From 50 to 340/360	Rtx-35, SPB-35, AT-35, Sup-Herb, MDN-35, BPX-35
DB-1701, DB-1701P	Pesticides, herbicides, TMS sugars, aroclors	14% Cyanopropyl-phenyl 86% dimethyl polysiloxane	Mid-polar	From -20 to 280/300	SPB-1701, CP-Sil 19 CB, Rtx-1701, CB-1701, OV-1701, 007-1701, BPX-10
HP-50+, DB-17	Drugs, glycols, pesticides, steroids	50% Phenyl 50% dimethylpolysiloxane	Mid-polar	From 40 to 280/300	Rtx-50, CP-Sil 19 CB, BPX-50, SP-2250
DB-17ms	Drugs, glycols, pesticides, steroids	50% Phenyl 50% dimethyl arylene siloxane	Mid-polar	From 40 to 320/340	HP-50+, Rtx-50, 007-17, SP-2250, SPB-50, BPX-50, SPB-17, AT-50
DB-200	Residual solvents, pesticides, herbicides	35% Trifluoropropyl 65% dimethyl polysiloxane	Polar	From 30 to 300/320	Rtx-200
DB-210		50% Trifluoropropyl 50% dimethyl polysiloxane	Polar	From 45 to 240/260	SP-2401
DB-225ms, DB-225	FAMEs, alditol acetates, neutral sterols	50% Cyanopropyl-phenyl 50% dimethyl polysiloxane	Polar	From 40 to 220/240	SP-2330, CP-Sil 43 CB, OV-225, Rtx-225, BP-225, 007-225

GC Columns Stationary Phase Applications Guide (Continued)

Agilent Phase	Application	Composition	Polarity	Approximate Temp Range (°C)	Similar Phases
HP-INNOWax	Alcohols, free organic acids, solvents, essential oils, flavors and fragrances	Polyethylene glycol	Polar	From 40 to 260/270	HP-20M, SUPELCOWAX 10, CP-WAX 52 CB, SUPEROX II, CB-WAX, Stabilwax, BP-20, 007-CW, Carbowax, DB-WAXetr, ZB-WAX
DB-WAX	Solvents, glycols, alcohols	Polyethylene glycol	Polar	From 20 to 250/260	HP-20M, SUPELCOWAX 10, CP-WAX 52 CB, SUPEROX II, CB-WAX, Stabilwax, BP-20, 007-CW, Carbowax, HP-INNOWax, Rtx-WAX, ZB-WAX
CAM	Amines, basic compounds	Polyethylene glycol-base modified	Polar	From 60 to 220/240	Stabilwax-DB, Carbowax Amine
HP-FFAP, DB-FFAP	Organic acids, alcohols, aldehydes, ketones, acrylates	Polyethylene glycol-acid modified	Polar	From 40 to 250	OV-351, SP-1000, Stabilwax-DA, 007-FFAP, Nukol
DB-23	FAMEs (requiring cis/trans resolution)	50% Cyanopropyl 50% dimethyl polysiloxane	Polar	From 40 to 250/260	SP-2330, Rtx-2330, 007-23, AT-Silar, BPX-70, SP-2340
CycloSil-β	Chiral compounds (general purpose)	30%-heptakis (2,3-di-O-methyl-6-O-t-butyl dimethylsilyl)-B-cyclodextrin in DB-1701	Mid-polar	From 35 to 260/280	LIPODEX C, Rt-β DEXm, β-DEX 110, β-DEX 120
HP-Chiral β	Chiral compounds (using a Nitrogen selective detector, NPD)	beta-Cyclodextrin in phenyl-based stationary phase	Mid-polar	From 30 to 240/250	LIPODEX C, Rt-βDEXm, β-DEX 110, β-DEX 120
PLOT Phases					
HP-PLOT Molesieve	Permanent and noble gases. Argon and oxygen separation at 35°C	5Å molecular sieve zeolite		From -60 to 300	None
HP-PLOT Al_2O_3 KCl	C1-C6 hydrocarbons in natural gas, refinery gas, fuel gas, synthetic gas, dienes	Aluminum Oxide KCl deactivated	Least polar	From -60 to 200	CP-Al_2O_3/KCl PLOT, Rt-Alumina PLOT, Alumina PLOT, Al_2O_3/KCl
HP-PLOT Al_2O_3 S	C1-C6 hydrocarbons in natural gas, refinery gas, fuel gas, synthetic gas, dienes	Aluminum Oxide "Sodium Sulfate" deactivated	Mid-polar	From -60 to 200	CP-Al_2O_3 PLOT Na_2SO_4

GC Columns Stationary Phase Applications Guide (Continued)

Agilent Phase	Application	Composition	Polarity	Approximate Temp Range (°C)	Similar Phases
GS-Alumina	C1-C6 hydrocarbons in natural gas, refinery gas, fuel gas, synthetic gas, dienes	Aluminum Oxide with proprietary deactivation	Most polar	From -60 to 200	Al_2O_3/KCl, Al_2O_3/Na_2SO_4, Rt-Alumina PLOT, Alumina PLOT
HP-PLOT Q	Hydrocarbons including isomers, CO_2, methane, air/CO, water, polar solvents, sulfur compounds	Polystyrene-divinylbenzene		From -60 to 270/290	CP PoraPLOT Q, CP PoraPLOT Q-HT, Rt-QPLOT, SupelQ PLOT, GS-Q
HP-PLOT U	C1 to C7 hydrocarbons, CO_2, methane, air/CO, water, oxygenates, amines, solvents, alcohols, ketones, aldehydes	Divinylbenzene/ethylene glycol dimethacrylate		From -60 to 190	PoraPlot U, RTU PLOT
GS-GasPro	C1 to C12 hydrocarbons, CO_2, trace-level sulfurs, hydride gases, inorganic gases, halocarbons, SF6, oxygen/nitrogen separation at -80°C	Proprietary, bonded silica-based		From -80 to 260/300	CP-Silica PLOT
GS-OxyPLOT	Oxygenates	Proprietary phase, high selectivity		To 350	CP-LowOX
GS-CarbonPLOT	C1 to C5 hydrocarbons, CO_2, air/CO, trace acetylene in ethylene, methane	Bonded monolithic carbon layer		From 0 to 360	Carbopack, CLOT, Carboxen-1006 PLOT, CP-CarboPLOT P7
Specialty Phases - Environmental					
DB-624		6% Cyanopropyl-phenyl, 94% dimethyl polysiloxane	Mid-polar	From -20 to 260	AT-624, Rtx-624, PE-624, 007-624, 007-502, CP-624, ZB-624, VF-624ms
DB-VRX	Volatile Organic Compounds using MSD, ELCD/PID	Proprietary phase	Non-polar	From -10 to 260	VOCOL, NON-PAKD, Rtx-Volatiles, PE-Volatiles, 007-624, HP-624, CP-624, Rtx-VRX, Rtx-VGC
DB-35ms	CLP Pesticides, Chlorinated Herbicides, PCBs, 508.1 Pesticides	35% Phenyl, 65% dimethyl arylene siloxane	Mid-polar	From 50 to 340/360	Rtx-35, SPB-35, AT-35, Sup-Herb, MDN-35, BPX-35
HP-5ms, DB-5, HP-5	Semivolatiles by EPA Method 8270	5% Phenyl, 95% dimethylpolysiloxane	Non-polar	From -60 to 325/350	SPB-5, XTI-5, Mtx-5, CP-Sil 8CB, SE-54, Rtx-5, BPX-5, MDN-5, Rtx-5ms

GC Columns Stationary Phase Applications Guide (Continued)

Agilent Phase	Application	Composition	Polarity	Approximate Temp Range (°C)	Similar Phases
DB-XLB (confirmation column)	PCB Congener Analysis (209 Congeners) CLP Pesticides, Chlorinated Herbicides, PCBs, 508.1 Pesticides	Proprietary phase	Non-polar	From 30 to 340/360	Rtx-XLB, MDN-12
DB-TPH	Leaking Underground Fuel Tank (LUFT) testing	Proprietary phase	Non-polar	From -10 to 290	None
DB-MTBE	MTBE in Soil and Water	Proprietary phase	Non-polar	From 35 to 260/280	None
Specialty Phases - Other					
HP-Fast GC Residual Solvents	Residual Solvents	6% Cyanopropyl-phenyl, 94% dimethyl polysiloxane	Mid-polar	From -20 to 260	DB-624, PE-624, 007-624, 007-502, CP-624, ZB-624
DB-ALC1	Blood Alcohol Testing	Proprietary phase	Mid-polar	From 20 to 260/280	Rtx-BAC1, Rtx-BAC2
DB-ALC2	Blood Alcohol Testing	Proprietary phase	Mid-polar	From 20 to 260/280	Rtx-BAC1, Rtx-BAC2
HP-Blood Alcohol	Blood Alcohol Testing	Proprietary phase	Mid-polar	From -60 to 270/290	None

Only Agilent's non-stick premium inlet liner o-rings are pre-cleaned and conditioned to eliminate out gassing contamination. Learn more at **www.agilent.com/chem/o-rings**.

ASTM Methods

Method Designation	Method Title	Column Recommendation	Part No.
D 1945	Standard Test Method for the Analysis of Natural Gas by GC	HP-PLOT Q, 15 m x 0.53 mm, 40.00 µm	19095P-MS9
		HP-PLOT Q, 15 m x 0.53 mm, 40.00 µm	19095P-QO3
D 1946	Standard Test Method for the Analysis of Reformed Gas by GC	HP-PLOT MoleSieve, 15 m x 0.53 mm, 50.00 µm	19095P-MS9
		HP-PLOT Q, 15 m x 0.53 mm, 40.00 µm	19095P-QO3
D 1983	Standard Test Method for Fatty Acid Composition by Gas-Liquid Chromatography of Methyl Esters	DB-WAX, 30 m x 0.25 mm, 0.25 µm	122-7032
D 2163	Standard Test Method for the Analysis of Liquified Petroleum (LP) Gases and Propene Concentrates by GC	HP-PLOT Al_2O_3 "KCl", 30 m x 0.53 mm, 15.00 µm	19095P-K23
		HP-PLOT Al_2O_3 "S", 30 m x 0.53 mm, 15.00 µm	19095P-S23
D 2268	Standard Test Method for Analysis of High-Purity n-Heptane and Isooctane by Capillary GC	DB-1, 60 m x 0.25 mm, 0.50 µm	122-106E
D 2306	Standard Test Method for C8 Aromatic Hydrocarbons by GC	HP-INNOWax, 60 m x 0.25 mm, 0.25 µm	19091N-136
D 2426	Standard Test Method for Butadiene Dimer and Styrene in Butadiene Concentrates by GC	DB-1, 30 m x 0.53 mm, 5.00 µm	125-1035
D 2427	Standard Test Method for Determination of C2 through C5 Hydrocarbons in Gasoline by GC	DB-1, 30 m x 0.53 mm, 5.00 µm	125-1035
		GS-Alumina, 30 m x 0.53 mm	115-3532
D 2504	Standard Test Method for Noncondensable Gases in C2 and Lighter Hydrocarbon Products by GC	HP-PLOT MoleSieve, 30 m x 0.53 mm, 50.00 µm	19095P-MS0
D 2505	Standard Test Method for Ethylene, Other Hydrocarbons, and Carbon Dioxide in High-Purity Ethylene by GC	GS-GasPro, 60 m x 0.32 mm	113-4362
D 2593	Standard Test Method for Butadiene Purity and Hydrocarbon Impurities by GC	GS-Alumina, 30 m x 0.53 mm	115-3532
D 2712	Standard Test Method for for Hydrocarbon Traces in Propylene Concentrates by GC	GS-Alumina, 50 m x 0.53 mm	115-3552

ASTM Methods (Continued)

Method Designation	Method Title	Column Recommendation	Part No.
D 2804	Standard Test Method for Purity of Methyl Ethyl Ketone by GC	DB-WAX, 30 m x 0.53 mm, 1.00 µm	125-7032
		DB-210, 15 m x 0.53 mm, 1.00 µm	125-0212
D 2887	Standard Test Method for Boiling Range Distribution of Petroleum Fractions by GC	DB-2887, 10 m x 0.53 mm, 3.00 µm	125-2814
Extended D 2887	Standard Test Method for Boiling Range Distribution of Petroleum Fractions by GC, to C60	HP-1, 10 m x 0.53 mm, 0.88 µm	19095Z-021
		HP-1, 5 m x 0.53 mm, 0.88 µm	19095Z-020
D 3054	Standard Test Method for Analysis of Cyclohexane by GC	DB-1, 60 m x 0.32 mm, 0.50 µm	123-106E
D 3257	Standard Test Method for Aromatics in Mineral Spirits by GC	DB-624, 30 m x 0.53 mm, 3.00 µm	125-1334
D 3329	Standard Test Method for Purity of Methyl Isobutyl Ketone by GC	DB-WAX, 30 m x 0.53 mm, 1.00 µm	125-7032
		DB-624, 30 m x 0.45 mm, 2.55 µm	124-1334
D 3432	Standard Test Method for Unreacted Toluene Diisocyanates in Urethane Prepolymers and Coating Solutions by GC	HP-1MS, 30 m x 0.32 mm, 1.00 µm	19091S-713
D 3447	Standard Test Method for Purity of Halogentated Organic Solvents	DB-624, 30 m x 0.53 mm, 3.00 µm	125-1334
D 3545	Standard Test Method for Alcohol Content and Purity of Acetate Esters by GC	DB-624, 30 m x 0.53 mm, 3.00 µm	125-1334
D 3687	Standard Test Method for Analysis of Organic Vapors Collected by the Activated Charcoal Tube Adsorption Method	DB-WAX, 30 m x 0.53 mm, 1.00 µm	125-7032
		DB-WAX, 30 m x 0.45 mm, 0.85 µm	124-7032
D 3695	Standard Test Method for Volatile Alcohols in Water by Direct Aqueous-Injection GC	DB-WAX, 30 m x 0.53 mm, 1.00 µm	125-7032
D 3710	Standard Test Method for Boiling Range Distribution of Gasoline and Gasoline Fractions by GC	DB-2887, 10 m x 0.53 mm, 3.00 µm	125-2814
D 3760	Standard Test Method for Analysis of Isopropylbenzene (Cumene) by GC	DB-WAX, 60 m x 0.32 mm, 0.25 µm	123-7062
		HP-1, 50 m x 0.32 mm, 0.52 µm	19091Z-115
D 3797	Standard Test Method for Analysis of o-Xylene by GC	HP-INNOWax, 60 m x 0.32 mm, 0.50 µm	19091N-216
D 3798	Standard Test Method for Analysis of p-Xylene by GC	HP-INNOWax, 60 m x 0.32 mm, 0.50 µm	19091N-216
D 3871	Standard Test Method for Purgeable Organic Compounds in Water Using Headspace Sampling	DB-VRX, 75 m x 0.45 mm, 2.55 µm	124-1574
D 3893	Standard Test Method for Purity of Methyl Amyl Ketone and Methyl Isoamyl Ketone by GC	DB-VRX, 30 m x 0.45 mm, 2.55 µm	124-1534
D 3973	Standard Test Method for Low-Molecular Weight Halogenated Hydrocarbons in Water	DB-VRX, 30 m x 0.45 mm, 2.55 µm	124-1534

ASTM Methods (Continued)

Method Designation	Method Title	Column Recommendation	Part No.
D 4415	Standard Test Method for Determination of Dimer in Acrylic Acid	DB-FFAP, 30 m x 0.32 mm, 0.25 µm	123-3232
D 4424	Standard Test Method for Butylene Analysis by GC	HP-PLOT Al_2O_3 "S", 50 m x 0.53 mm, 15.00 µm	19095P-S25
D 4443	Standard Test Method for Residual Vinyl Chloride Monomer Content in PPB Range in Vinyl Chloride Homo- and Co-Polymers by Headspace GC	DB-VRX, 30 m x 0.45 mm, 2.55 µm	124-1534
D 4735	Standard Test Method for Determination of Trace Thiophene in Refined Benzene by GC	DB-FFAP, 30 m x 0.45 mm, 0.85 µm	124-3232
D 4773	Standard Test Method for Propylene Glycol Monomethyl Ether, Dipropylene Glycol Monomethyl Ether, and Propylene Glycol Monomethyl Ether Acetate	Custom	100-2000
D 4864	Standard Test Method for Determination of Traces of Methanol in Propylene Concentrates by GC	DB-WAX, 30 m x 0.45 mm, 0.85 µm	124-7032
D 4947	Standard Test Method for Chlordane and Heptachlor Residues in Indoor Air	DB-5, 30 m x 0.53 mm, 1.50 µm	125-5032
		DB-608, 30 m x 0.53 mm, 0.83 µm	125-1730
D 4961	Standard Test Method for GC Analysis of Major Organic Impurities in Phenol Produced by the Cumene Process	DB-FFAP, 30 m x 0.45 mm, 0.85 µm	124-3232
		HP-PLOT Q, 15 m x 0.53 mm, 40.00 µm	19095P-QO3
D 4983	Standard Test Method for Cyclohexylamine Morpholine and Diethylaminoethanol in Water and Condensed Steam by Direct Aqueous Injection GC	HP-5MS, 30 m x 0.32 mm, 1.00 µm	19091S-213
		CAM, 30 m x 0.53 mm, 1.00 µm	115-2132
D 5008	Standard Test Method for Ethyl Methyl Pentonal Content and Purity Value of 2-Ethylhexanol by GC	HP-1, 15 m x 0.53 mm, 5.00 µm	19095Z-621
		HP-INNOWax, 30 m x 0.32 mm, 0.25 µm	19091N-113
D 5060	Standard Test Method for Determining Impurities in High-Purity Ethylbenzene by GC	HP-INNOWax, 60 m x 0.32 mm, 0.50 µm	19091N-216
D 5075	Standard Test Method for Nicotine in Indoor Air	DB-5, 30 m x 0.53 mm, 1.50 µm	125-5032
		DB-5, 30 m x 0.32 mm, 1.00 µm	123-5033
D 5134	Standard Test Method for Detailed Analysis of Petroleum Naphthas Through n-Nonane by Capillary GC	HP-PONA, 50 m x 0.20 mm, 0.50 µm	19091S-001
D 5135	Standard Test Method for Analysis of Styrene by Capillary GC	HP-INNOWax, 60 m x 0.32 mm, 0.50 µm	19091N-216
D 5175	Standard Test Method for Organohalide Pesticides and Polychlorinated Biphenyls in Water by Microextraction and GC	DB-1, 30 m x 0.32 mm, 1.00 µm	123-1033
		DB-608, 30 m x 0.32 mm, 0.50 µm	123-1730
		DB-XLB, 30 m x 0.25 mm, 0.25 µm	122-1232
D 5303	Standard Test Method for Trace Carbonyl Sulfide in Propylene by GC	GS-GasPro, 30 m x 0.32 mm,	113-4332
		HP-PLOT Q, 30 m x 0.53 mm, 40.00 µm	19095P-QO4
D 5307	Standard Test Method for Determination of Boiling Range Distribution of Crude Petroleum by GC	HP-1, 7.5 m x 0.53 mm, 5.00 µm	19095Z-627

ASTM Methods (Continued)

Method Designation	Method Title	Column Recommendation	Part No.
D 5310	Standard Test Method for Tar Acid Composition by Capillary GC	HP-5MS, 30 m x 0.25 mm, 0.25 µm	19091S-433
		DB-225ms, 30 m x 0.25 mm, 0.25 µm	122-2932
D 5316	Standard Test Method for 1, 2-Dibromoethane and 1, 2-Dibromo-3-Chloropropane in Water by Microextraction and GC	HP-1MS, 30 m x 0.32 mm, 1.00 µm	19091S-713
		DB-624, 30 m x 0.45 mm, 2.55 µm	124-1334
D 5317	Standard Test Method for Determination of Chlorinated Organic Acid Compounds in Water by GC with Electron Capture Detector	HP-5MS, 30 m x 0.25 mm, 0.25 µm	19091S-433
		DB-1701P, 30 m x 0.25 mm, 0.25 µm	122-7732
		DB-XLB, 30 m x 0.25 mm, 0.25 µm	122-1232
		DB-35ms, 30 m x 0.25 mm, 0.25 µm	122-3832
D 5320	Standard Test Method for Determination of 1, 1-Trichloroethane and Methylene Chloride in Stabilized Trichloroethylene and Tetrachloroethylene	DB-1, 30 m x 0.53 mm, 3.00 µm	125-1034
		DB-VRX, 30 m x 0.32 mm, 1.80 µm	123-1534
D 5399	Standard Test Method for Boiling Point Distribution of Hydrocarbon Solvents by GC	DB-2887, 30 m x 0.32 mm, 1.80 µm	125-2814
D 5441	Standard Test Method for Analysis of Methyl Tert-Butyl Ether (MTBD) by GC	HP-PONA, 50 m x 0.20 mm, 0.50 µm	19091S-001
		DB-Petro, 100 m x 0.25 mm, 0.50 µm	122-10A6
D 5442	Standard Test Method for Analysis of Petroleum Waxes by GC	DB-1, 25 m x 0.32 mm, 0.25 µm	123-1022
		DB-5, 15 m x 0.25 mm, 0.25 µm	122-5012
D 5475	Standard Test Method for Nitrogen – and Phosphorus-Containing Pesticides in Water by GC with a Nitrogen Phosphorus Detector	HP-5MS, 30 m x 0.25 mm, 0.25 µm	19091S-433
		DB-1701P, 30 m x 0.25 mm, 0.25 µm	122-7732
		DB-XLB, 30 m x 0.25 mm, 0.25 µm	122-1232
		DB-35ms, 30 m x 0.25 mm, 0.25 µm	122-3832
D 5480	Standard Test Method for Engine Oil Volatility by GC	DB-PS1, 15 m x 0.53 mm, 0.15 µm	145-1011
D 5501	Standard Test Method for Determination of Ethanol Content of Denatured Fuel Ethanol by GC	HP-1, 100 m x 0.25 mm, 0.50 µm	19091Z-530
D 5507	Standard Test Method for Determination of Trace Organic Impurities in Monomer Grade Vinyl Chloride by Capillary Column/Multi-dimensional GC	HP-PLOT Q, 15 m x 0.53 mm, 40.00 µm	19095P-QO3
		HP-PLOT U, 30 m x 0.53 mm, 0.20 µm	19095P-UO4
D 5508	Standard Test Method for Determinationof Residual Acrylonitrile Monomer in Styrene-Acyrlonitrile Co-polymer Resins and Nitrile-Butadiene Rubber by Headspace Capillary GC	HP-PLOT Q, 30 m x 0.53 mm, 40.00 µm	19095P-QO4
D 5580	Standard Test Method for Determination of Benzene, Toluene, Ethylbenzene, p/m-Xylene, C9 and Heavier Aromatics, and Total Aromatics in Finished Gasoline by GC	DB-1, 30 m x 0.53 mm, 5.00 µm	125-1035
D 5599	Standard Test Method for Determination of Oxygenates in Gasoline by GC and Oxygen Selective Flame Ionization Detection	DB-5, 30 m x 0.25 mm, 0.25 µm	122-5032
D 5623	Standard Test Method for Sulfur Compounds in Light Petroleum Liquids by GC and Sulfur Selective Detection	HP-1, 30 m x 0.32 mm, 4.00 µm	19091Z-613
D 5713	Standard Test Method for Analysis of High Purity Benzene for Cyclohexane Feedstock by Capillary GC	DB-Petro, 50 m x 0.20 mm, 0.50 µm	128-1056

ASTM Methods (Continued)

Method Designation	Method Title	Column Recommendation	Part No.
D 5739	Standard Practice for Oil Spill Source Identification by GC and Positive Ion Electron Impact Low Resolution Mass Spectrometry	DB-5, 30 m x 0.25 mm, 0.25 µm	122-5032
		DB-TPH, 30 m x 0.32 mm, 0.25 µm	123-1632
D 5769	Standard Test Method for Determination of Benzene, Toluene, and Total Aromatics in Finished Gasoline by GC/MS	HP-1, 60 m x 0.25 mm, 1.00 µm	19091Z-236
D 5790	Standard Test Method for Measurement of Purgeable Organic Compounds in Water by Capillary Column GC/MS	DB-VRX, 60 m x 0.25 mm, 1.40 µm	122-1564
		DB-VRX, 20 m x 0.18 mm, 1.00 µm	121-1524
		DB-624, 60 m x 0.25 mm, 1.40 µm	122-1364
		DB-624, 20 m x 0.18 mm, 1.00 µm	121-1324
D 5812	Standard Test Method for Determination of Organochlotine Pesticides in Water by Capillary Column GC	HP-5MS, 30 m x 0.25 mm, 0.25 µm	19091S-433
		DB-1701P, 30 m x 0.25 mm, 0.25 µm	122-7732
		DB-XLB, 30 m x 0.25 mm, 0.25 µm	122-1232
		DB-35ms, 30 m x 0.25 mm, 0.25 µm	122-3832
D 5917	Standard Test Method for Trace Impurities in Monocyclic Aromatic Hydrocarbons by GC and External Calibration	HP-INNOWax, 60 m x 0.32 mm, 0.25 µm	19091N-116
D 5974	Standard Test Method for Fatty and Rosin Acids in Tall Oil Fraction Products by Capillary GC	DB-23, 60 m x 0.25 mm, 0.25 µm	122-2362
D 5986	Standard Test Method for Determination of Oxygenates, Benzene, Toluene, C8-C12 Aromatics and Total Aromatics in Finished Gasoline by GC/FTIR	HP-1, 60 m x 0.53 mm, 5.00 µm	19095Z-626
D 6144	Standard Test Method for Trace Impurities in Alpha-Methylstyrene by Capillary GC	HP-1, 60 m x 0.25 mm, 1.00 µm	19091Z-236
D 6159	Standard Test Method for Determination of Hydrocarbon Impurities in Ethylene by GC	HP-PLOT Al_2O_3 "KCl", 50 m x 0.53 mm, 15.00 µm	19095P-K25
		GS-Alumina, 50 m x 0.53 mm,	115-3552
		DB-1, 50 m x 0.53 mm,	125-1035
D 6160	Standard Test Method for Determination of PCBs in Waste Materials by GC	HP-5MS, 30 m x 0.32 mm, 0.25 µm	19091S-413
		DB-XLB, 30 m x 0.25 mm, 0.25 µm	122-1232
D 6352	Standard Test Method for Boiling Range Distribution of Petroleum Distillates in Boiling Range from 174 to 700 by GC	DB-HT SimDis, 5 m x 0.53 mm, 0.15 µm	145-1001
D 6417	Standard Test Method for Estimation of Engine Oil Volatility by Capillary GC	DB-HT SimDis, 5 m x 0.53 mm, 0.15 µm	145-1001
D 2360	Standard Test Method for Trace Impurities in Monocyclic Aromatic Hydrocarbons by GC	HP-INNOWax, 60 m x 0.32 mm, 0.25 µm	19091N-116
E 1616	Standard Test Method for Analysis of Acetic Anhydride Using GC	HP-1, 50 m x 0.32 mm, 0.52 µm	19091Z-115
E 1863	Standard Test Method for Analysis of Acrylonitrile By GC	DB-WAXetr, 60 m x 0.32 mm, 1.00 µm	123-7364
E 202	Standard Test Method for Analysis of Ethylene Glycols and Propylene Glycols	DB-624, 30 m x 0.53 mm, 3.00 µm	125-1334
E 475	Standard Test Method for Assay of Di-tert-Butyl Peroxide Using GC	HP-5, 30 m x 0.53 mm, 5.00 µm	19095J-623

Environmental/EPA Methods

Many possible column and instrument combinations can be used to obtain successful Environmental and EPA Anlayses. Listed below are a few of the columns Agilent recommends for these analyses. The following recommendations are based upon GCs equipped with split/splitless injectors (except for the volatiles methods). Other column configurations may be suitable with different instrument configurations. To tailor your analytical system to your particular needs, contact your local Agilent office for the best column recommendation.

Environmental/EPA Methods

Analyte Type	EPA Method Reference	Common Sample Preparation	Detector Types	Sample Matrix	Recommended Agilent Column
Volatiles					
Trihalomethanes	501	Purge and trap, direct injection, headspace	ELCD, ECD	Drinking water	124-1534, 124-1334
Volatile Organic Compounds (VOCs)	502.2, 8021, CLP-Volatiles	Purge and trap, direct injection, headspace	PID, ELCD	Drinking water, waste water, solid wastes	124-1574, 124-1374
Purgeable Halogenated Organics	601, 8010	Purge and trap, headspace for screening	PID, ELCD	Waste water, solid wastes	124-1574, 124-1374
Purgeable Aromatic Organics	503.1, 602, 8020	Purge and trap, headspace for screening	PID	Drinking water, waste water, solid wastes	124-1534, 124-1334
Volatile Organic Compounds (VOCs) Using MSD	524.2, 624, 8240, 8260, CLP-VOCs	Purge and trap, direct injection, headspace	MSD	Drinking water, waste water, solid wastes	122-1564, 122-1364, 19091R-306
Volatile Organic Compounds (VOCs) Using 5973 MSD	524.2, 624, 8240, 8260, CLP-VOCs	Purge and trap, direct injection, headspace	MSD (5973)	Drinking water, waste water, solid wastes	121-1524, 121-1324
EDB and DBCP	504.1, 8011	Microextraction with Hexane	ECD	Drinking water, solid wastes	121-1324, 124-1534
Acrylonitrile and Acrolein	603, 8015, 8031	Purge and trap, liquid extraction, sonication	FID, NPD	Waste water, solid wastes	124-1334, 124-1534

Environmental/EPA Methods

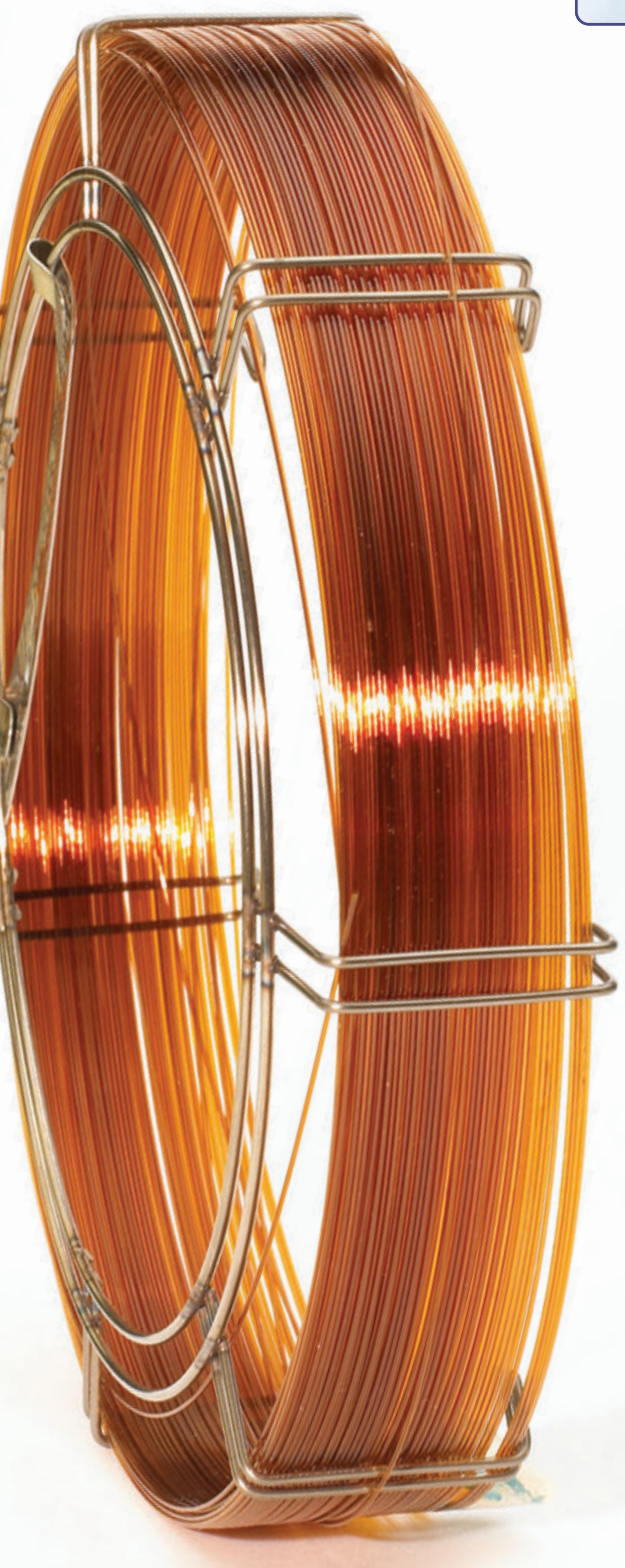
Analyte Type	EPA Method Reference	Common Sample Preparation	Detector Types	Sample Matrix	Recommended Agilent Column
Semivolatiles					
Semivolatile Organic Compounds	525, 625, 8270	Liquid extraction, sonication, soxhlet extraction, SPE	MSD	Drinking water, waste water, solid wastes	19091S-133
Phenols	528, 604, 8040, 8041	Liquid extraction, sonication, soxhlet extraction,derivatization	ECD, FID	Waste water, solid wastes	122-5532, 122-1232, 125-5532, 125-6837
Phthalate Esters	506, 606, 8060, 8061	Liquid extraction, sonication, soxhlet extraction, SPE	ECD, FID	Drinking water, waste water, solid wastes	122-5532, 125-5532, 125-6837
Benzidines	605	Liquid extraction	ECD	Waste water	122-5532, 125-5532, 125-6837
Nitrosamines	607, 8070	Liquid extraction, sonication, soxhlet extraction, SPE	NPD	Waste water, solid wastes	122-5532, 125-5532
Nitroaromatics and Isophorone	609, 8090	Liquid extraction, sonication, soxhlet extraction, SPE	ECD, FID	Waste water, solid wastes	19091S-133, 125-5532, 125-6837
Polynuclear Aromatic Hydrocarbons (PAHs)	610, 8100	Liquid extraction, sonication, soxhlet extraction, SPE	FID	Waste water, solid wastes	122-5532, 123-5532, 122-0132
Chlorinated Hydrocarbons	612, 8120, 8121	Liquid extraction, sonication, soxhlet extraction, SPE	ECD	Waste water, solid wastes	123-5536, 19091S-113, 123-103E
Chlorinated Disinfection Byproducts	551, 551.1A	Liquid extraction, derivatization	ECD	Drinking water	122-5533, 122-1033
Halogenated Acetic Acids	552, 552.1, 552.2	Liquid extraction, derivatization	ECD	Drinking water	123-3832, 123-1236
Pesticides, Herbicides, and PCBs					
Organochlorine Pesticides and PCBs	552, 552.1, 552.2	Liquid extraction, derivatization	ECD	Drinking water	123-3832, 123-1236

United States Pharmacopoeia (USP) GC Phases

USP	Phase Composition	Agilent Phase Recommendation
G1	Dimethylpolysiloxane oil	HP-1*, DB-1*, HP-1ms*, DB-1ms*
G2	Dimethylpolysiloxane gum	HP-1*, DB-1*, HP-1ms*, DB-1ms*
G3	50% Phenyl – 50% methylpolysiloxane	DB-17*, HP-50+*
G5	3-cyanopropyl polysiloxane	DB-23
G6	Trifluoropropylmethylpolysilicone	DB-200, DB-210
G7	50% 3-cyanopropyl – 50% phenylmethylsilicone	DB-225, DB-225ms
G14	Polyethylene glycol (average molecular weight of 950-1,050)	DB-WAX
G15	Polyethylene glycol (average molecular weight of 3,000-3,700)	DB-WAX
G16	Polyethylene glycol (average molecular weight of 15,000)	DB-WAX*
G17	75% Phenyl – 25% methylpolysiloxane	DB-17, HP-50+
G19	25% Phenyl – 25% cyanopropylmethylsilicone	DB-225*, DB-225ms
G20	Polyethylene glycol (average molecular weight of 380-420)	DB-WAX
G25	Polyethylene glycol TPA (Carbowax 20M terephthalic acid)	DB-FFAP*, HP-FFAP*
G27	5% Phenyl – 95% methylpolysiloxane	DB-5*, HP-5*, HP-5ms*, DB-5ms
G28	25% Phenyl – 75% methylpolysiloxane	DB-35, HP-35, DB-35ms
G32	20% Phenylmethyl – 80% dimethylpolysiloxane	DB-35, HP-35, DB-35ms
G35	Polyethylene glycol & diepoxide esterified with nitroterepthalic acid	DB-FFAP*, HP-FFAP*
G36	1% Vinyl – 5% phenylmethylpolysiloxane	DB-5, HP-5, HP-5ms, DB-5ms
G38	Phase G1 plus a tailing inhibitor	DB-1, HP-1, HP-1ms, DB-1ms
G39	Polyethylene glycol (average molecular weight of 1,500)	DB-WAX
G41	Phenylmethyldimethylsilicone (10% phenyl substituted)	DB-5, HP-5, HP-5ms, DB-5ms
G42	35% Phenyl – 65% dimethylvinylsiloxane	DB-35*, HP-35*, DB-35ms
G43	6% Cyanopropylphenyl – 94% dimethylpolysiloxane	DB-624*, DB-1301
G45	Divinylbenzene-ethylene glycol-dimethacrylate	HP-PLOT U*
G46	14% Cyanopropylphenyl – 86% methylpolysiloxane	DB-1701*

*Indicates an exact equivalent

GC Applications



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Hydrocarbon Processing Industry – here you'll find applications – such as the analysis of sulfur compounds in propylene – that you can use right away to meet regulatory requirements, improve efficiency, and maintain good environmental stewardship. *See page 52.*

Food, Flavors, and Fragrances – we'll discuss how to ensure quality, safety, and regulatory compliance for fragrances, perfumes, and essential oils. Applications focus on chiral compounds, menthol, and FAMEs. *See page 55.*

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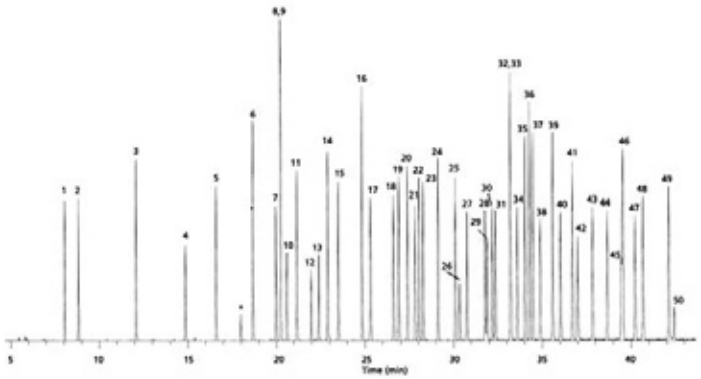
Organochlorine Pesticides I EPA Method 8081A

Column: DB-35ms
122-3832
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 35 cm/sec, measured at 50°C
Oven: 50°C for 1 min
50-100°C at 25°/min
100-300°C at 5°/min
300°C for 5 min
Injection: Splitless, 250°C
30 sec purge activation time
Detector: MSD, 300°C transfer line
Full scan at m/z 50-500
Sample: 1 µL of 35 µg/mL composite 8081A standards, Accustandard Inc.



1. 1,2-Dibromo-3-chloropropane
2. 4-Chloro-3-nitrobenzotrifluoride (SS)
3. Hexachloropentadiene
4. 1-Bromo-2-nitrobenzene (IS)
5. Terrazole
6. Chloroneb
7. Trifluralin
8. 2-Bromobiphenyl (SS)
9. Tetrachloro m-xylene (SS)
10.
11. Propachlor
12. Di-allate A
13. Di-allate B
14. Hexachlorobenzene
15.
16. Pentachloronitrobenzene (IS)
17.
18.
19. Heptachlor
20. Alachlor
21.
22. Chlorothalonil
23. Aldrin
24. Dacthal
25. Isodrin
26. Kelthane
27. Heptachlor epoxide
28.
29. trans-Nonachlor
30.
31. Endosulfan I
32. Captan
33. p,p'-DDE
34. Dieldrin
35. Chlorobenzilate
36. Perthane
37. Chloropropylate
38. Endrin
39. p,p'-DDD
40. Endosulfan II
41. p,p'-DDT
42. Endrin aldehyde
43. Endosulfan sulfate
44. Dibutylchlorendate (SS)
45. Captafol
46. Methoxychlor
47. Endrin ketone
48. Mirex
49. cis-Permethrin
50. trans-Permethrin

Standards used were a composite of individual solutions supplied courtesy of Accustandard Inc., 25 Science Park, New Haven, CT 06511, 800-442-5290.

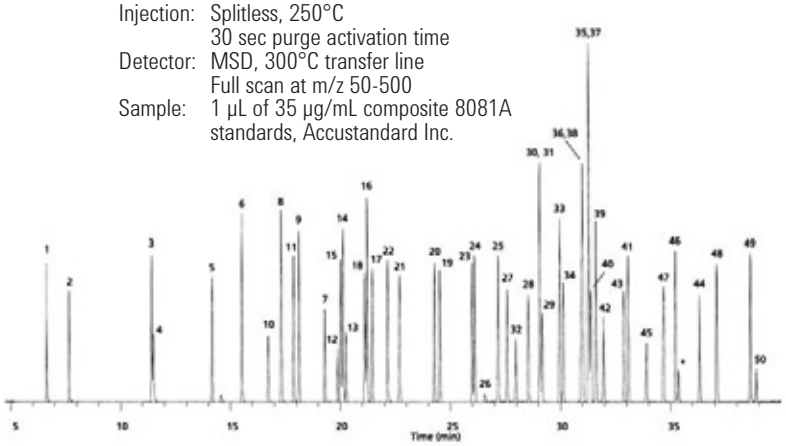
Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Splitless, single taper, deactivated, 4mm ID, 5181-3316
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

* Breakdown Products
SS - Surrogate Standard
IS - Internal Standard

Organochlorine Pesticides II EPA Method 8081A

Column: DB-5ms
122-5532
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 35 cm/sec, measured at 50°C
Oven: 50°C for 1 min
50-100°C at 25°/min
100-300°C at 5°/min
300°C for 5 min
Injection: Splitless, 250°C
30 sec purge activation time
Detector: MSD, 300°C transfer line
Full scan at m/z 50-500
Sample: 1 µL of 35 µg/mL composite 8081A standards, Accustandard Inc.



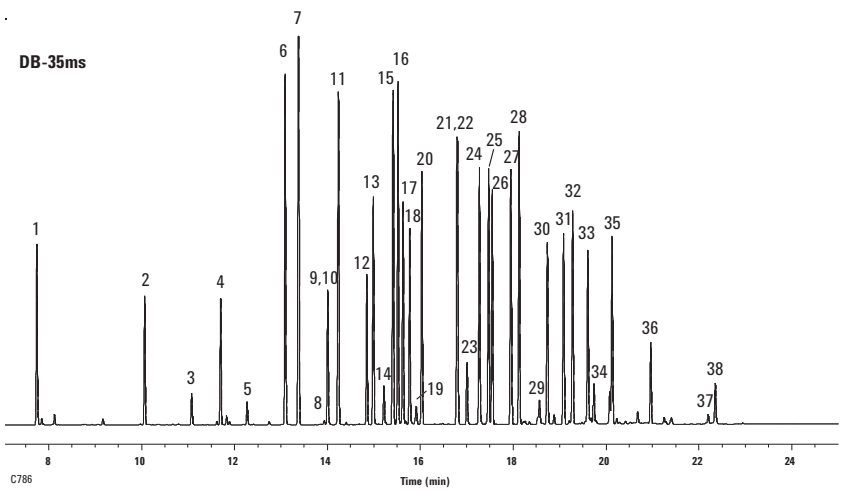
1. 1,2-Dibromo-3-chloropropane
2. 4-Chloro-3-nitrobenzotrifluoride (SS)
3. Hexachloropentadiene
4. 1-Bromo-2-nitrobenzene (IS)
5. Terrazole
6. Chloroneb
7. Trifluralin
8. 2-Bromobiphenyl (SS)
9. Tetrachloro m-xylene (SS)
10.
11. Propachlor
12. Di-allate A
13. Di-allate B
14. Hexachlorobenzene
15.
16. Pentachloronitrobenzene (IS)
17.
18.
19. Heptachlor
20. Alachlor
21.
22. Chlorothalonil
23. Aldrin
24. Dacthal
25. Isodrin
26. Kelthane
27. Heptachlor epoxide
28.
29. trans-Nonachlor
30.
31. Endosulfan I
32. Captan
33. p,p'-DDE
34. Dieldrin
35. Chlorobenzilate
36. Perthane
37. Chloropropylate
38. Endrin
39. p,p'-DDD
40. Endosulfan II
41. p,p'-DDT
42. Endrin aldehyde
43. Endosulfan sulfate
44. Dibutylchlorendate (SS)
45. Captafol
46. Methoxychlor
47. Endrin ketone
48. Mirex
49. cis-Permethrin
50. trans-Permethrin

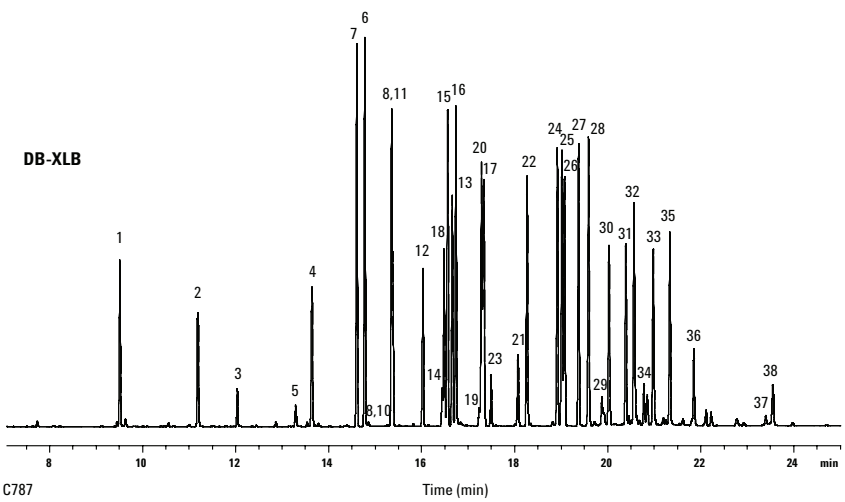
Pesticides, EPA 508.1

Column: DB-35ms
123-3832
30 m x 0.32 mm, 0.25 µm
Column: DB-XLB
123-1236
30 m x 0.32 mm, 0.50 µm

Carrier: Helium at 45 cm/sec (EPC in constant flow mode)
Oven: 75°C for 0.5 min
75-300°C at 10° C/min
300°C for 2 min
Injection: Splitless, 250°C
30 sec purge activation time
Detector: µECD, 350°C
Nitrogen makeup gas
(column + makeup flow = 30 mL/min constant flow)
Sample: 50 pg per component

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct connect, single taper, deactivated, 4mm ID, G1544-80730
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267





1. Hexachlorocyclopentadiene
2. Etridiazole
3. Chloroneb
4. Trifluralin
5. Propachlor
6. Hexachlorobezene
7.
8. Atrazine
9. Pentachloronitrobenzene
10. Simazine
11.
12.
13. Heptachlor
14. Alachlor
15.
16. Chlorothalonil
17. Aldrin
18. Metribuzin
19. Metolachlor
20. DCPA
21. 4,4'-Dibromobiphenyl
22. Heptachlor epoxide
23. Cyanazine
24.
25.
26. Endosulfan I
27. 4,4'-DDE
28. Dieldrin
29. Chlorobenzilate
30. Endrin
31. 4,4'-DDD
32. Endosulfan II
33. 4,4'-DDT
34. Endrin aldehyde
35. Endosulfan sulfate
36. Methoxychlor
37. cis-Permethrin
38. trans-Permethrin

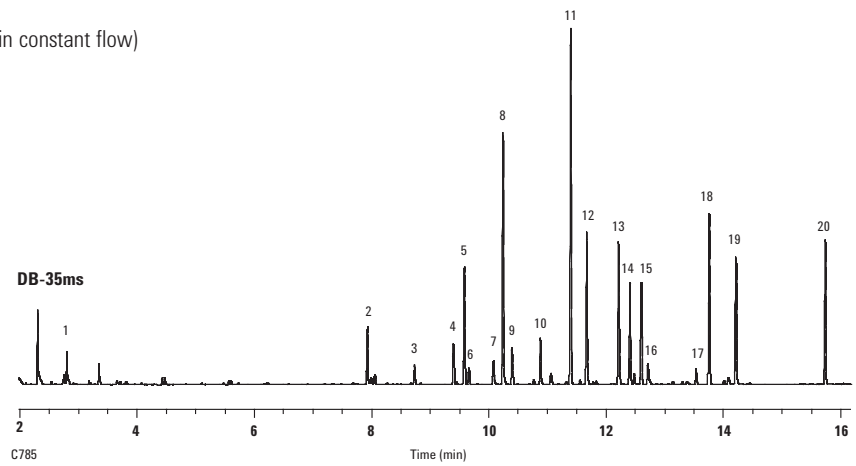
Phenoxy Acid Herbicides - Methyl Derivatives, EPA 8151A

Column: DB-35ms
123-3832
30 m x 0.32 mm, 0.25 µm

Carrier: Helium at 45 cm/sec (EPC in constant flow mode)
Oven: 50°C for 0.5 min
50-100°C at 25°C/min
100-320°C at 12°C/min
320°C for 2 min
Injection: Splitless, 250°C
30 sec purge activation time
Detector: µECD, 350°C
Nitrogen makeup gas
(column + makeup flow = 30 mL/min constant flow)
Sample: 50 pg per component

1. Dalapon
2. 3,5-Dichlorobenzoic acid
3. 4-Nitrophenol
4. Methyl-2,4-dichlorophenylacetate (SS)
5. Dicamba
6. MCPP
7. MCPA
8. 4,4
9. Dichloroprop
10. 2,4-D
11. Pentachlorophenol
12. 2,4,5-T,P
13. 2,4,5-T
14. Chloramben
15. Dinoseb
16. 2,4-DB
17. Bentazone
18. DCPA
19. Picloram
20. Acifluorofen

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Splitless, single taper, deactivated, 4mm ID, 5181-3316
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267



Only Agilent's Premium Inlet septa have a proprietary plasma treated surface to assure a non-stick septum every time, without compromising the cleanliness and integrity of your GC system. Learn more at **www.agilent.com/chem/septa**.

Herbicides

Column: DB-XLB
122-1232
30 m x 0.25 mm, 0.25 µm

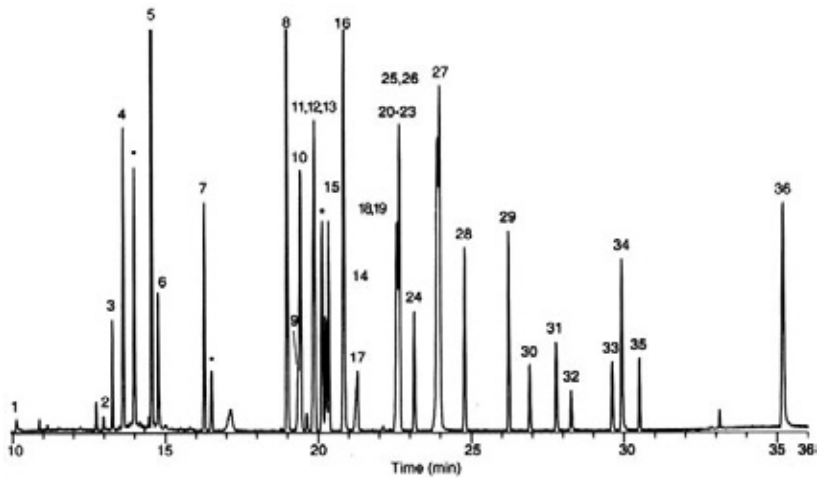
Carrier: Helium at 32 cm/sec, measured at 50°C
Oven: 50°C for 1 min
50-180°C at 10°/min
180-230°C at 5°/min
230-320°C at 10°/min
320°C for 2 min

1. Monuron
2. Diuron
3. EPTC
4. Dichlobenil
5. Vernolate
6. Pebulate
7. Molinate
8. Sulfallate
9. Atraton
10. Prometon
11. Atrazine
12. Propazine
13. Simazine
14. Terbuthylazine
15. Pronamide
16. Secbumeton
17. Terbacil
18. Alachlor
19. Propanil
20. Ametryne
21. Prometryne
22. Simetryn
23. Metribuzin
24. Terbutryn
25. Metolachlor
26. Bromacil
27. Dacthal
28. Diphenamid
29. Butachlor
30. Napropamide
31. Carboxin
32. Tricyclazole
33. Norflurazon
34. Hexazinone
35. Difolotan
36. Fluridone

* Impurity

Injection: Splitless, 250°C
30 sec purge activation time
Detector: MSD, 300°C transfer line
Full scan 50-400
Sample: 2 µL x 10-50 ng/µL solution in acetone

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Splitless, single taper, deactivated, 4mm ID, 5181-3316
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

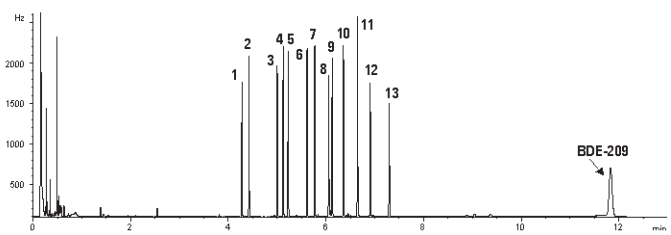


PBDEs by ECD

Column: DB-XLB
15 m x 0.18 mm ID, 0.07 µm
Agilent Technologies custom column

1. 2,2',4-TriBDE (BDE-17)
2. 2,4,4'-TriBDE (BDE-28)
3. 2,3',4',6-Tetra-BDE (BDE-71)
4. 2,2',4,4'-Tetra-BDE (BDE-47)
5. 2,3',4,4'-TetraBDE (BDE-66)
6. 2,2',4,4',6-PentaBDE (BDE-100)
7. 2,2',4,4',5-PentaBDE (BDE-99)
8. 2,2',3,4,4'-PentaBDE (BDE-85)
9. 2,2',4,4',5,6'-HexaBDE (BDE-154)
10. 2,2',4,4',5,5'-HexaBDE (BDE-153)
11. 2,2',3,4,4',5'-HexaBDE (BDE-138)
12. 2,2',3,4,4',5',6-HeptaBDE (BDE-183)
13. 2,3,3',4,4',5,6-HeptaBDE (BDE-190)
14. DecaBDE (BDE-209) (12.5 mg/mL)

Carrier: Hydrogen at 72 cm/sec at 100°C
(4.0 mL/min), constant flow mode
Oven: 100°C for 0.5 min
100°C to 300°C at 30°C/min
300°C for 5 min
Injection: Split, 250°C
Split ratio 20:1
Detector: ECD, 300°C
Peak, Congener (2.5 mg/mL)
Sample: 1 µL

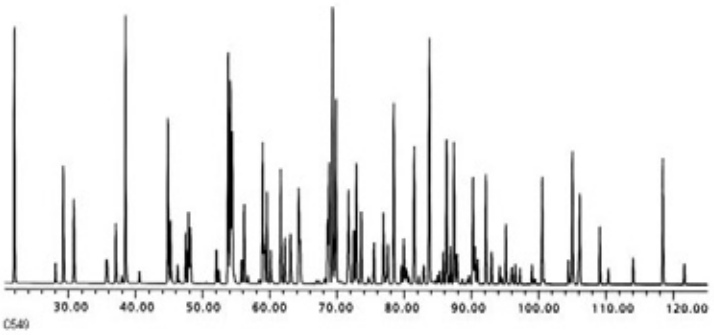


Special thanks to Accustandard, Inc. of New Haven , CT, for PBDE standards.

Aroclors 1016-1268 (without 1221)

Column: DB-XLB
121-1232
30 m x 0.18 mm, 0.18 µm

Carrier: Helium at 37 cm/sec, measured at 150°C
Oven: 100°C for 1 min
100-265°C at 1.2°/min
Injection: Hot On-column, 250°C
Detector: MSD, 340°C transfer line, SIM
Sample: 1 µL in isooctane, 12.5 ppm

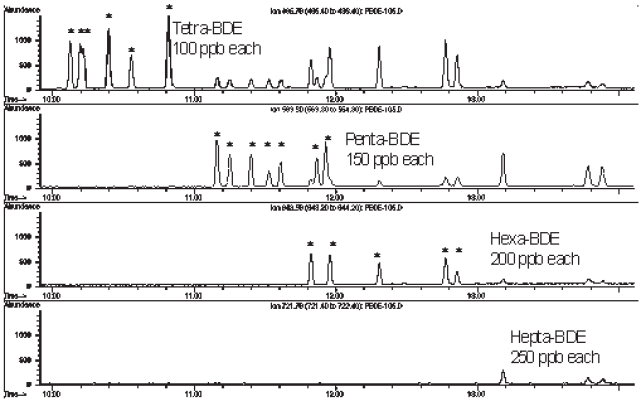


Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct connect, single taper, deactivated, 4mm ID, G1544-80730
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

PBDEs

Column: DB-XLB
122-1231
30 m x 0.25 mm, 0.10 µm

Carrier: Helium at 38 cm/sec at 100°C (1.2mL/min), constant flow mode
Oven: 100°C for 1 min; 100°C to 340°C at 20°C/min, 340°C for 12 min
Injection: Cool-on-column, oven-track mode
Detector: Agilent 5973 MSD, 325°C transfer line, EI SIM (ions monitored: 231.8, 248.0, 327.9, 398.6, 400.5, 405.8, 845.7, 563.6, 643.5, 721.4, 799.3)
Sample: 0.5 µL



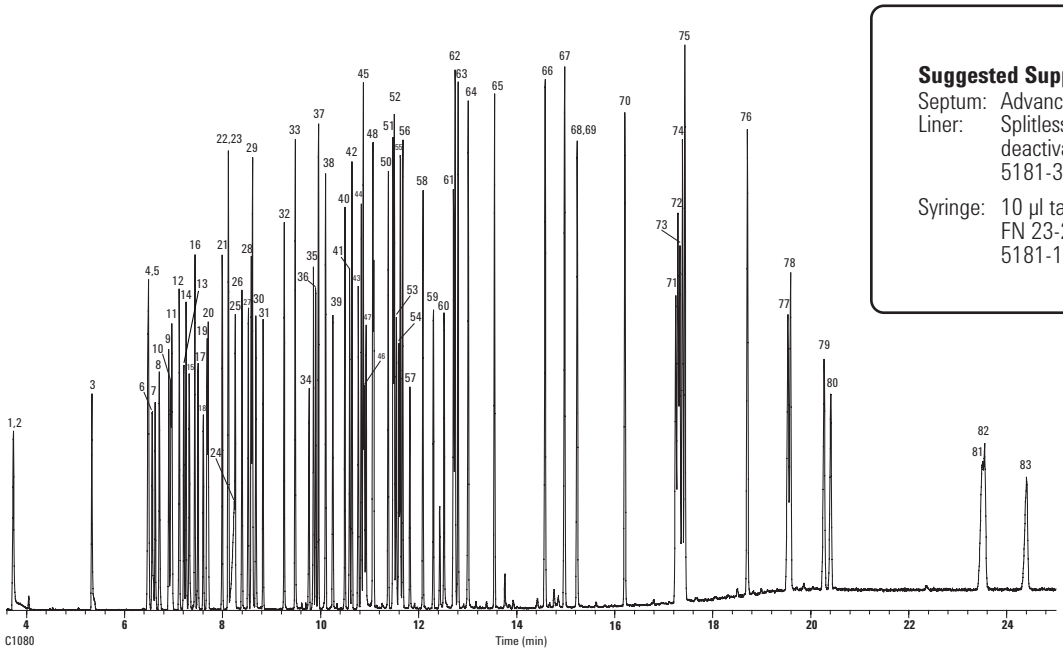
For a complete application note, visit www.agilent.com/chem, select "Online Literature" from the Literature Library and type 5989-0094EN into the "Keyword" field.

Semivolatile Compounds, EPA Method 8270

Column: HP-5ms
19091S-133
30 m x 0.25 mm, 0.50 µm

Carrier: Ramped flow 1.2 mL/min for 0.0 min
Ramp at 99 mL/min to 2.0 mL/min
2.0 mL/min for 0.35 min
Ramp at 10 mL/min to 1.2 mL/min

Oven: 40°C for 1.0 min
40-100°C at 15°C/min
100-240°C at 20°C/min
240-310°C at 10°C/min
Injection: Splitless, 250°C
30 mL/min purge flow at 0.35 min
Detector: 5973 MSD, 310°C transfer line
Scan range 35-500 amu, 3.25 scans/sec
Sample: 1 µL of 50 ng standard



Suggested Supplies

Septum: Advanced Green, 5183-4759
Liner: Splitless, single taper, deactivated, 4mm ID, 5181-3316
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

1. n-Nitrosodimethylamine
2. Pyridine
3. 2-Fluorophenol
4. Phenol-d5
5. Phenol
6. Aniline
7. Bis(2-chloroethyl) ether
8. 2-Chlorophenol
9. 1,3-Dichlorobenzene
10. 1,4-Dichlorobenzene-d4
11. 1,4-Dichlorobenzene
12. Benzyl alcohol
13. 1,2-Dichlorobenzene
14. 2-Methylphenol
15. Bis(2-chloroisopropyl) ether
16. 4-Methylphenol
17. n-Nitroso-di-n-propylamine
18. Hexachloroethane
19. Nitrobenzene-d5
20. Nitrobenzene
21. Isophorone
22. 2-Nitrophenol
23. 2,4-Dimethylphenol
24. Benzoic acid
25. Bis(2-chloroethoxy) methane
26. 2,4-Dichlorophenol
27. 1,2,4-Trichlorobenzene
28. Naphthalene-d8
29. Naphthalene
30. 4-Chloroaniline
31. Hexachlorobutadiene
32. 4-Chloro-3-methylphenol
33. 2-Methylnaphthalene
34. Hexachlorocyclopentadiene
35. 2,4,6-Trichlorophenol
36. 2,4,5-Trichlorophenol
37. 2-Fluorobiphenyl
38. 2-Chloronaphthalene
39. 2-Nitroaniline
40. Dimethylphthalate
41. 2,6-Dinitrotoluene
42. Acenaphthylene
43. 3-Nitroaniline
44. Acenaphthene-d10
45. Acenaphthene
46. 2,4-Dinitrophenol
47. 4-Nitrophenol
48. Dibenzofuran
49. 2,4-Dinitrotoluene
50. Diethylphthalate
51. 4-Chlorophenyl-phenyl ether
52. Fluorene
53. 4-Nitroaniline
54. 4,6-Dinitro-2-methylphenol
55. n-Nitrosodiphenylamine
56. Azobenzene
57. 2,4,6-Tribromophenol
58. 4-Bromophenyl-phenylether
59. Hexachlorobenzene
60. Pentachlorophenol
61. Phenanthrene-d10
62. Phenanthrene
63. Anthracene
64. Carbazole
65. Di-n-butylphthalate
66. Fluoranthene
67. Pyrene
68. Terphenyl-d14
69. Benzidine
70. Butylbenzylphthalate
71. 3,3'-Dichlorobenzidine
72. Benzo[a]anthracene
73. Chrysene-d12
74. Chrysene
75. Bis(2-ethylhexyl) phthalate
76. Di-n-octylphthalate
77. Benzo[b]fluoranthene
78. Benzo[k]fluoranthene
79. Benzo[a]pyrene
80. Perylene-d12
81. Indeno[1,2,3-cd]pyrene
82. Dibenz[a,h]anthracene
83. Benzo[g,h,I]perylene

A variety of Agilent HP-5ms and DB-5ms columns can be used for 8270 and similar semivolatiles applications. The column shown above was chosen to maximize inertness and robustness to residues with a thicker 0.5 µm film, but the price paid is a slightly longer run time. An HP-5ms, 30 m x 0.25 mm ID, 0.25 µm, P/N 19091S-433 would give shorter run times, with slightly less inertness and robustness. A DB-5ms, 30 m x 0.25 mm ID, 0.25 µm, P/N 122-5532, would give slightly less inertness, but offer better resolution of PAHs such as Benzo[b]fluoranthene and Benzo[k]fluoranthene. A DB-5ms, 20 m x 0.18 mm x 0.18 µm, P/N 121-5522, can offer significantly reduced run times with a modest loss of inertness.

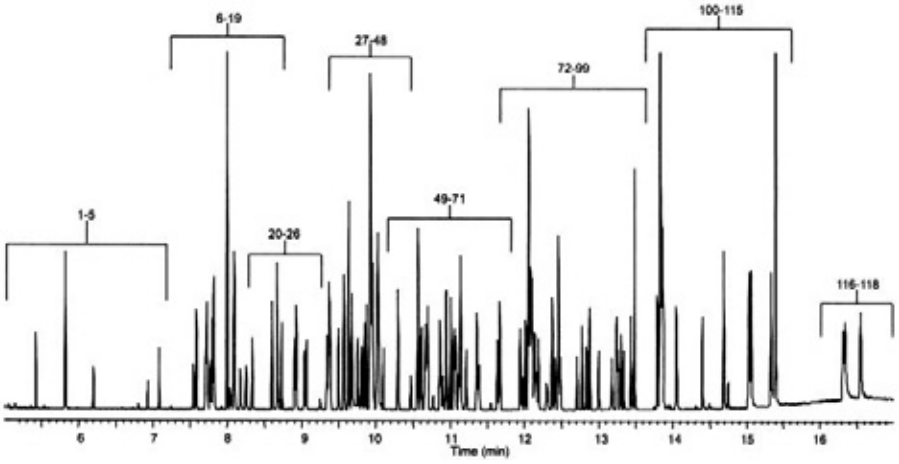
EPA Method 525.2

Column: DB-5ms
122-5532
30 m x 0.25 mm, 0.25 µm

Carrier: Helium, at 32 cm/sec, measured at 45°C, constant flow mode
Oven: 45°C for 1 min
45-130°C at 30°/min
130°C for 3 min
130-180°C at 12°/min
180-240°C at 7°/min
240-325°C at 12°/min
325°C for 5 min
Injection: Splitless, 300°C
1.0 min purge activation time
FocusLiner

Detector: MSD, 325°C transfer line
Full scan m/z 45-450
Sample: Composite mixture of Accustandard Method 525.2 standards (M-525.2-SV-ASL, M-525.2-FS-ASL, M-525.2-CP-ASL, M-525.2-NP1-ASL, M-525.2-NP2-ASL): target compounds at 2 ng/µL, IS/SS at 5 ng/µL

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct connect, single taper, deactivated, 4mm ID, G1544-80730
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

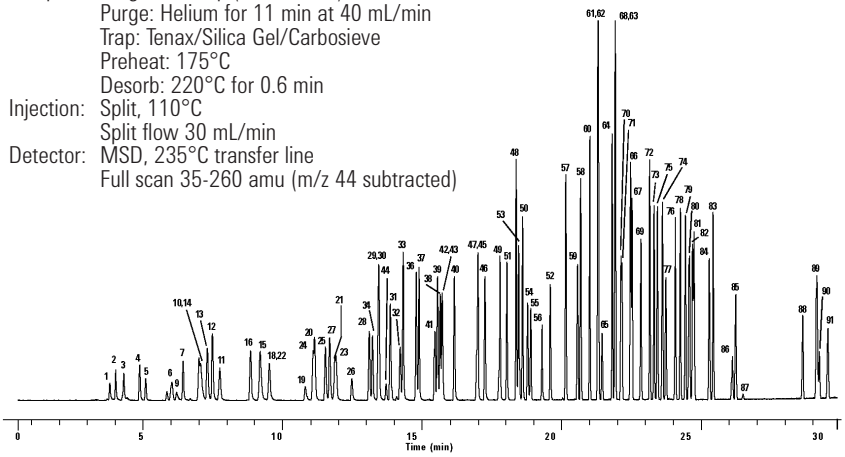


EPA Volatiles by GC/MS (Split Injector)

Column: DB-VRX
122-1564
60 m x 0.25 mm, 1.40 µm

Carrier: Helium at 30 cm/sec, measured at 45°C
Oven: 45°C for 10 min
45-190°C at 12°/min
190°C for 2 min
190-225°C at 6°/min
225°C for 1 min
Sampler: Purge and Trap (O.I.A. 4560)
Purge: Helium for 11 min at 40 mL/min
Trap: Tenax/Silica Gel/Carbosieve
Preheat: 175°C
Desorb: 220°C for 0.6 min
Injection: Split, 110°C
Split flow 30 mL/min
Detector: MSD, 235°C transfer line
Full scan 35-260 amu (m/z 44 subtracted)

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal kit, 5188-5367

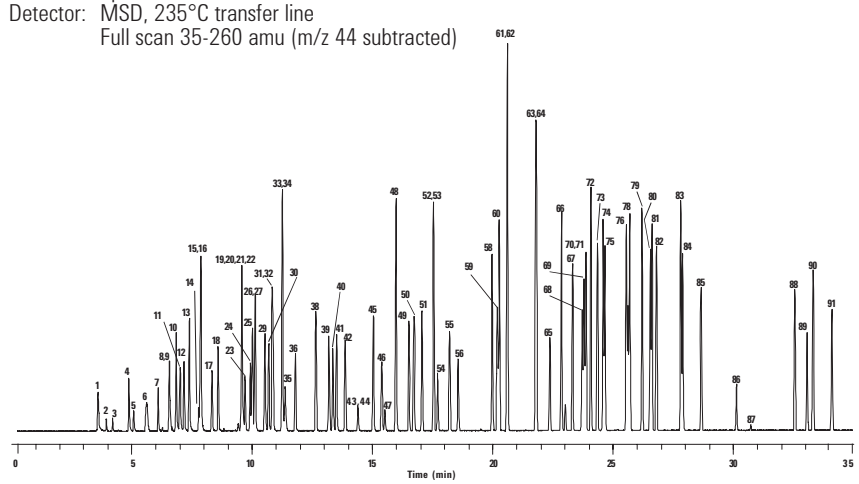


Column: DB-624
122-1364
60 m x 0.25 mm, 1.40 µm

Carrier: Helium at 30 cm/sec, measured at 45°C
Oven: 45°C for 10 min
45-190°C at 12°/min
190°C for 2 min
190-225°C at 6°/min
225°C for 1 min
Sampler: Purge and Trap (O.I.A. 4560)
Purge: Helium for 11 min at 40 mL/min
Trap: Tenax/Silica Gel/Carbosieve
Preheat: 175°C
Desorb: 220°C for 0.6 min
Injection: Split, 110°C
Split flow 30 mL/min
Detector: MSD, 235°C transfer line
Full scan 35-260 amu (m/z 44 subtracted)

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal kit, 5188-5367

IS - Internal Standard
SS - Surrogate Standard
Note: Some compounds not present in both chromatograms



1. Dichlorodifluoromethane
2. Chloromethane
3. Vinyl chloride
4. Bromomethane
5. Chloroethane
6. Trichlorofluoromethane
7. Diethyl ether
8. 1,1-Dichloroethene
9. Acetone
10. Iodomethane
11. Carbon disulfide
12. Allyl chloride
13. Methylene chloride
14. Acrylonitrile
15. Methyl-tert-butyl ether
16. trans-1,2-Dichloroethene
17. Hexane
18. 1,1-Dichloroethane
19. 2-Butanone
20. cis-1,2-Dichloroethene
21. 2,2-Dichloropropane
22. Propionitrile
23. Methyl acrylate
24. Methacrylonitrile
25. Bromochloromethane
26. Tetrahydrofuran
27. Chloroform
28. Pentafluorobenzene (IS)
29. 1,1,1-Trichloroethane
30. 1-Chlorobutane
31. 1,1-Dichloropropene
32. Carbon tetrachloride
33. Benzene
34. 1,2-Dichloroethane
35. 2,2-Dimethylhexane
36. Fluorobenzene (IS)
37. 1,4-Difluorobenzene (IS)
38. Trichloroethene
39. 1,2-Dichloropropane
40. Methyl methacrylate
41. Dibromomethane
42. Bromodichloromethane
43. 2-Nitropropane
44. Chloroacetonitrile
45. cis-1,3-Dichloropropene
46. 4-Methyl-2-pentanone
47. 1,1-Dichloro-2-propanone
48. Toluene
49. trans-1,3-Dichloropropene
50. Ethyl methacrylate
51. 1,1,2-Trichloroethane
52. Tetrachloroethene
53. 1,3-Dichloropropane
54. 2-Hexanone
55. Dibromochloromethane
56. 1,2-Dibromoethane
57. 1-Chloro-3-fluorobenzene (IS)
58. Chlorobenzene
59. 1,1,1,2-Tetrachloroethane
60. Ethylbenzene
61. m-Xylene
62. p-Xylene
63. o-Xylene
64. Styrene
65. Bromoform
66. Isopropylbenzene
67. 4-Bromofluorobenzene (SS)
68. 1,1,2,2-Tetrachloroethane
69. Bromobenzene
70. 1,2,3-Trichloropropane
71. trans-1,4-Dichloro-2-butene
72. n-Propylbenzene
73. 2-Chlorotoluene
74. 1,3,5-Trimethylbenzene
75. 4-Chlorotoluene
76. tert-Butylbenzene
77. Pentachloroethane
78. 1,2,4-Trimethylbenzene
79. sec-Butylbenzene
80. 1,3-Dichlorobenzene
81. p-Isopropyltoluene
82. 1,4-Dichlorobenzene
83. n-Butylbenzene
84. 1,2-Dichlorobenzene
85. Hexachloroethane
86. 1,2-Dibromo-3-chloropropane
87. Nitrobenzene
88. 1,2,4-Trichlorobenzene
89. Hexachlorobutadiene
90. Naphthalene
91. 1,2,3-Trichlorobenzene

High Speed VOC, EPA Method 8260

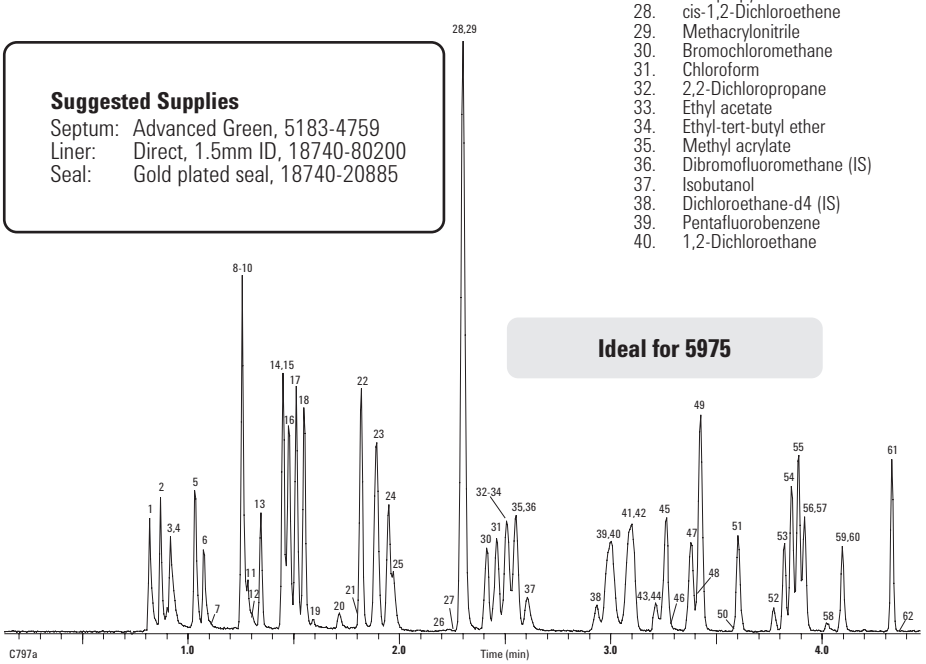
Column: DB-VRX
121-1524
20 m x 0.18 mm, 1.00 µm

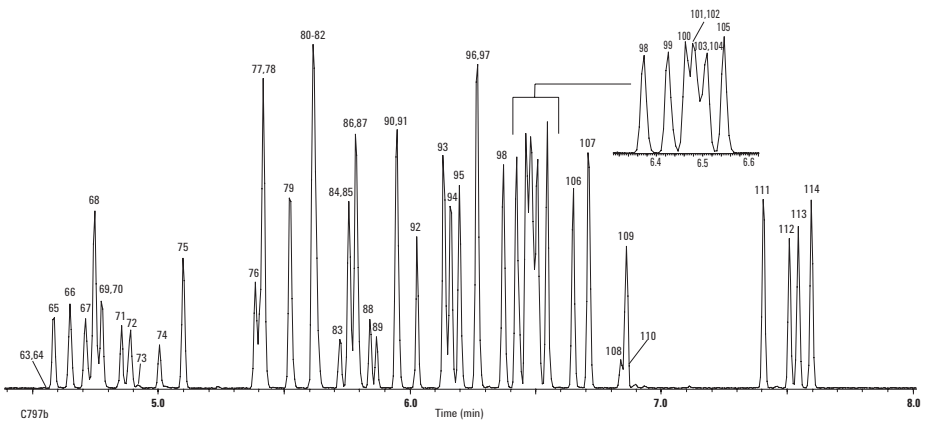
Carrier:	Helium at 55 cm/sec (1.5 mL/min)	
Oven:	45°C for 3.0 minutes	190-225°C at 20°C/min
	45-190°C at 36°C/min	225°C for 0.5 min
Sampler:	Purge and Trap	Preheat: 245°C
	(Tekmar 3100)	Desorb: 250°C for 1min
	Purge: 11 min	Bake: 260°C for 10 min
	Trap: Vocarb 3000	Line & valve: 100°C
Injection:	Split, 150°C	
	Split ratio 60:1	
Detector:	Agilent 5973 MSD,	Source temperature: 200°C
	Scan range: 35-260 amu	Transfer line temp:
	Scan rate: 3.25 scans/sec	200°C
	Quad temperature: 150°C	
Sample:	5 mL	

- Halogentated and aromatic analytes at 40 ppb
- Internal standards at 20 ppb
- Polar analytes (i.e., ethers, alcohols and ketones at 100-800 ppb)

Suggested Supplies

Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal, 18740-20885





Ideal for 5975

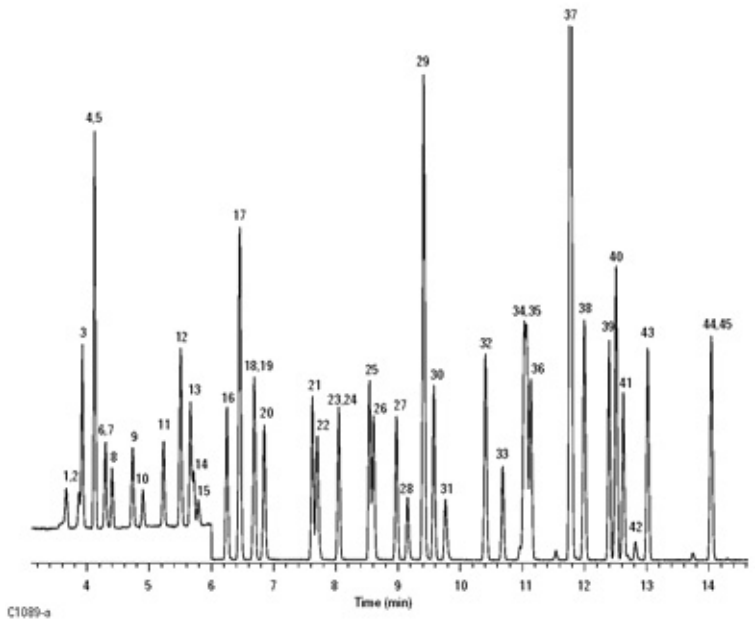
1. Dichlorodifluoromethane
2. Chloromethane
3. Hydroxypropionitrile
4. Vinyl chloride
5. Bromomethane
6. Chloroethane
7. Ethanol
8. Acetonitrile
9. Acrolein
10. Trichlorofluoromethane
11. Isopropyl alcohol
12. Acetone
13. Ethyl ether
14. 1,1-Dichloroethene
15. tert-Butyl alcohol
16. Acrylonitrile
17. Methylene chloride
18. Allyl chloride
19. Allyl alcohol
20. 1-Propanol
21. Propargyl alcohol
22. trans-1,2-Dichloroethene
23. MTBE
24. 1,1-Dichloroethane
25. Propionitrile
26. 2-Butanone
27. Diisopropyl ether
28. cis-1,2-Dichloroethene
29. Methacrylonitrile
30. Bromochloromethane
31. Chloroform
32. 2,2-Dichloropropane
33. Ethyl acetate
34. Ethyl-tert-butyl ether
35. Methyl acrylate
36. Dibromofluoromethane (IS)
37. Isobutanol
38. Dichloroethane-d4 (IS)
39. Pentafluorobenzene
40. 1,2-Dichloroethane
41. 1,1,1-Trichloroethane
42. 1-Chlorobutane
43. Crotonaldehyde
44. 2-Chloroethanol
45. 1,1-Dichloropropene
46. 1-Butanol
47. Carbon tetrachloride
48. Chloroacetonitrile
49. Benzene
50. tert-Amylmethyl ether
51. Fluorobenzene (IS)
52. 2-Pentanone
53. Dibromomethane
54. 1,2-Dichloropropane
55. Trichloroethene
56. Bromodichloromethane
57. 2-Nitropropane
58. 1,4-Dioxane
59. Epichlorohydrin
60. Methyl methacrylate
61. cis-1,3-Dichloropropene
62. Propiolactone
63. Bromoacetone
64. Pyridine
65. trans-1,3-Dichloropropene
66. 1,1,2-Trichloroethane
67. Toluene-d8 (IS)
68. Toluene
69. 1,3-Dichloropropane
70. Paraldehyde
71. Ethyl methacrylate
72. Dibromochloromethane
73. 3-Chloropropionitrile
74. 1,2-Dibromoethane
75. Tetrachloroethene
76. 1,1,1,2-Tetrachloroethane
77. 1-Chlorohexane
78. Chlorobenzene
79. Ethylbenzene
80. Bromoform
81. m-Xylene
82. p-Xylene
83. trans-Dichlorobutene
84. 1,3-Dichloro-2-propanol
85. Styrene
86. 1,1,2,2-Tetrachloroethane
87. o-Xylene
88. 1,2,3-Trichlropropane
89. cis-Dichlorobutene
90. 4-Bromofluorobenzene (IS)
91. Isopropylbenzene
92. Bromobenzene
93. Propylbenzene
94. 2-Chlorotoluene
95. 4-Chlorotoluene
96. 1,3,5-Trimethylbenzene
97. Pentachloroethane
98. tert-Butylbenzene
99. 1,2,4-Trimethylbenzene
100. sec-Butylbenzene
101. 1,3-Dichlorobenzene
102. Benzylchloride
103. 1,4-Dichlorobenzene-d4 (IS)
104. 1,4-Dichlorobenzene
105. Isopropyltoluene
106. 1,2-Dichlorobenzene
107. Butylbenzene
108. 1,2-Dibromo-3-chloropropane
109. Hexachloroethane
110. Nitrobenzene
111. 1,2,4-Trichlorobenzene
112. Naphthalene
113. Hexachlorobutadiene
114. 1,2,3-Trichlorobenzene

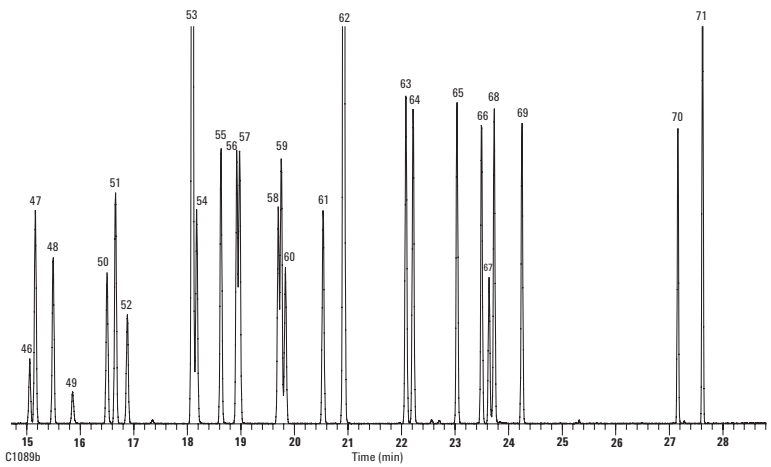
EPA Air Analysis Method TO-15 (1 ppbV Standard)

Agilent wishes to thank Entech Instruments for providing this chromatogram.

Column: DB-5ms
123-5563
60 m x 0.32 mm, 1.00 µm

Carrier: Helium, 1.5 mL/min
Oven: 35°C for 5 min
35-140°C at 6°C/min
140-220°C at 15°C/min
220°C for 3 min
Sampler: Entech 7100 cryogenic sample preconcentrator
Detector: GC/MS 6890/5973N
Scan 29-180 amu 0-6 min
33-280 amu 6-30 min
Electron Impact 70 eV
Sample: 400 mL sample load,
All compounds at 10 ppbV except
Formaldehyde (50 ppbV), Acetaldehyde (20 ppbV),
Propanol (20 ppbV), Acetone (30 ppbV),
2-Butanone (30 ppbV)





		Quantitation Ion
1.	Formaldehyde	30
2.	Propene	41
3.	Dichlorodifluoromethane	85
4.	Chloromethane	50
5.	Dichlorotetrafluoroethane	85
6.	Acetaldehyde	29
7.	Vinyl chloride	62
8.	1,3-Butadiene	39
9.	Bromomethane	94
10.	Chloroethane	64
11.	Bromoethene	106
12.	Trichlorofluoromethane	101
13.	Acetone	58
14.	Propanal	29
15.	Isopropyl alcohol	45
16.	1,1-Dichloroethene	61
17.	1,1,2-Trichloro-1,2-2-trifluoroethane	101
18.	Methylene chloride	49
19.	3-Chloro-1-propene (Allyl chloride)	76
20.	Carbon disulfide	76
21.	trans-1,2-Dichloroethene	96
22.	tert-Butyl methyl ether (MTBE)	73
23.	1,1-Dichloroethane	63
24.	Vinyl acetate	43
25.	2-Butanone (MEK)	72
26.	n-Hexane	57
27.	cis-1,2-Dichloroethene	96
28.	Ethyl acetate	43
29.	Bromochloromethane (IS)	128
30.	Chloroform	83
31.	Tetrahydrofuran	42
32.	1,1,1-Trichloroethane	97
33.	1,2-Dichloroethane	62
34.	Benzene	78
35.	Carbon tetrachloride	117
36.	Cyclohexane	56
37.	1,4-Difluorobenzene (IS)	114
38.	2,2,4-Trimethylpentane (Isooctane)	57
39.	n-Heptane	41
40.	Trichloroethene	130
41.	1,2-Dichloropropane	63
42.	1,4-Dioxane	88
43.	Bromodichloromethane	83
44.	4-Methyl-2-pentanone (MIBK)	43
45.	cis-1,3-Dichloropropene	75
46.	trans-1,3-Dichloropropene	75
47.	Toluene	91
48.	1,1,2-Trichloroethane	97
49.	2-Hexanone	43
50.	Dibromochloromethane	129
51.	Tetrachloroethene	166
52.	1,2-Dibromoethane	107
53.	Chlorobenzene-d5 (IS)	117
54.	Chlorobenzene	112
55.	Ethylbenzene	91
56.	m-Xylene	91
57.	p-Xylene	91
58.	Styrene	104
59.	o-Xylene	91
60.	Bromoform	173
61.	1,1,2,2-Tetrachloroethane	83
62.	4-Bromofluorobenzene	95
63.	4-Ethyltoluene	105
64.	1,3,5-Trimethylbenzene	105
65.	1,2,4-Trimethylbenzene	105
66.	1,3-Dichlorobenzene	146
67.	Benzyl chloride	91
68.	1,4-Dichlorobenzene	146
69.	1,2-Dichlorobenzene	146
70.	1,2,4-Trichlorobenzene	180
71.	Hexachlorobutadiene	225

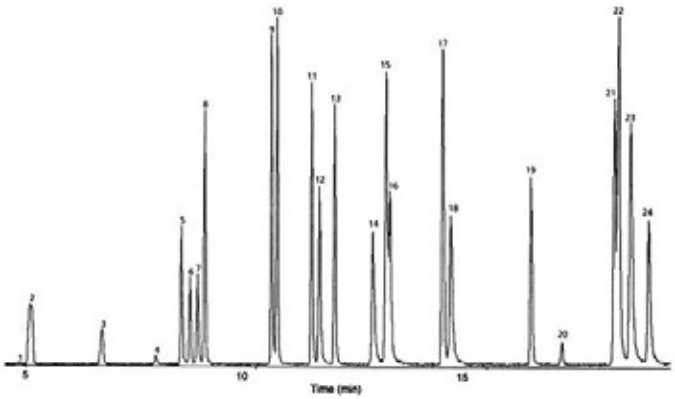
Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal, 18740-20885

C_1 and C_2 Halocarbons (Freons)

Column: GS-GasPro
113-4362
60 m x 0.32 mm

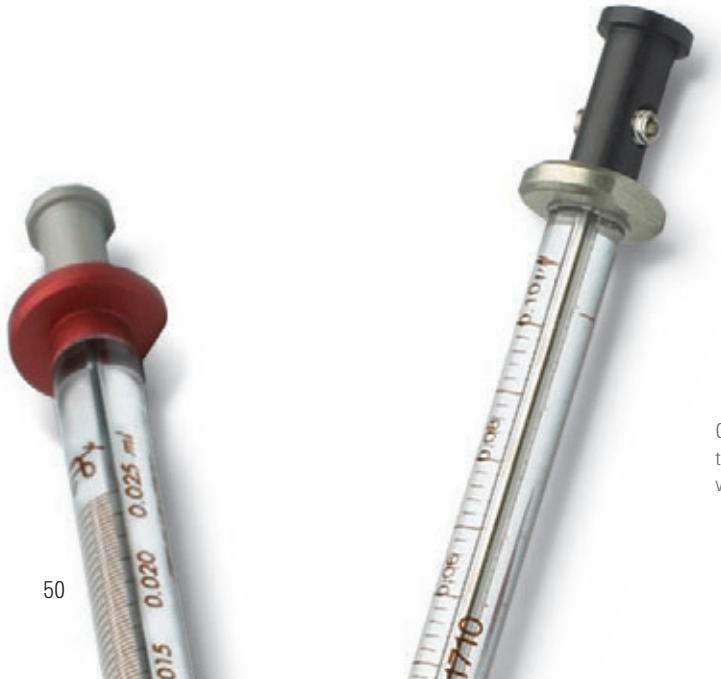
Carrier: Helium at 35 cm/sec, constant velocity
Oven: 40°C for 2 min,
40-120°C at 10°/min
120°C for 3 min
120-200°C at 10°/min
Injection: Splitless, 250°C
0.20 min purge activation time
Detector: MSD, 280°C,
full scan 45-180 amu
Sample: 1.0 µL of 100 ppm mixture
of Accustandard M-REF &
M-REF-X in methanol

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Splitless, single taper, deactivated, 4mm ID, 5181-3316
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267



		Freon #
1.	Chlorotrifluoromethane*	13
2.	Trifluoromethane	23
3.	Bromotrifluoromethane	13B1
4.	Chloropentafluoroethane	115
5.	Pentafluoroethane	125
6.	1,1,1-Trifluoroethane	143a
7.	Dichlorodifluoromethane	12
8.	Chlorodifluoromethane	22
9.	1,1,1,2-Tetrafluoroethane	134a
10.	Chloromethane	40
11.	1,1,2,2-Tetrafluoroethane	134
12.	Bromochlorodifluoromethane	12B1
13.	1,1-Difluoroethane	152a
14.	1,2-Dichloro-1,1,2,2-tetrafluoroethane	114
15.	2-Chloro-1,1,1,2-tetrafluoroethane	124
16.	1-Chloro-1,1-difluoroethane	142b
17.	Dichlorofluoromethane	21
18.	Trichlorofluoromethane	11
19.	Chloroethane	160
20.	Dichloromethane	
21.	1,1-Dichloro-1-fluoroethane	141b
22.	2,2-Dichloro-1,1,1-trifluoroethane	123
23.	1,1,2-Trichloro-1,2,2-trifluoroethane	113
24.	1,2-Dibromo-1,1,2,2-tetrafluoroethane	114B2

**Peak not shown*

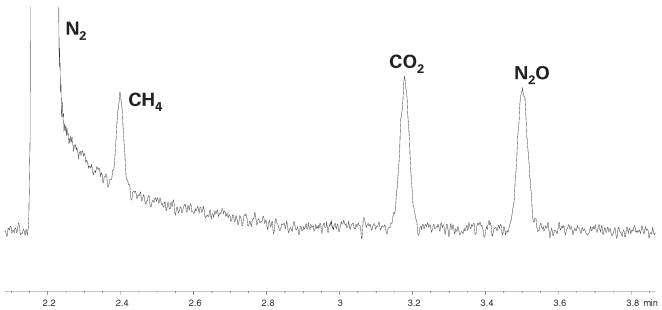


GC PAL Liquid Injection Syringes have the ability to inject a wide range of sample volumes, up to 500 µl for LVI applications.

N_2O I

Column: HP-PLOT Q
19095P-Q04
30 m x 0.53 mm, 40.00 µm

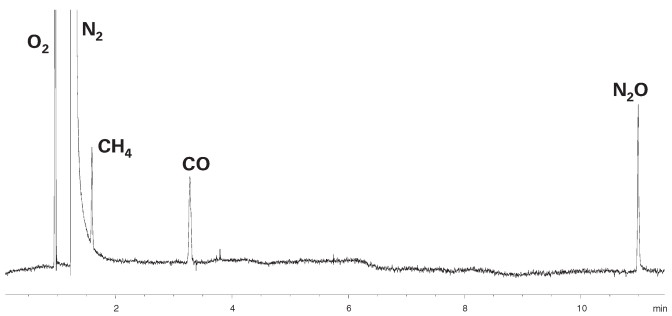
Carrier: Helium, 5 psi (approximately 8 mL/min)
Oven: 35°C isothermal
Injection: Split ratio 1:3
Detector: TCD, 200°C
Sample: 250 µL injected
approximately 200 ppmV methane
200 ppmV CO_2
250 ppmV N_2O (nitrogen balance gas)



N_2O II

Column: HP-PLOT Molesieve
19095P-MS6
30 m x 0.53 mm, 25.00 µm

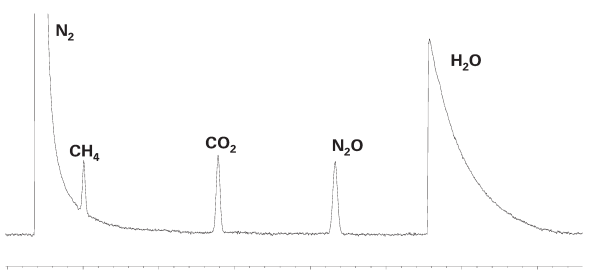
Carrier: Helium, 6 psi (approximately 10 mL/min)
Oven: 50°C (5 min), 25°C/min to 200°C and hold
Injection: Split ratio 1:4
Detector: TCD, 250°C
Column compensation on
Sample: 250 µL injected
approximately 200 ppmV methane
200 ppmV CO_2
250 ppmV N_2O (nitrogen balance gas)



N_2O III

Column: GS-CarbonPLOT
113-3133
30 m x 0.32 mm, 3.00 µm

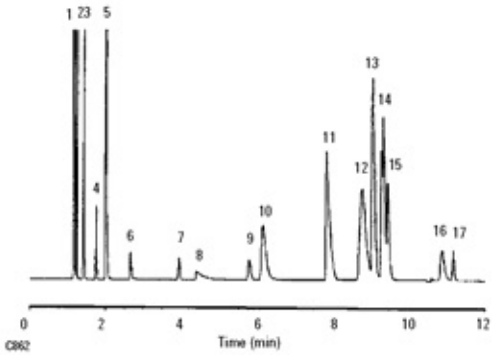
Carrier: Helium, 12 psi (approximately 3 mL/min)
Oven: 35°C isothermal
Injection: Split ratio 1:4
Detector: TCD, 200°C
Sample: 250 µL injected
approximately 200 ppmV methane
200 ppmV CO_2
250 ppmV N_2O (nitrogen balance gas)



Refinery Gas

Column: HP-PLOT Q
19095P-QO4
30 m x 0.53 mm, 40.00 µm

Carrier: Helium p=9.0 psi @ 60°C
Oven: 60°C for 5 min
60-200°C at 20°C/min
200°C for 1 min
Injection: Split, 250°C
Split flow 100mL/min
0.25 cc valve
Detector: TCD, 250°C
Sample: Refinery gas and others



1. Air/CO
2. C_1
3. CO_2
4. Ethylene
5. C_2
6. H_2O
7. COS
8. H_2O
9. Propylene
10. C_3
11. MeOH
12. i-C_4
13. t-C_4
14. n-C_4
15. cis-C_4
16. i-C_5
17. n-C_5

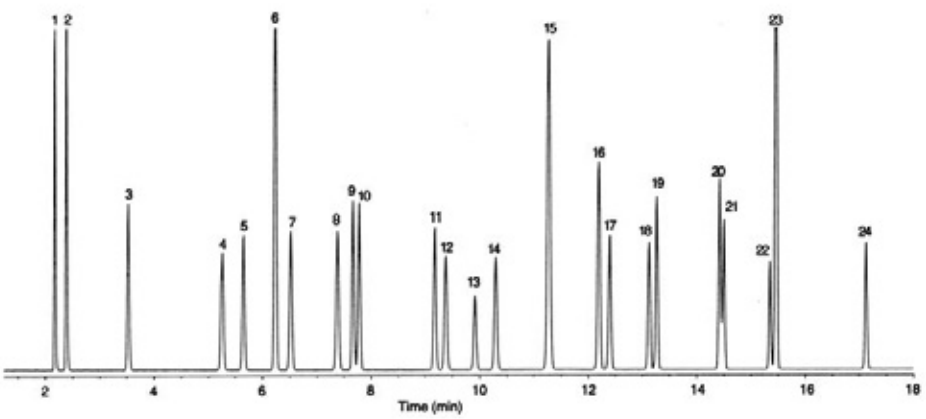
Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal, 18740-20885

Volatile Sulfur Compounds

Column: DB-1
123-1035
30 m x 0.32 mm, 5.00 µm

Carrier: Helium at 23 cm/sec (H_2S at 50°C)
Oven: 50°C for 4 min, 50-120°C at 20°/min, 120°C for 4 min, 120-220°C at 25°/min, 220°C for 2.5 min
Injection: Split, 200°C
Split ratio 1:10
Detector: PFPD (OI Analytical), 220°C
Sample: 600 µL of sulfur gas standard
3 ppmV each component

Agilent wishes to thank Air Toxics, Ltd. (Folsom, CA) for providing the standard mixture shown in this chromatogram.



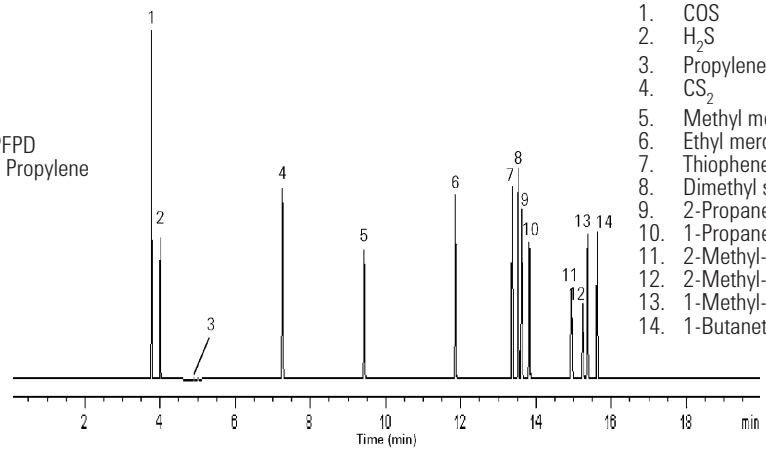
1. Hydrogen sulfide
2. Carbonyl sulfide
3. Methyl mercaptan
4. Ethyl mercaptan
5. Dimethyl sulfide
6. Carbon disulfide
7. 2-Propanethiol
8. 2-Methyl-2-propanethiol
9. 1-Propanethiol
10. Ethyl methyl sulfide
11. Thiophene
12. 2-Methyl-1-propanethiol
13. Diethyl sulfide
14. 1-Butanethiol
15. Methyl disulfide
16. 2-Methylthiophene
17. 3-Methylthiophene
18. Tetrahydrothiophene
19. 1-Pentanethiol
20. 2-Ethylthiophene
21. 2,5-Dimethylthiophene
22. 1-Hexanethiol
23. Ethyl disulfide
24. 1-Heptanethiol

Sulfur Compounds in Propylene (1 ppm)

Column: GS-GasPro
113-4332
30 m x 0.32 mm

Oven: 60°C for 2.5 minutes
60-250°C at 10°C/min
Injection: OI Analytical Volatiles Inlet
Split ratio 5:1
200 µL gas sampling valve
Detector: OI Analytical Model 5380 PFPD
Sample: 1 ppm Sulfur compounds in Propylene

Chromatogram courtesy of OI Analytical.



1. COS
2. H_2S
3. Propylene
4. CS_2
5. Methyl mercaptan
6. Ethyl mercaptan
7. Thiophene
8. Dimethyl sulfide
9. 2-Propanethiol
10. 1-Propanethiol
11. 2-Methyl-2-propanethiol
12. 2-Methyl-1-propanethiol
13. 1-Methyl-1-propnaethiol
14. 1-Butanethiol

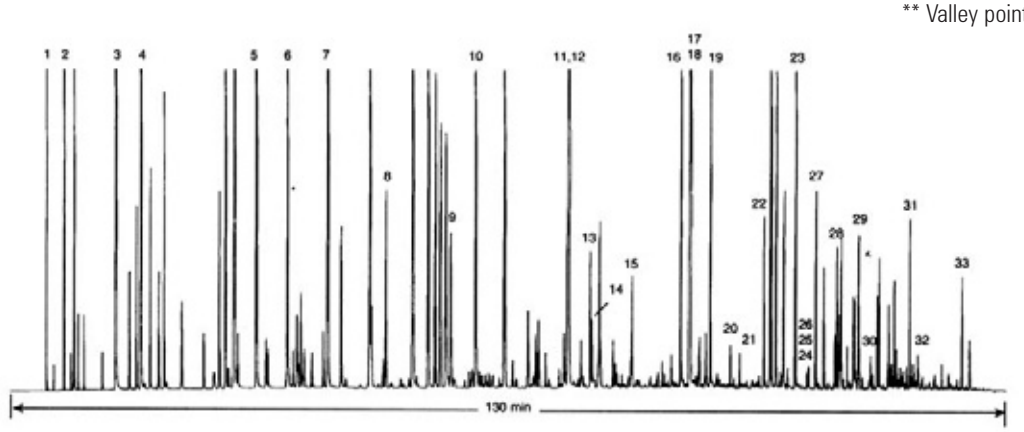
Unleaded Gasoline

Column: DB-Petro
122-10A6
100 m x 0.25 mm, 0.50 µm

Carrier: Helium at 25.6 cm/sec
Oven: 0°C for 15 min
0-50°C at 1°/min
50-130°C at 2°/min
130-180°C at 4°/min
180°C for 20 min
Injection: Split, 200°C
Split ratio 1:300
Detector: FID, 250°C
Nitrogen makeup gas
at 30 mL/min
Sample: 1 µL of neat sample

1. Methane
2. n-Butane
3. Isopentane
4. n-Pentane
5. n-Hexane
6. Methylcyclopentane
7. Benzene
8. Cyclohexane
9. Isooctane
10. n-Heptane
11. Toluene *
12. 2,3,3-Trimethylpentane
13. 2-Methylheptane
14. 4-Methylheptane
15. n-Octane
16. Ethylbenzene
17. m-Xylene **
18. p-Xylene
19. o-Xylene
20. n-Nonane
21. Isopropylbenzene
22. Propylbenzene
23. 1,2,4-Trimethylbenzene
24. Isobutylbenzene
25. sec-Butylbenzene
26. n-Decane
27. 1,2,3-Trimethylbenzene
28. Butylbenzene
29. n-Undecane
30. 1,2,4,5-Tetramethylbenzene
31. Naphthalene
32. Dodecane
33. Tridecane

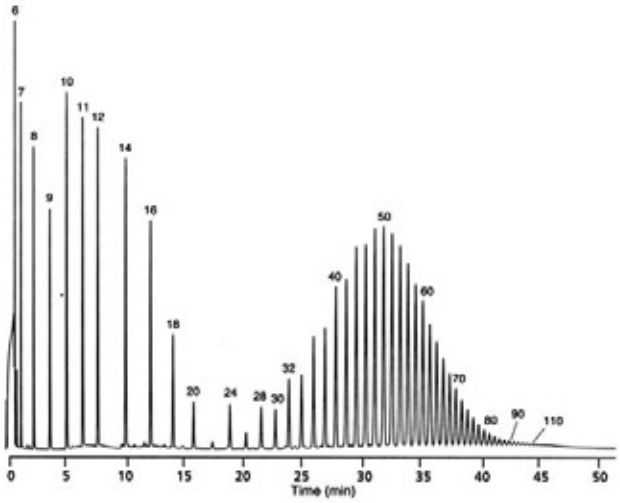
* Valley point with 12 = 78%
** Valley point with 18 = 87%

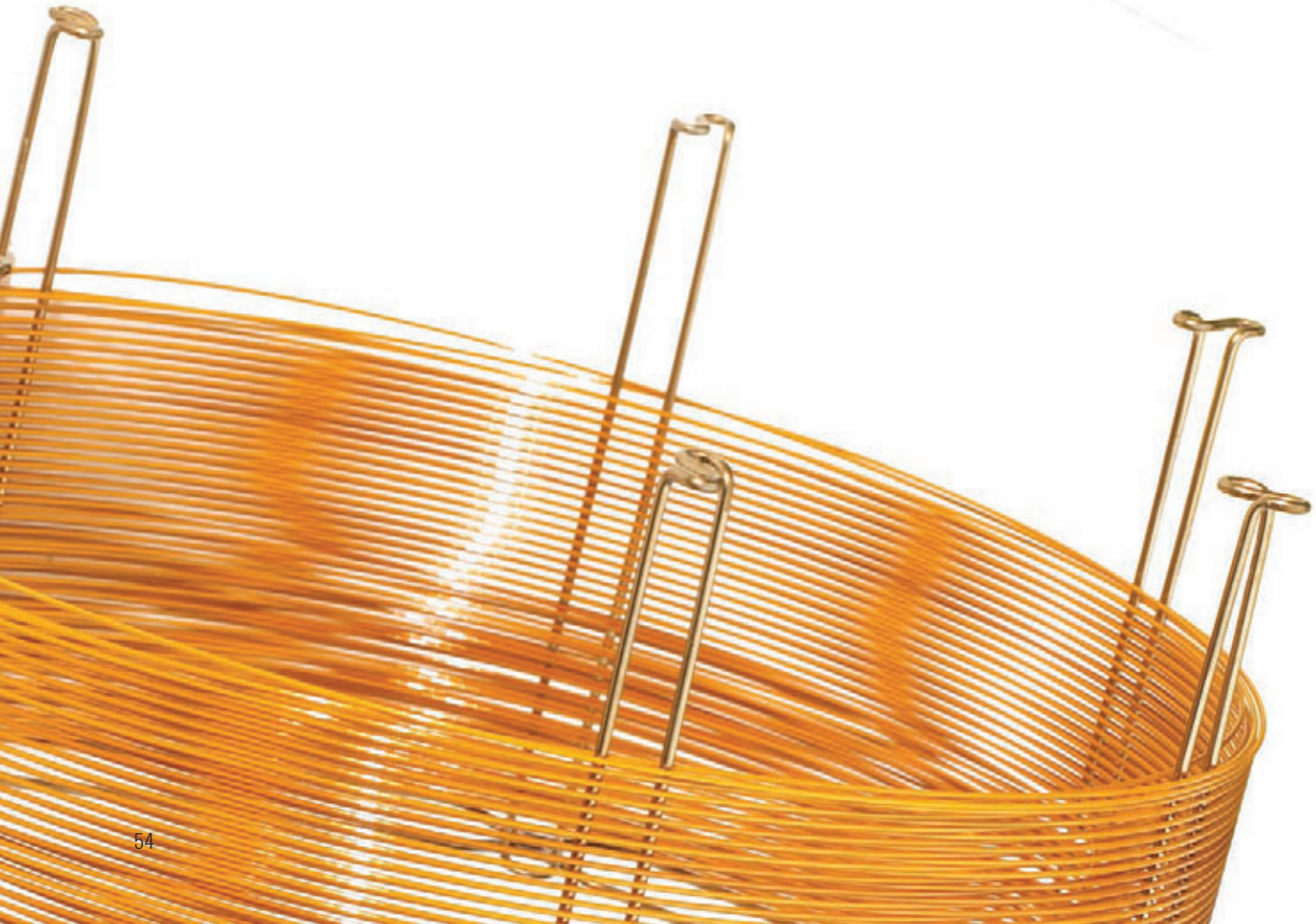


n-Paraffin Standard

Column: DB-HT SimDis
145-1001
5 m x 0.53 mm, 0.15 µm

Carrier: Helium at 18 mL/min, measured at 35°C
Oven: -30-430°C at 10°/min
Injection: OPTIC PTV
55-450°C at 2°/sec
Detector: FID, 450°C
Nitrogen makeup gas at 15 mL/min
Sample: 0.5 µL of about 2% n-paraffins in CS_2





Fragrance Reference Standard I

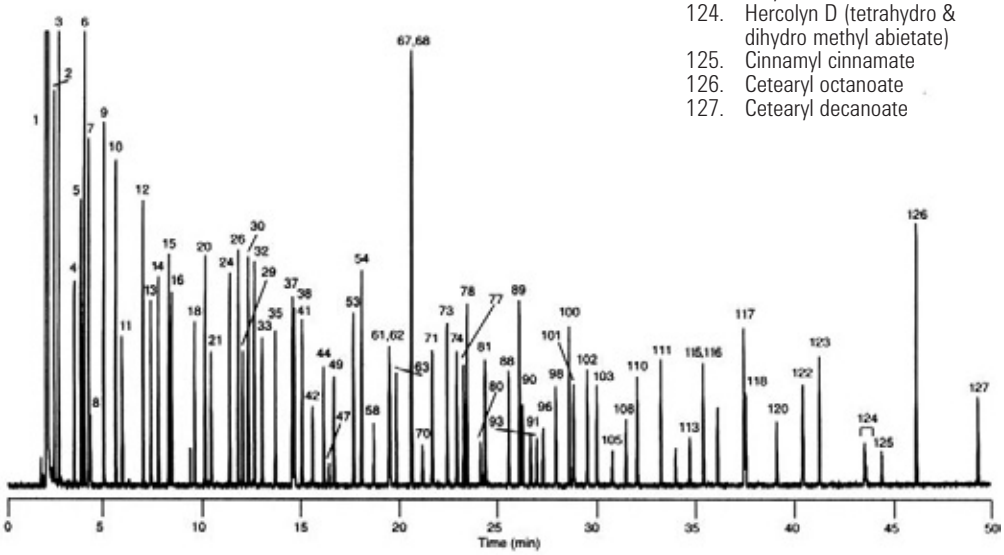
Column: DB-1
122-1032
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 25 cm/sec, measured at 150°C
Oven: 40°C for 1 min
40-290°C at 5°/min
Injection: Split, 250°C
Split ratio 1:50
Detector: MSD, 300°C transfer line
Sample: 1 µL of a 1:20 dilution of neat sample in acetone

Many thanks to Carl Frey, Manager of Analytical Services, Dragoco, and Kevin Myung, Director of Flavor and Perfumery Research, Bush Boake Allen, Inc. for contributing to this work.

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Split, single taper, low pressure drop, glass wool, 5183-4647
Seal: Gold plated seal, 18740-20885
Syringe: Syringe, 5 µl tapered, FN 23-26s/42/HP, 5181-1273

1. Acetone
2. 2,3-Butanedione (diacetyl)
3. Ethyl acetate
4. 2,3-Pentanedione (acetyl propionyl)
5. Ethyl propionate
6. Methyl butyrate
7. 3-Methylbutyl alcohol
8. 2-Methylbutyl alcohol
9. Isobutyl acetate
10. Ethyl butyrate
11. Furfural
12. Ethyl isovalerate
13. Hexanol
14. Allyl butyrate
15. Ethyl pentanoate
16. Hexylene glycol
17.
18. Benzaldehyde
19.
20. Camphene
21. 3,5,5-Trimethylhexanol
22. Sabinene
23.
24. Ethyl hexanoate
25. Myrcene
26. Hexyl acetate
cis-Linalool oxide
Methyl benzoate
trans-Linalool oxide
28. Methyl-cresol
29. Benzyl alcohol
30. para-Cymene
31. 1,8-Cineol
32. Limonene
33. 2,6-Dimethylhept-5-enal
34.
35. Octanol
37. Ethyl heptanoate
38. Linalool
39. Benzene ethanol
41. Rose oxide, cis-rose
42. Rose oxide, trans-rose
43. Camphor
44. Citronellal
45. Benzyl acetate
46. Menthone
47. Isoborneol
48. Isomenthone
49. Borneol
51. Terpinen-4-ol
52.
53. Ethyl octanoate
54. Octyl acetate
56. Fenchyl acetate
57. Citronellol
58. Neral
59. Carvonel
Phenylethyl acetate
60. Geraniol
61. Linalyl acetate
62. Geranial
63. Hydroxycitronellal
64. Citronellyl formate
66. Bornyl acetate
67. Vertenex (isomer 1)
68. Ethyl nonanoate
69. Geranyl formate
70. Vertenex (isomer 2)
71.
72. Citronellyl acetate
73. Neryl acetate
74. Geranyl acetate
76. Diphenyl oxide
78. Ethyl decanoate
79.
80. Florazone (isomer 1)
81. Florazone (isomer 2)
82.
83. Citronellyl propionate
85. 3,7-Guaiadiene
88. Dodecanol
89. Ethyl undecanoate
90. Eugenyl acetate
91. Frambione
(raspberry ketone)
93. Isoamyl salicylate
94.
95. cis-Nerolidol
96. Rosatol (rosetone)
Geranyl butyrate
97. trans-Nerolidol
98. n-Amyl salicylate
99. Phenylethyl tiglate
100. Ethyl dodecanoate
101. Benzophenone
102. Dibenzyl ether
103.
104. Citronellyl tiglate
105. Evernyl
106. Geranyl tiglate
107. Geranyl-2-methyl valerate
108. Celestocide
109. Heptadec-1-ene
110. Benzyl benzoate
111. Ethyl tetradecanoate
112. Benzyl salicylate
113. Tonalid
114. Nonadec-1-ene
115. Isopropylmyristate
116. Ethyl pentadecanoate
Nonadecane
117. Ethyl hexadecanoate
118. Musk T (ethylene brassylate)
119. Eicosane
120. Cinnamyl phenyl acetate
121. Heneicosane
122. Phenyl ethyl cinnamate
123. Ethyl octadecanoate
124. Hercolyn D (tetrahydro & dihydro methyl abietate)
125. Cinnamyl cinnamate
126. Cetearyl octanoate
127. Cetearyl decanoate



Fragrance Reference Standard II

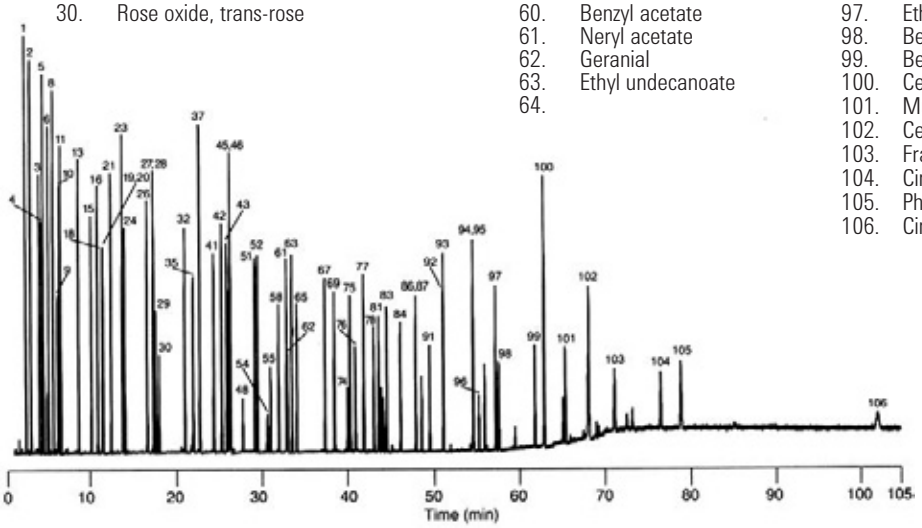
Column: DB-WAX
122-7032
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 25 cm/sec, measured at 150°C
Oven: 45°C for 2 min
45-250°C at 3°/min
250°C for 34 min
Injection: Split, 250°C
Split ratio 1:50
Detector: MSD, 250°C transfer line
Sample: 1 µL of a 1:20 dilution of neat sample in acetone

Many thanks to Carl Frey, Manager of Analytical Services, Dragoco, and Kevin Myung, Director of Flavor and Perfumery Research, Bush Boake Allen, Inc. for contributing to this work.

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Split, single taper, low pressure drop, glass wool, 5183-4647
Seal: Gold plated seal, 18740-20885
Syringe: Syringe, 5 µl tapered, FN 23-26s/42/HP, 5181-1273

1. Acetone
2. Ethyl acetate
3. Ethyl propionate
4. 2,3-Butanedione (diacetyl)
5. Methyl butyrate
6. Isobutyl acetate
7.
8. Ethyl butyrate
9. 2,3-Pentanedione (acetyl propionyl)
10. Camphene
11. Ethyl isovalerate
12.
13. Ethyl pentanoate
14. Myrcene
15. Allyl butyrate
16. Limonene
17. 1,8-Cineol
18. 3,5,5-Trimethylhexanol
19. 3-Methylbutyl alcohol
20. 2-Methylbutyl alcohol
21. Ethyl hexanoate
22.
23. p-Cymene
24. Hexyl acetate
25. Terpinolene
26. Ethyl heptanoate
27. 2,6-Dimethylhept-5-enal (MelonalTM)
28. Rose oxide, cis-rose
29. Hexanol
30. Rose oxide, trans-rose
31. Methyl-para-cresol
32. Ethyl octanoate
33. cis-Linalool oxide
34. Menthone
35. Furfural
36. trans-Linalool oxide
37. Octyl acetate
38. Isomenthone
39.
40. Camphor
41. Benzaldehyde
42. Ethyl nonanoate
43. Linalool
44. Linalyl acetate
45. Vertenex (isomer 1)
46. Octanol
47.
48. Vertenex (isomer 2)
49. Terpinen-4-ol
50. Methyl benzoate
51. Hexylene glycol
52. Ethyl decanoate
53. Citronellyl acetate
54. Isoborneol
55. Neral
56.
57. Geranyl formate
58. Borneol
59.
60. Benzyl acetate
61. Neryl acetate
62. Geranial
63. Ethyl undecanoate
64.
65. Geranyl acetate
66. Citronellol
67. Ethyl dodecanoate
68. Geraniol
69. Benzyl alcohol
70. Geranyl butyrate
71. Nonadecane
72. Benzene ethanol
73. Nonadec-1-ene
74. Florazone (isomer 1)
75. Florazone (isomer 2)
76. Hydroxycitronellal
77. Dodecanol
78. Diphenyl oxide
79. Citronellyl tiglate
80. Eugenyl methyl ether
81.
83. Ethyl tetradecanoate
84. n-Amyl salicylate
85. Geranyl tiglate
86. Ethyl pentadecanoate
87. Isopropylmyristate
90. Phenylethyl tiglate
91. Rosatol (rosetone)
92. Eugenyl acetate
93. Ethyl hexadecanoate
94.
95. Dibenzyl ether
96. Tonalid
97. Ethyl octadecanoate
98. Benzophenone
99. Benzyl benzoate
100. Cetearyl octanoate
101. Musk T (ethylene brassylate)
102. Cetearyl decanoate
103. Frambione (raspberry ketone)
104. Cinnamyl phenyl acetate
105. Phenyl ethyl cinnamate
106. Cinnamyl cinnamate

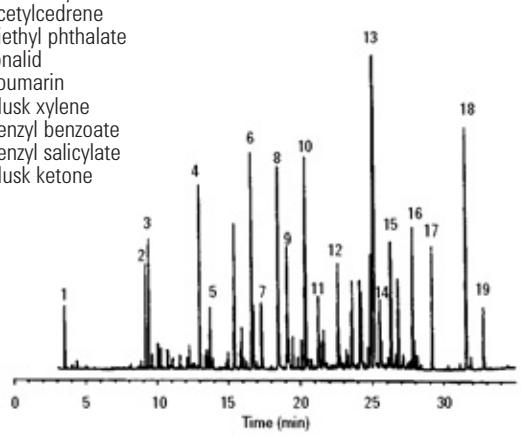


Perfume

Column: HP-INNOWax
19091N-133
30 m x 0.25 mm, 0.25 µm

Carrier: Helium, 30 cm/sec
0.9 mL/min constant flow
Oven: 80°C for 1 min
80-250°C at 5°C/min
250°C for 2 min
Injection: Split, 250°C
Split ratio 20:1
Detector: MSD, 280°C

1. Limonene
2. Linalool
3. Linalyl acetate
4. Benzyl acetate
5. Citronellol
6. Benzene ethanol
7.
8. Carvocrol and geraiol
9. Isoamyl salicylate
10. n-Amyl salicylate
11. Commamyl acetate
12. Acetylcedrene
13. Diethyl phthalate
14. Tonalid
15. Coumarin
16. Musk xylene
17. Benzyl benzoate
18. Benzyl salicylate
19. Musk ketone

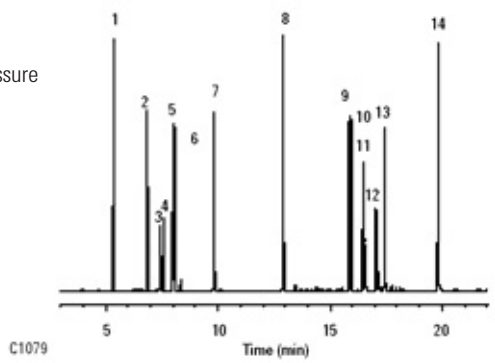


Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Split, single taper, low pressure drop, glass wool, 5183-4647
Seal: Gold plated seal, 18740-20885
Syringe: Syringe, 5 µl tapered, FN 23-26s/42/HP, 5181-1273

Chiral Compounds in Essential Oils and Fragrances

Column: HP-Chiral β
19091G-B233
30 m x 0.25 mm, 0.25 µm

Carrier: Hydrogen, 39 cm/sec, Constant pressure
Oven: 65° C for 1 min
65-170° C at 5° C/min
Injection: Split, 250°C
Split ratio 30:1
Detector: FID, 300°C
Sample: 1 µL
0.25 ng/µL each analyte in Hexane

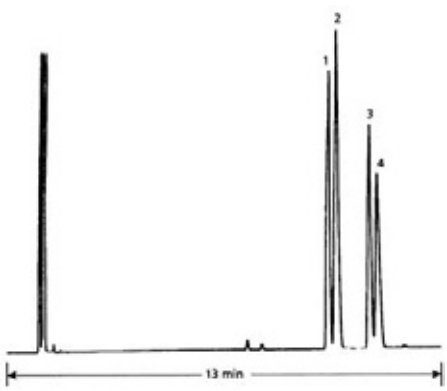


1. 1,2-Dimethylbenzene
2. Myrcene
3. (-)-Camphene
4. (+)-Camphene
5.
6.
7. Cineole
8. (+)-Citronellal
9. 1S,2R,5S-(+)-Menthol
10. 1R,2S,5R-(-)-Menthol
11.
12. (+/-)-Isoborneol
13. (+)-Borneol
14. trans-Cinnamaldehyde

Menthol

Column: Cyclodex-β
112-2532
30 m x 0.25 mm, 0.25 µm

Carrier: Hydrogen, 55 cm/sec
Oven: 105° C isothermal
Injection: Split, 250°C
Split ratio 1:100
Detector: FID, 300°C
Nitrogen makeup gas at 30 mL/min
Sample: 1 µL of 1 µg/µL each chloroform

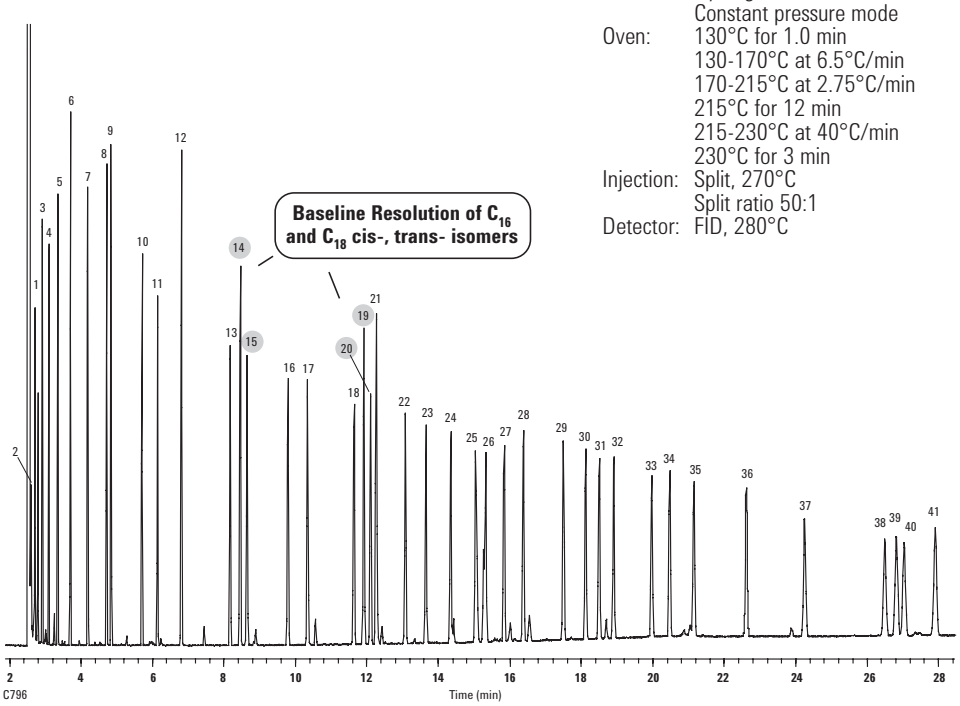


1. (+)-Neomenthol
2. (-)- Neomenthol
3. (+)-Menthol
4. (-)-Menthol

FAMEs

Column: DB-23
122-2362
60 m x 0.25 mm, 0.25 µm

Chromatogram provided courtesy of Steve Watkins and Jeremy Ching, FAME Analytics, http://www.fameanalytics.com



Carrier: Hydrogen at 43 cm/sec
Constant pressure mode
Oven: 130°C for 1.0 min
130-170°C at 6.5°C/min
170-215°C at 2.75°C/min
215°C for 12 min
215-230°C at 40°C/min
230°C for 3 min
Injection: Split, 270°C
Split ratio 50:1
Detector: FID, 280°C

1. C6:0
2. C7:0
3. C8:0
4. C9:0
5. C10:0
6. C11:0
7. C12:0
8. BHT
9. C13:0
10. C14:0
11. C14:1n5
12. C15:0
13. C16:0
14. C16:1n7(trans)
15. C16:1n7(cis)
16. C17:0
17. C17:1
18. C18:0
19. C18:1n9(trans)
20. C18:1n9(cis)
21. C18:1n7
22. C18:2n6
23. C18:3n6
24. C18:3n3
25. C18:2(d9,11)
26. C18:2(d10,12)
27. C20:0
28. C20:1n9
29. C20:2n6
30. C20:3n6
31. C20:4n6
32. C20:3n3
33. C20:5n3
34. C22:0
35. C22:1n9
36. C22:2n6
37. C22:4n6
38. C22:5n3
39. C24:0
40. C22:6n3
41. C24:1n9

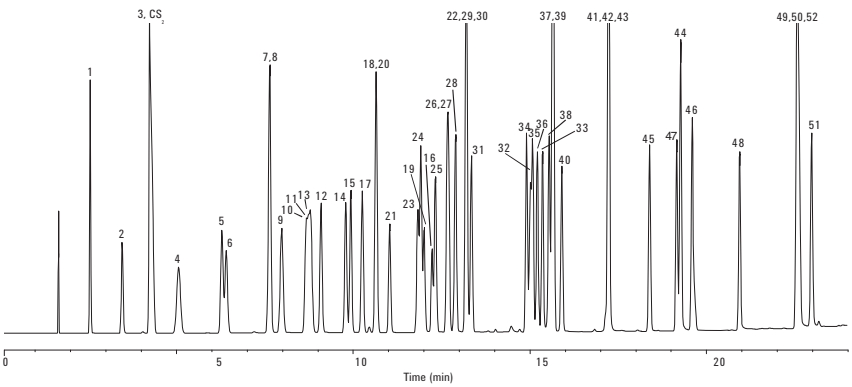
Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Split, single taper, low pressure drop, glass wool, 5183-4647
Seal: Gold plated seal, 18740-20885
Syringe: Syringe, 5 µl tapered, FN 23-26s/42/HP, 5181-1273

Alcohols

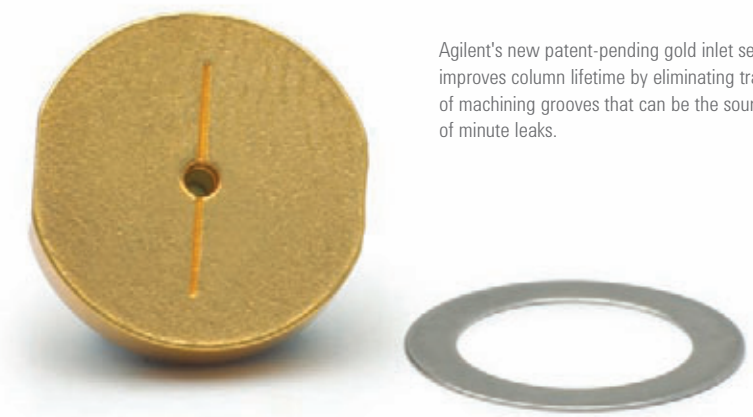
Column: DB-624
125-1334
30 m x 0.53 mm, 3.00 µm

Carrier: Helium at 30 cm/sec, measured at 40°C
Oven: 40°C for 5 min
40-260°C at 10°C/min
260°C for 3 min
Injection: Split, 250°C
Split ratio 1:10
Detector: FID, 300°C
Nitrogen makeup gas at 30 mL/min
Sample: 1 µL of 0.01-0.05% each solvent in CS_2

1. Acetaldehyde
2. Acrolein
3. Acetone
4. Propionaldehyde
5. Isobutyraldehyde
6. Methacrolein
7. Butyraldehyde
8. 2-Butanone (MEK)
9. Crotonaldehyde
10. 3-Methyl-2-butanone
11. 2-Pentanone
12. 3-Pentanone
13. Valeraldehyde (pentanal)
14. 4-Methyl-2-pentanone (MIBK)
15. 2-Methyl-3-pentanone
16. 3-Hexanone
17. Cyclopentanone
18. 2-Hexanone
19. Hexanal
20. Furfural
21. 4-Heptanone
22. 3-Heptanone
23. 2-Heptanone
24. Cyclohexanone
25. Heptanal
26. Benzaldehyde
27. Octyl aldehyde
28. o-Tolualdehyde
29. m-Tolualdehyde
30. p-Tolualdehyde
31. Nonyl aldehyde
32. Methanol
33. Ethanol
34. Isopropanol
35. tert-Butanol
36. 2-Propen-1-ol (allyl alcohol)
37. 1-Propanol
38. 2-Propyn-1-ol (propargyl alcohol)
39. sec-Butanol
40. 2-Methyl-3-buten-2-ol
41. Isobutanol
42. 2-Methoxyethanol (methyl Cellosolve)
43. 3-Buten-1-ol
44. 2-Methyl-2-butanol (tert-amyl alcohol)
45. 1-Butanol
46. 2-Buten-1-ol (crotyl alcohol)
47. Ethylene glycol
48. 1-Penten-3-ol
49. 2-Pentanol
50. Glycidol
51. 3-Pentanol
52. 2-Ethoxyethanol (Cellosolve)



Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Split, single taper, low pressure drop, glass wool, 5183-4647
Seal: Gold plated seal, 18740-20885
Syringe: Syringe, 5 µl tapered, FN 23-26s/42/HP, 5181-1273



Agilent's new patent-pending gold inlet seal improves column lifetime by eliminating traces of machining grooves that can be the source of minute leaks.

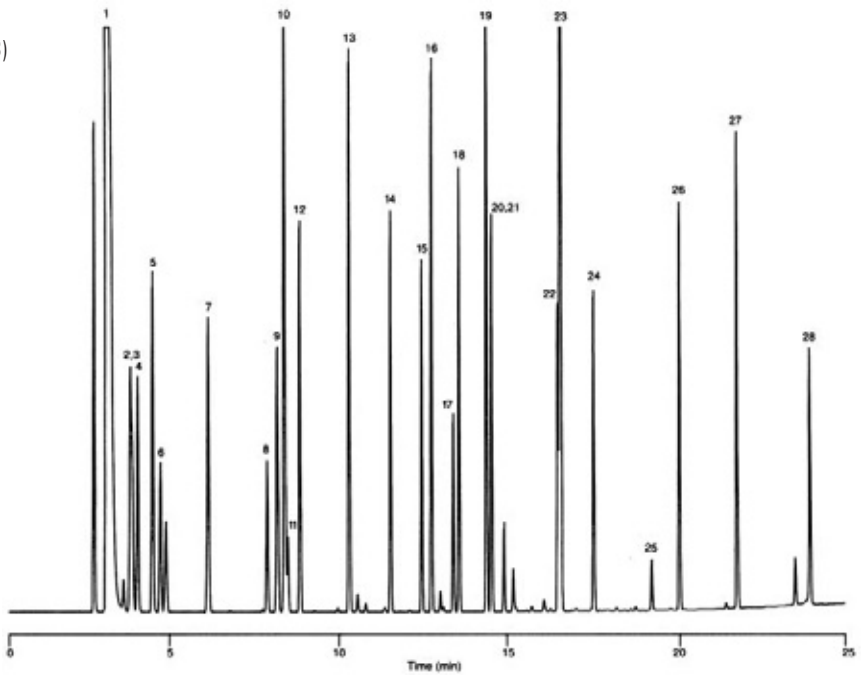
Halogenated Hydrocarbons

Column: DB-624
123-1334
30 m x 0.32 mm, 1.80 µm

Carrier: Helium at 35 cm/sec
Oven: 35°C for 5 min
35-245°C at 10°/min
Injection: Split, 250°C
Split ratio 1:50
Detector: FID, 300°C
Nitrogen makeup gas at 30 mL/min

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: General Purpose Split/Splitless Liner, taper, glass wool, 5183-4711
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

1. Pentane
2. Iodomethane
3. 1,1-Dichloroethene
4. 1,1,2-Trichlorotrifluoroethane (Freon-113)
5. 3-Chloropropene (allyl chloride)
6. Methylene chloride
7. 1,1-Dichloroethane
8. Chloroform
9. 1,1,1-Trichloroethane
10. 1-Chlorobutane
11. Carbon tetrachloride
12. 1,2-Dichloroethane
13. 1,2-Dichloropropane
14. cis-1,2-Dichloropropene
15. trans-1,2-Dichloropropene
16. 1,1,2-Trichloroethane
17. 1,1,1,2-Tetrachloroethane
18. 1,2-Dibromoethane (EDB)
19. 1-Chlorohexane
20. trans-1,4-Dichloro-2-butene
21. Iodoform
22. Hexachlorobutadiene
23. 1,2,3-Trichloropropane
24. 1,1,2,2-Tetrachloroethane
25. Pentachloroethane
26. 1,2-Dibromo-3-chloropropane (DBCP)
27. Hexachloroethane
28. Hexachlorocyclopentadiene



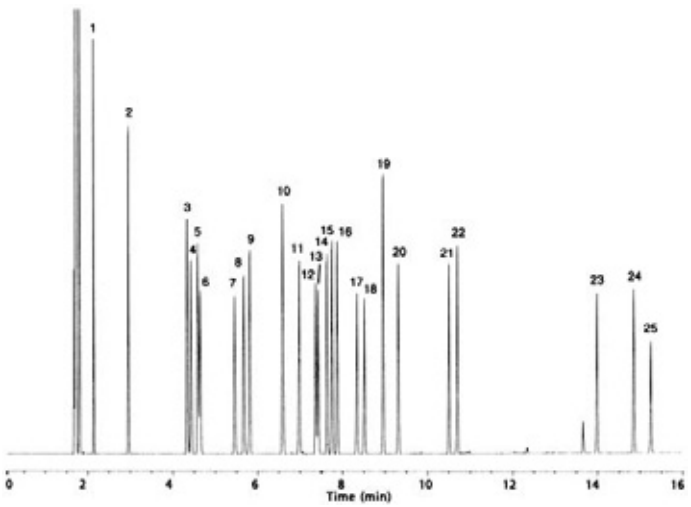
Aromatic Solvents

Column: DB-200
122-2032
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 31 cm/sec
Oven: 50°C for 5 min
50-160°C at 10°/min
Injection: Split, 250°C
Split ratio 1:100
Detector: FID, 300°C
Nitrogen makeup gas at 30 mL/min
Sample: 0.5 µL of 0.5 µg/µL
standard in hexane

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: General Purpose Split/Splitless Liner, taper, glass wool, 5183-4711
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

1. Benzene
2. Toluene
3. Ethylbenzene
4. Chlorobenzene
5. p-Xylene
6. m-Xylene
7. o-Xylene
8. Styrene
9. Isopropylbenzene
10. n-Propylbenzene
11. 2-Chlorotoluene
12. 3-Chlorotoluene
13. 4-Chlorotoluene
14. tert-Butylbenzene
15. sec-Butylbenzene
16. Isobutylbenzene
17. 1,3-Dichlorobenzene
18. 1,4-Dichlorobenzene
19. n-Butylbenzene
20. 1,2-Dichlorobenzene
21. 1,3-Diisopropylbenzene
22. 1,4-Diisopropylbenzene
23. 2-Nitrotoluene
24. 3-Nitrotoluene
25. 4-Nitrotoluene



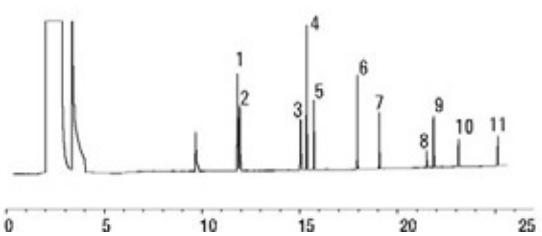
Phenols

Column: HP-5ms
19091S-433
30 m x 0.25 mm, 0.25 µm

Carrier: Helium, 33 cm/sec, constant flow
Oven: 35°C for 5 min
35-220°C at 8°C/min
Injection: Splitless, 250°C
Detector: FID, 300°C
Sample: 1 µL
20 µg/mL phenols in methylene chloride

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct connect, single taper, deactivated, 4mm ID, G1544-80730
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

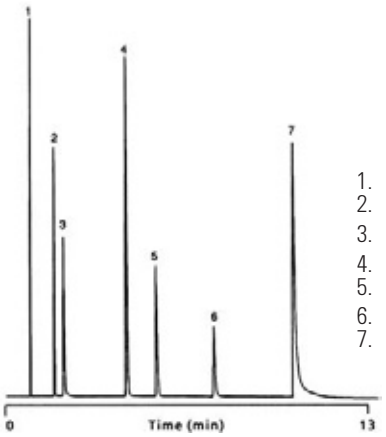
1. Phenol
2. 2-Chlorophenol
3. 2-Nitrophenol
4. 2,4-Dimethylphenol
5. 2,4-Dichlorophenol
6. 4-Chloro-3-methylphenol
7. 2,4,6-Trinitrophenol
8. 2,4-Dinitrophenol
9. 4-Nitrophenol
10. 2-Methyl-4,6-dinitrophenol
11. Pentachlorophenol



Inorganic Gases

Column: GS-GasPro
113-4332
30 m x 0.32 mm

Carrier: Helium at 53 cm/sec
Oven: 25°C for 3 min
25-200°C at 10°/min
200°C Hold
Injection: Split, 200°C
Split ratio 1:50
Detector: TCD, 250°C
Sample: 50 µL



1. Nitrogen
2. CO_2
3. SF_6
4. COS
5. H_2S
6. Ethylene oxide
7. SO_2

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal, 18740-20885

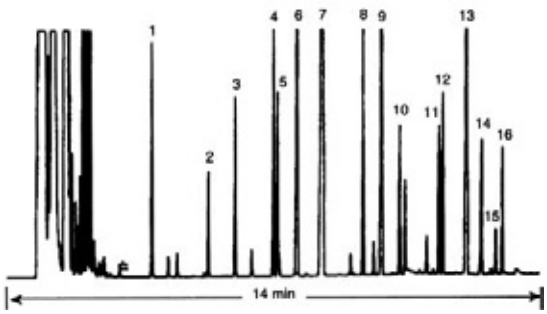
Amphetamines and Precursors - TMS Derivatives

Column: DB-5
121-5023
20 m x 0.18 mm, 0.40 µm

Carrier: Helium at 39 cm/sec, measured at 100°C
Oven: 100-240°C at 10°/min
Injection: Split, 250°C
Split ratio 1:100
Detector: FID, 300°C
Nitrogen makeup gas at 30 mL/min
Sample: 1 µL of 2 µg/µL each in pyridine

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: General Purpose Split/Splitless Liner, taper, glass wool, 5183-4711
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

1. Phenylacetone
2. Dimethylamphetamine
3. Amphetamine
4. Phentermine
5. Methamphetamine
6. Methyl ephedrine
7. Nicotinamine
8. Ephedrine
9. Phenacetin
10. 3,4-Methylenedioxyamphetamine (MDA)
11. 3,4-Methylenedioxymethylamphetamine
12. 4-Methyl-2,5-dimethoxyamphetamine (STP)
13. Phenyl ephedrine
14. 3,4-Methylenedioxyethylamphetamine (MDE; Eve)
15. Caffeine
16. Benzphetamine



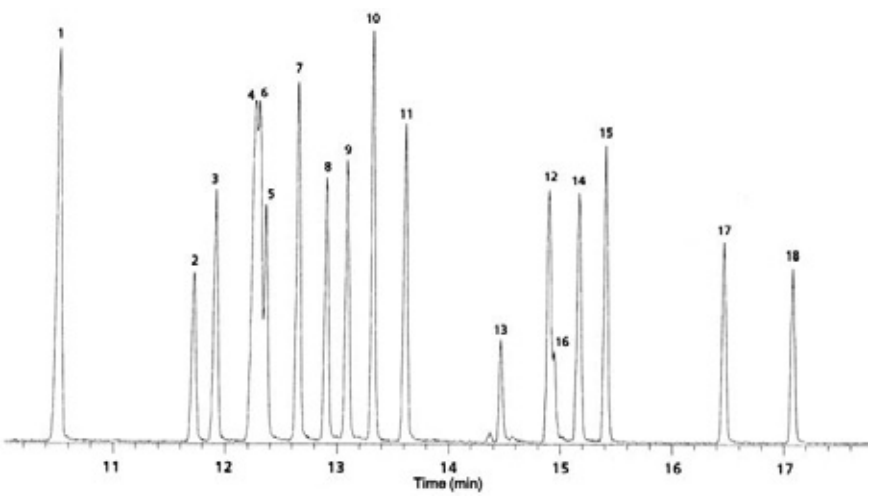
Barbiturates

Column: DB-35ms
122-3832
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 31 cm/sec, measured at 50°C
Oven: 50°C for 0.5 min
50-150°C at 25°/min
150-300°C at 10°/min
Injection: Splitless, 250°C
30 sec purge activation time
Detector: MSD, 280°C transfer line
full scan at m/z 40-270

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Splitless, single taper, deactivated, 4mm ID, 5181-3316
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

1. Barbital
2. Allobarbital
3. Aprobarbital
4. Butabarbital
5. Butethal
6. Butalbital
7. Amobarbital
8. Talbutal
9. Pentobarbital
10. Methohexital
11. Secobarbital
12. Hexobarbital
13. Thiopental
14. Cyclopentylbarbital
15. Mephobarbital
16. Thiamylal
17. Phenobarbital
18. Alphenal



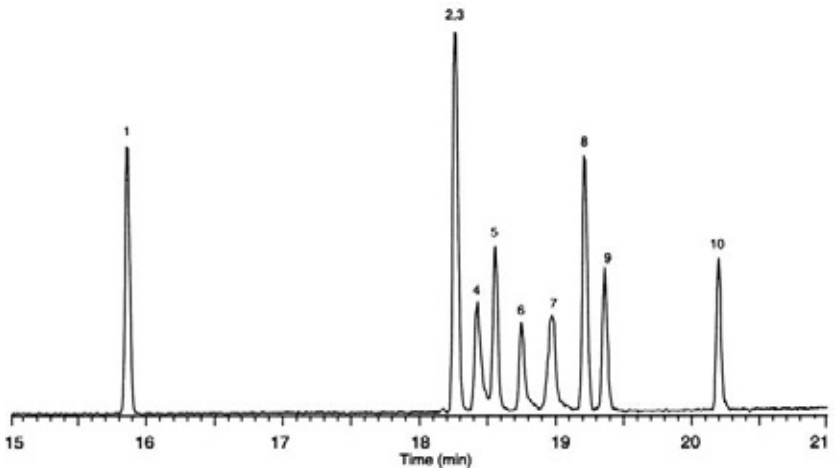
Narcotics

Column: DB-5ms
122-5532
30 m x 0.25 mm, 0.25 µm

Carrier: Helium at 31 cm/sec, measured at 50°C
Oven: 50°C for 0.5 min
50-150°C at 25°/min
150-325°C at 10°/min
Injection: Splitless, 250°C
30 sec purge activation time
Detector: MSD, 300°C transfer line
full scan at m/z 40-380

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct connect, single taper, deactivated, 4mm ID, G1544-80730
Seal: Gold plated seal, 18740-20885
Syringe: 10 µl tapered, FN 23-26s/42/HP, 5181-1267

1. Dextromethorphan
2. Codeine
3. Dihydrocodeine
4. Norcodeine
5. Ethylmorphine
6. Morphine
7. Normorphine
8. 6-Acetylcodeine
9. 6-Monoacetylmorphine
10. Heroin



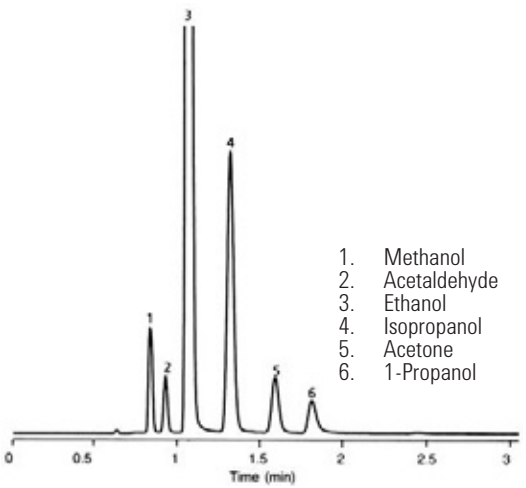
Blood Alcohols I (Static Headspace/Split)

Column: DB-ALC1
125-9134
30 m x 0.53 mm, 3.00 µm

Carrier: Helium at 80 cm/sec, measured at 40°C
Oven: 40°C Isothermal
Sampler: Headspace
Injection: Split, 250°C
Split ratio 1:10
Detector: FID, 300°C
Nitrogen makeup gas at 23 mL/min

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal, 18740-20885

1. Methanol
2. Acetaldehyde
3. Ethanol
4. Isopropanol
5. Acetone
6. 1-Propanol



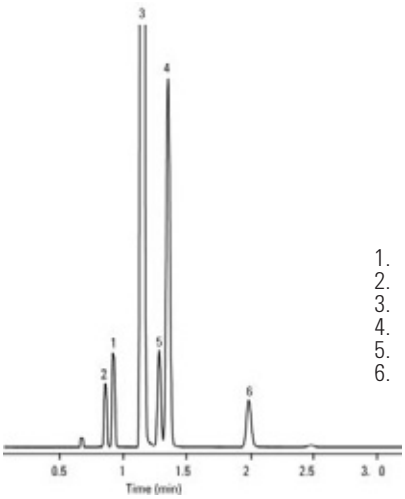
Blood Alcohols II (Static Headspace/Split)

Column: DB-ALC1
125-9134
30 m x 0.53 mm, 3.00 µm

Carrier: Helium at 80 cm/sec, measured at 40°C
Oven: 40°C Isothermal
Sampler: Headspace
Oven: 70°C
Loop: 80°C
Transfer Line: 90°C
Vial Equil. Time: 10 min
Pressurization Time: 0.20 min
Loop Fill Time: 0.20 min
Loop Equil. Time: 0.05 min
Inject Time: 0.1 - 0.2 min
Sample Loop Size: 1.0 mL

Injection: Split, 250°C
Split ratio 1:10
Detector: FID, 300°C
Nitrogen makeup gas at 23 mL/min
Sample: 0.1% Ethanol, 0.001% Others

Suggested Supplies
Septum: Advanced Green, 5183-4759
Liner: Direct, 1.5mm ID, 18740-80200
Seal: Gold plated seal, 18740-20885



1. Methanol
2. Acetaldehyde
3. Ethanol
4. Isopropanol
5. Acetone
6. 1-Propanol

Residual Solvents, DMI Diluent

Special thanks to Julie Kancler, Brian Wallace, Teledyne.

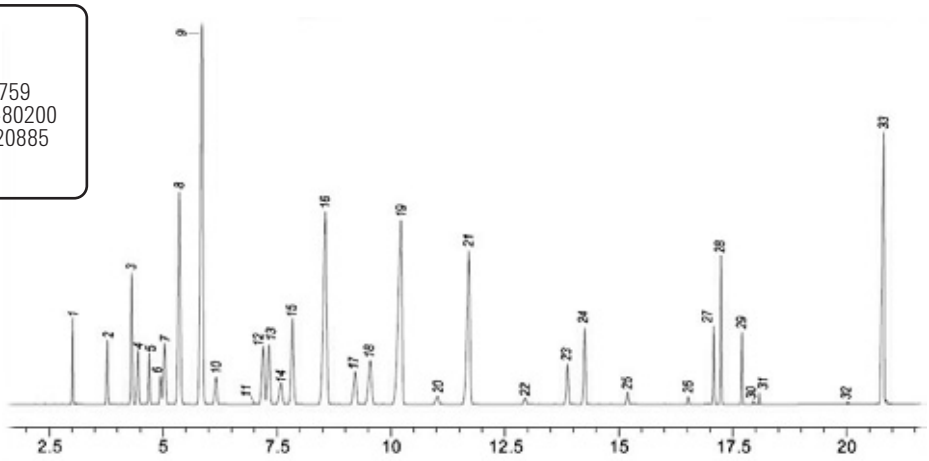
Column: DB-624
123-1364
60 m x 0.32 mm, 1.80 µm

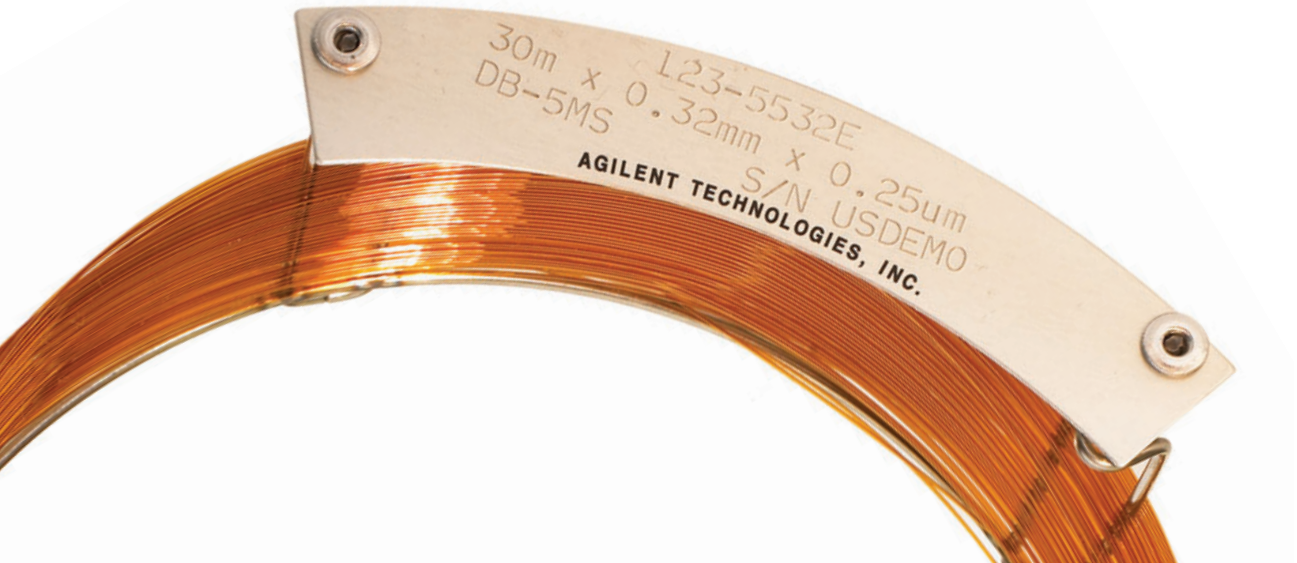
Oven:	50-60°C, 1°C/min
	60-115°C, 9.2°C/min
	115-220°C, 35°C/min
	220°C - hold 6 min
Sampler:	Headspace
	Platen 140°C
	Transfer line, valve 250°C
	Sample Loop 2mL
Injection:	Split, 250°C
	Split ratio 1:18
Detector:	FID, 270°C
	Nitrogen makeup
Sample:	5,000 ppm standard

1. Methanol
2. Ethanol
3. Acetone
4. 2-Propanol
5. Acetonitrile
6. Methylene chloride
7. 2-Methyl-2-propanol (tert-butanol)
8. MTBE
9. Hexane
10. 1-Propanol
11. DMI impurity
12. 2-Butanone (MEK)
13. Ethyl acetate
14. 2-Butanol
15. Tetrahydrofuran
16. Cyclohexane
17. Isopropyl acetate
18. 1,2-Dimethoxyethane
19. Heptane
20. 1-Methoxy-2-propanol
21. Methylcyclohexane
22. 2-Ethoxyethanol
23. MIBK (2-Pentanone)
24. Toluene
25. 1-Pentanol
26. n,n-Dimethylformamide (DMF)
27. Ethyl benzene
28. m,p-Xylene
29. o-Xylene
30. Dimethyl sulfoxide (DMSO)
31. n,n-Dimethylacetamide
32. n-Methylpyrrolidone
33. 1,3-Dimethyl-2-imidazolidinone (DMI)

Suggested Supplies

Septum:	Advanced Green, 5183-4759
Liner:	Direct, 1.5mm ID, 18740-80200
Seal:	Gold plated seal, 18740-20885





GC Capillary Columns

More than just essential products... reliable results!

With the lowest bleed levels, the highest inertness, and the tightest column-to-column reproducibility, Agilent J&W capillary columns perform better than any columns on the market. On the following pages, you will find...

Low-bleed GC/MS Columns – are specifically designed to chromatograph a broad range of trace-level samples, and offer low bleed and high inertness even at higher temperatures. *See page 68*.

Premium Polysiloxane Columns – are stable, robust, and versatile and are available in a wide variety of stationary phases. *See page 77*.

Polyethylene Glycol (PEG) columns – offer a variety of unique phase characteristics to meet the varying needs of your laboratory, thanks to Agilent's strict quality control of the cross-linking and deactivation processes. *See page 94*.

Specialty Columns – meet Agilent's uncompromising standards for high-temperature, life science, pesticide, petroleum, semivolatile, and volatile applications. *See page 101*.

PLOT Columns – deliver superior separation for compounds that are gases at room temperature. They are also ideal for analyzing fixed gases, low molecular weight hydrocarbon isomers, volatile polymer compounds, and reactive analytes such as gases, amines, and hydrides. *See page 110*.

The following pages feature some of Agilent's most popular column selections. For a complete listing of Agilent's GC columns, see Agilent's Essential Chromatography and Spectroscopy Catalog or contact your local Agilent representative or Agilent Authorized Distributor.

Columns for GC/MS

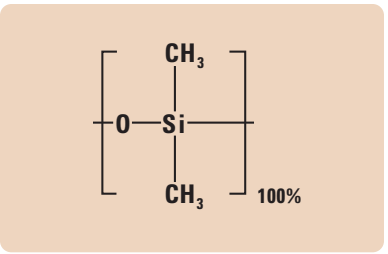
There is a rapidly increasing population of benchtop GC/MS instruments in analytical laboratories that analyze a broadening range of trace level, higher temperature samples. These samples require increasingly inert, lower bleed, higher temperature columns. In response to this growing need, Agilent Technologies deliberately designed several "ms" columns to chromatograph a broader range of low level samples and generate lower bleed even at higher temperatures.

What makes an Agilent J&W low bleed column unique? Unique polymer chemistry and proprietary surface deactivation, both of which have contributed to columns that adhere to the tightest quality control specifications in the industry for bleed, inertness, selectivity and efficiency. Agilent J&W "ms" columns utilize special surface deactivation and siloxane chemistries which enhance the chromatographic performance of siloxane polymers.

The mass spectrum of septum bleed can look very much like GC column bleed, so the two are often confused. An easy way to tell the two apart: Column bleed will be a rise in the baseline, not peaks. If you see bleed peaks, these generally come from lower quality septa or septa being used beyond their operating limits. To minimize septa contributions to background bleed use quality Agilent BTO, Long Life, or Advanced Green septa.

The Agilent 5975C Series GC/MSD combines innovative design features to boost your lab's productivity, and advanced analytical capabilities that help you achieve better results faster. Learn more at **www.agilent.com/chem/5975C**.

DB-1ms



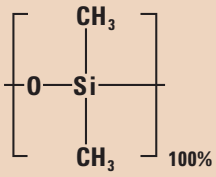
Structure of Dimethylpolysiloxane

- 100% Dimethylpolysiloxane, identical selectivity to DB-1
- Non-polar
- Very low bleed characteristics, ideal for GC/MS
- Improved acid performance compared to standard 100% Dimethylpolysiloxane columns
- Improved signal-to-noise ratio for better sensitivity and mass spectral integrity
- 340/360°C upper temperature limit
- Excellent general purpose column
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: HP-1ms, Rtx-1ms, CP-Sil 5 CB Low Bleed/MS, MDN-1, AT-1, ZB-1ms

DB-1ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.10	10	0.10	-60 to 340/360	127-0112
0.10	10	0.40	-60 to 340/360	127-0113
0.10	20	0.10	-60 to 340/360	127-0122
0.10	20	0.40	-60 to 340/360	127-0123
0.18	20	0.18	-60 to 340/360	121-0122
0.20	12	0.33	-60 to 340/350	128-0112
0.20	25	0.33	-60 to 340/350	128-0122
0.25	15	0.25	-60 to 340/360	122-0112
0.25	30	0.10	-60 to 340/360	122-0131
0.25	30	0.25	-60 to 340/360	122-0132
0.25	60	0.25	-60 to 340/360	122-0162
0.32	15	0.25	-60 to 340/360	123-0112
0.32	30	0.10	-60 to 340/360	123-0131
0.32	30	0.25	-60 to 340/360	123-0132
0.32	60	0.25	-60 to 340/360	123-0162



Structure of Dimethylpolysiloxane

HP-1ms

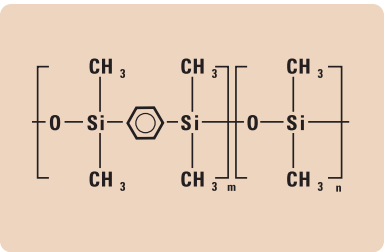
- 100% Dimethylpolysiloxane
- Identical selectivity to HP-1
- Non-polar
- Low bleed characteristics
- Excellent general purpose column
- Improved signal-to-noise ratio for better sensitivity and mass spectral integrity
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: DB-1ms, Rtx-1ms, CP-Sil 5 CB Low Bleed/MS, MDN-1, AT-1, ZB-1ms

HP-1ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	-60 to 325/350	19091S-677
0.20	25	0.33	-60 to 325/350	19091S-602
0.25	15	0.25	-60 to 325/350	19091S-931
0.25	30	0.10	-60 to 325/350	19091S-833
0.25	30	0.25	-60 to 325/350	19091S-933
0.25	30	0.50	-60 to 325/350	19091S-633
0.25	30	1.00	-60 to 325/350	19091S-733
0.25	60	0.25	-60 to 325/350	19091S-936
0.32	15	0.25	-60 to 325/350	19091S-911
0.32	25	0.52	-60 to 325/350	19091S-612
0.32	30	0.25	-60 to 325/350	19091S-913
0.32	30	1.00	-60 to 325/350	19091S-713
0.32	60	0.25	-60 to 325/350	19091S-916

DB-5ms



Structure of Poly(dimethylsiloxy)poly (1,4-bix(dimethylsiloxy)phenylen)siloxane

- Phenyl Arylene polymer virtually equivalent to a (5%-Phenyl)-methylpolysiloxane
- Non-polar
- Very low bleed characteristics, ideal for GC/MS
- Excellent inertness for active compounds
- Improved signal-to-noise ratio for better sensitivity and mass spectral integrity
- Bonded and cross-linked
- Solvent rinsable
- MSD testing and certification available
- Exact replacement of HP-5TA
- Close equivalent to USP Phase G27
- Test mix available

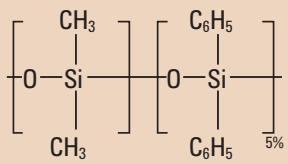
Similar Phases: Rtx-5ms, PTE-5, CP-Sil 8 CB Low Bleed/MS, BPX-5, AT-5ms, ZB-5ms

DB-5ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	-60 to 325/350	121-5522
0.18	20	0.36	-60 to 325/350	121-5523
0.18	40	0.18	-60 to 325/350	121-5542
0.20	12	0.33	-60 to 325/350	128-5512
0.20	25	0.33	-60 to 325/350	128-5522
0.20	50	0.33	-60 to 325/350	128-5552
0.25	15	0.10	-60 to 325/350	122-5511
0.25	15	0.25	-60 to 325/350	122-5512
0.25	15	0.50	-60 to 325/350	122-5516
0.25	15	1.00	-60 to 325/350	122-5513
0.25	25	0.25	-60 to 325/350	122-5522
0.25	25	0.40	-60 to 325/350	122-552A
0.25	30	0.10	-60 to 325/350	122-5531
0.25	30	0.25	-60 to 325/350	122-5532
0.25	30	0.50	-60 to 325/350	122-5536
0.25	30	1.00	-60 to 325/350	122-5533
0.25	50	0.25	-60 to 325/350	122-5552
0.25	60	0.10	-60 to 325/350	122-5561
0.25	60	0.25	-60 to 325/350	122-5562
0.25	60	1.00	-60 to 325/350	122-5563

DB-5ms (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	15	0.10	-60 to 325/350	123-5511
0.32	15	0.25	-60 to 325/350	123-5512
0.32	15	1.00	-60 to 325/350	123-5513
0.32	25	0.52	-60 to 325/350	123-5526
0.32	30	0.10	-60 to 325/350	123-5531
0.32	30	0.25	-60 to 325/350	123-5532
0.32	30	0.50	-60 to 325/350	123-5536
0.32	30	1.00	-60 to 325/350	123-5533
0.32	60	0.10	-60 to 325/350	123-5561
0.32	60	0.25	-60 to 325/350	123-5562
0.32	60	0.50	-60 to 325/350	123-5566
0.32	60	1.00	-60 to 325/350	123-5563
0.53	15	1.50	-60 to 300/320	125-5512
0.53	30	0.50	-60 to 300/320	125-5537
0.53	30	1.00	-60 to 300/320	125-553J
0.53	30	1.50	-60 to 300/320	125-5532



Structure of Diphenyldimethylpolysiloxane

HP-5ms

- (5%-Phenyl)-methylpolysiloxane
- Identical selectivity to HP-5
- Non-polar
- Very low bleed characteristics, ideal for GC/MS
- Excellent inertness for active compounds including acidic and basic compounds
- Improved signal-to-noise ratio for better sensitivity and mass spectral integrity
- Bonded and cross-linked
- Solvent rinsable
- Equivalent to USP Phase G27

Similar Phases: Rtx-5MS, Rtx-5 Amine, DB-5ms, PTE-5, CP-Sil 8CB Low Bleed/MS, BPX-5, ZB-5ms

HP-5ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	-60 to 325/350	19091S-577
0.20	12	0.33	-60 to 325/350	19091S-101
0.20	25	0.33	-60 to 325/350	19091S-102
0.20	50	0.33	-60 to 325/350	19091S-105
0.25	15	0.10	-60 to 325/350	19091S-331
0.25	15	0.25	-60 to 325/350	19091S-431
0.25	15	1.00	-60 to 325/350	19091S-231
0.25	30	0.10	-60 to 325/350	19091S-333
0.25	30	0.25	-60 to 325/350	19091S-433
0.25	30	0.50	-60 to 325/350	19091S-133
0.25	30	1.00	-60 to 325/350	19091S-233
0.25	60	0.10	-60 to 325/350	19091S-336
0.25	60	0.25	-60 to 325/350	19091S-436
0.32	25	0.52	-60 to 325/350	19091S-112
0.32	30	0.10	-60 to 325/350	19091S-313
0.32	30	0.25	-60 to 325/350	19091S-413
0.32	30	0.50	-60 to 325/350	19091S-113
0.32	30	1.00	-60 to 325/350	19091S-213
0.32	60	0.25	-60 to 325/350	19091S-416

DB-XLB

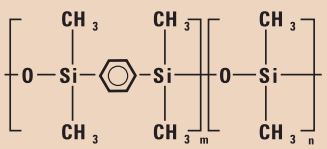
- EXceptionally Low Bleed
- Low polarity
- Extended temperature limit of 340/360°C
- Unique selectivity
- Excellent inertness for active compounds
- Ideal for confirmational analyses
- Excellent for pesticides, herbicides, PCBs and PAHs
- Ideal for GC/MS
- MSD testing and certification available
- Bonded and cross-linked
- Solvent rinsable

Note: "DB-XLB is designed for inhibiting column bleed at high temperatures. It also appears to have inadvertently inherited an exceptional ability for separating many PCB congeners when used with MS detection. This stellar performance was maximized after careful optimization of the column dimensions, temperature programs, and carrier gas flow conditions..." (Frame, G. Analytical Chemistry News & Features, Aug. 1, 1997, 468A-475A)

Similar Phases: Rtx-XLB, MDN-12

DB-XLB

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	30 to 340/360	121-1222
0.18	30	0.18	30 to 340/360	121-1232
0.20	12	0.33	30 to 340/360	128-1212
0.20	25	0.33	30 to 340/360	128-1222
0.25	15	0.10	30 to 340/360	122-1211
0.25	15	0.25	30 to 340/360	122-1212
0.25	30	0.10	30 to 340/360	122-1231
0.25	30	0.25	30 to 340/360	122-1232
0.25	30	0.50	30 to 340/360	122-1236
0.25	30	1.00	30 to 340/360	122-1233
0.25	60	0.25	30 to 340/360	122-1262
0.32	30	0.25	30 to 340/360	123-1232
0.32	30	0.50	30 to 340/360	123-1236
0.32	60	0.25	30 to 340/360	123-1262
0.53	15	1.50	30 to 320/340	125-1212
0.53	30	1.50	30 to 320/340	125-1232



Structure of Poly(dimethylsiloxy)poly (1,4-bix(dimethylsiloxy)phenylen)siloxane

DB-35ms

- Virtually equivalent to a (35%-Phenyl)-methylpolysiloxane
- Midpolarity
- Very low bleed characteristics, ideal for GC/MS
- Extended temperature limit of 340/360°C
- Excellent inertness for active compounds
- Ideal for confirmational analyses
- Bonded and cross-linked
- Solvent rinsable
- Replaces HP-35ms
- Close equivalent to USP Phase G42

Similar Phases: Rtx-35, SPB-35, AT-35, Sup-Herb, MDN-35, BPX-35

DB-35ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	50 to 340/360	121-3822
0.20	15	0.33	50 to 340/360	128-3812
0.20	25	0.33	50 to 340/360	128-3822
0.25	15	0.25	50 to 340/360	122-3812
0.25	30	0.15	50 to 340/360	122-3831
0.25	30	0.25	50 to 340/360	122-3832
0.25	60	0.25	50 to 340/360	122-3862
0.32	15	0.25	50 to 340/360	123-3812
0.32	30	0.25	50 to 340/360	123-3832
0.53	30	0.50	50 to 320/340	125-3837
0.53	30	1.00	50 to 320/340	125-3832

DB-17ms

- Virtually equivalent to (50%-Phenyl)-methylpolysiloxane
- 320/340°C upper temperature limit
- Very low bleed midpolarity column, ideal for GC/MS
- Excellent inertness for active compounds
- Enhanced mass spectral integrity
- Bonded and cross-linked
- Solvent rinsable
- Best column for CLP pesticides

Similar Phases: HP-50+, Rtx-50, 007-17, SP-2250, SPB-50, BPX-50, SPB-17, AT-50

DB-17ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	40 to 320/340	121-4722
0.25	15	0.15	40 to 320/340	122-4711
0.25	15	0.25	40 to 320/340	122-4712
0.25	30	0.15	40 to 320/340	122-4731
0.25	30	0.25	40 to 320/340	122-4732
0.25	60	0.25	40 to 320/340	122-4762
0.32	15	0.25	40 to 320/340	123-4712
0.32	30	0.25	40 to 320/340	123-4732

DB-225ms

- Virtually equivalent to (50%-Cyanopropylphenyl)-methylpolysiloxane
- Mid/high polarity
- Excellent for separations of cis- and trans-fatty acid methyl esters (FAMEs)
- Low bleed
- Bonded and cross-linked
- Solvent rinsable
- Close equivalent to USP Phase G7

Similar Phases: HP-225, SP-2330, CP-Sil 43 CB, Rtx-225, BP-225, OV-225, 007-225, AT-225

DB-225ms

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	15	0.25	40 to 240	122-2912
0.25	30	0.25	40 to 240	122-2932
0.25	60	0.25	40 to 240	122-2962
0.32	30	0.25	40 to 240	123-2932

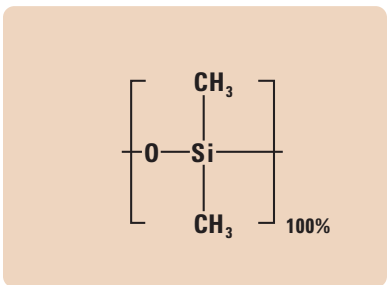
Premium Polysiloxane Columns

Polysiloxanes are the most common stationary phases. They are available in the greatest variety and are stable, robust and versatile. Standard polysiloxanes are characterized by the repeating siloxane backbone. Each silicon atom contains two functional groups. The type and amount of the groups distinguish each stationary phase and its properties.

DB-1

- 100% Dimethylpolysiloxane
- Non-polar
- Excellent general purpose column
- Wide range of applications
- Low bleed
- High temperature limit
- Bonded and cross-linked
- Solvent rinsable
- Wide range of column dimensions available
- Equivalent to USP Phase G2

Similar Phases: HP-1, Ultra-1, SPB-1, CP-Sil 5 CB Low Bleed/MS, Rtx-1, BP-1, OV-1, OV-101, 007-1(MS), SP-2100, SE-30, CP-Sil 5 CB MS, ZB-1, AT-1, MDN-1, ZB-1



Structure of Dimethylpolysiloxane

Agilent's certified vials are manufactured with the same high-quality design, technical expertise, and exacting specifications that go into every Agilent instrument. Learn more at **www.agilent.com/chem/vials**.

Vial caps are designed and fabricated for proper sealing and trouble-free operation with Agilent autosamplers.

DB-1

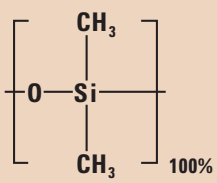
ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.05	10	0.05	-60 to 325/350	126-1012
0.05	10	0.20	-60 to 325/350	126-1013
0.10	5	0.12	-60 to 325/350	127-100A
0.10	10	0.10	-60 to 325/350	127-1012
0.10	10	0.40	-60 to 325/350	127-1013
0.10	20	0.10	-60 to 325/350	127-1022
0.10	20	0.40	-60 to 325/350	127-1023
0.10	40	0.20	-60 to 325/350	127-1046
0.10	40	0.40	-60 to 325/350	127-1043
0.15	10	1.20	-60 to 325/350	12A-1015
0.18	10	0.18	-60 to 325/350	121-1012
0.18	10	0.18	-60 to 325/350	121-1012E*
0.18	10	0.20	-60 to 325/350	121-101A
0.18	10	0.40	-60 to 325/350	121-1013
0.18	10	0.40	-60 to 325/350	121-1013E*
0.18	20	0.18	-60 to 325/350	121-1022
0.18	20	0.18	-60 to 325/350	121-1022E*
0.18	20	0.40	-60 to 325/350	121-1023
0.18	40	0.40	-60 to 325/350	121-1043
0.18	40	0.40	-60 to 325/350	121-1043E*
0.20	12	0.33	-60 to 325/350	128-1012
0.20	25	0.33	-60 to 325/350	128-1022
0.20	50	0.33	-60 to 325/350	128-1052
0.25	15	0.10	-60 to 325/350	122-1011
0.25	15	0.25	-60 to 325/350	122-1012
0.25	15	1.00	-60 to 325/350	122-1013
0.25	25	0.25	-60 to 325/350	122-1022
0.25	30	0.10	-60 to 325/350	122-1031
0.25	30	0.25	-60 to 325/350	122-1032
0.25	30	0.50	-60 to 325/350	122-103E
0.25	30	1.00	-60 to 325/350	122-1033
0.25	50	0.25	-60 to 325/350	122-1052
0.25	60	0.10	-60 to 325/350	122-1061
0.25	60	0.25	-60 to 325/350	122-1062
0.25	60	0.50	-60 to 325/350	122-106E
0.25	60	1.00	-60 to 325/350	122-1063
0.25	100	0.50	-60 to 325/350	122-10AE
0.25	150	1.00	-60 to 325/350	122-10G3

DB-1 (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	15	0.10	-60 to 325/350	123-1011
0.32	15	0.25	-60 to 325/350	123-1012
0.32	15	1.00	-60 to 325/350	123-1013
0.32	15	3.00	-60 to 280/300	123-1014
0.32	15	5.00	-60 to 280/300	123-1015
0.32	25	0.12	-60 to 325/350	123-1027
0.32	25	0.25	-60 to 325/350	123-1022
0.32	25	0.52	-60 to 325/350	123-1026
0.32	25	1.05	-60 to 325/350	123-102F
0.32	30	0.10	-60 to 325/350	123-1031
0.32	30	0.25	-60 to 325/350	123-1032
0.32	30	0.50	-60 to 325/350	123-103E
0.32	30	1.00	-60 to 325/350	123-1033
0.32	30	1.50	-60 to 300/320	123-103B
0.32	30	3.00	-60 to 280/300	123-1034
0.32	30	5.00	-60 to 280/300	123-1035
0.32	50	0.25	-60 to 325/350	123-1052
0.32	50	0.52	-60 to 325/350	123-1056
0.32	50	1.05	-60 to 325/350	123-105F
0.32	50	1.20	-60 to 325/350	123-105C
0.32	50	5.00	-60 to 280/300	123-1055
0.32	60	0.10	-60 to 325/350	123-1061
0.32	60	0.25	-60 to 325/350	123-1062
0.32	60	0.50	-60 to 325/350	123-106E
0.32	60	1.00	-60 to 325/350	123-1063
0.32	60	1.50	-60 to 300/320	123-106B
0.32	60	2.00	-60 to 280/300	123-106G
0.32	60	3.00	-60 to 280/300	123-1064
0.32	60	5.00	-60 to 280/300	123-1065
0.45	30	1.27	-60 to 325/350	124-1032
0.45	30	2.55	-60 to 260/280	124-1034
0.53	5	2.65	-60 to 325/350	125-100B
0.53	5	5.00	-60 to 325/350	125-1005
0.53	7.5	1.5	-60 to 325/350	125-1002
0.53	10	2.65	-60 to 260/280	125-10HB
0.53	10	5.00	-60 to 260/280	125-10H5
0.53	15	0.15	-60 to 340/360	125-1011
0.53	15	0.25	-60 to 320/340	125-101K
0.53	15	0.50	-60 to 300/320	125-1017
0.53	15	1.00	-60 to 300/320	125-101J

DB-1 (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.53	15	1.50	-60 to 300/320	125-1012
0.53	15	3.00	-60 to 260/280	125-1014
0.53	15	5.00	-60 to 260/280	125-1015
0.53	25	1.00	-60 to 300/320	125-102J
0.53	25	5.00	-60 to 260/280	125-1025
0.53	30	0.10	-60 to 340/360	125-1039
0.53	30	0.25	-60 to 320/340	125-103K
0.53	30	0.50	-60 to 300/320	125-1037
0.53	30	1.00	-60 to 300/320	125-103J
0.53	30	1.50	-60 to 300/320	125-1032
0.53	30	2.65	-60 to 260/280	125-103B
0.53	30	3.00	-60 to 260/280	125-1034
0.53	30	5.00	-60 to 260/280	125-1035
0.53	50	5.00	-60 to 260/280	125-1055
0.53	60	1.00	-60 to 300/320	125-106J
0.53	60	1.50	-60 to 300/320	125-1062
0.53	60	3.00	-60 to 260/280	125-1064
0.53	60	5.00	-60 to 260/280	125-1065
0.53	105	5.00	-60 to 260/280	125-10B5



Structure of Dimethylpolysiloxane

HP-1

- 100% Dimethylpolysiloxane
- Non-polar
- Excellent general purpose column – "Industry Standard"
- Wide range of applications
- Superior performance for low molecular weight alcohols (<C5)
- High temperature limit
- Bonded and cross-linked
- Solvent rinsable
- Wide range of column dimensions available
- Equivalent to USP Phase G2

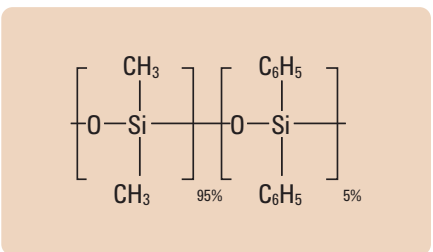
Similar Phases: DB-1, Ultra-1, SPB-1, CP-Sil 5 CB, Rtx-1, BP-1, OV-1, OV-101, 007-1(MS), SP-2100, SE-30, CP-Sil 5 CB MS, ZB-1, AT-1, MDN-1, ZB-1

HP-1

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	-60 to 325/350	19091Z-577
0.20	12	0.33	-60 to 325/350	19091-60312
0.20	17	0.10	-60 to 325/350	19091Z-008
0.20	25	0.11	-60 to 325/350	19091Z-002
0.20	25	0.33	-60 to 325/350	19091Z-102
0.20	25	0.50	-60 to 325/350	19091Z-202
0.20	50	0.11	-60 to 325/350	19091Z-005
0.20	50	0.33	-60 to 325/350	19091Z-105
0.20	50	0.50	-60 to 325/350	19091Z-205
0.25	15	0.10	-60 to 325/350	19091Z-331
0.25	15	0.25	-60 to 325/350	19091Z-431
0.25	15	1.00	-60 to 325/350	19091Z-231
0.25	30	0.10	-60 to 325/350	19091Z-333
0.25	30	0.25	-60 to 325/350	19091Z-433
0.25	30	1.00	-60 to 325/350	19091Z-233
0.25	60	0.25	-60 to 325/350	19091Z-436
0.25	60	1.00	-60 to 325/350	19091Z-236
0.25	100	0.50	-60 to 325/350	19091Z-530
0.32	15	0.25	-60 to 325/350	19091Z-411
0.32	15	1.00	-60 to 325/350	19091Z-211
0.32	25	0.17	-60 to 325/350	19091Z-012
0.32	25	0.52	-60 to 325/350	19091Z-112
0.32	25	1.05	-60 to 325/350	19091Z-212
0.32	30	0.10	-60 to 325/350	19091Z-313
0.32	30	0.25	-60 to 325/350	19091Z-413
0.32	30	1.00	-60 to 325/350	19091Z-213
0.32	30	3.00	-60 to 260/280	19091Z-513
0.32	30	4.00	-60 to 260/280	19091Z-613
0.32	30	5.00	-60 to 260/280	19091Z-713
0.32	50	0.17	-60 to 325/350	19091Z-015
0.32	50	0.52	-60 to 325/350	19091Z-115
0.32	50	1.05	-60 to 325/350	19091Z-215
0.32	60	0.25	-60 to 325/350	19091Z-416
0.32	60	1.00	-60 to 325/350	19091Z-216
0.32	60	5.00	-60 to 260/280	19091Z-716
0.53	5	0.15	-60 to 320/400	19095Z-220
0.53	5	0.88	-60 to 320/400	19095Z-020
0.53	5	2.65	-60 to 260/280	19095S-100
0.53	7.5	5.00	-60 to 260/280	19095Z-627

HP-1 (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.53	10	0.88	-60 to 300/320	19095Z-021
0.53	10	2.65	-60 to 260/280	19095Z-121
0.53	15	0.15	-60 to 320/400	19095Z-221
0.53	15	1.50	-60 to 300/320	19095Z-321
0.53	15	3.00	-60 to 260/280	19095Z-421
0.53	15	5.00	-60 to 260/280	19095Z-621
0.53	30	0.88	-60 to 300/320	19095Z-023
0.53	30	1.50	-60 to 300/320	19095Z-323
0.53	30	2.65	-60 to 260/280	19095Z-123
0.53	30	3.00	-60 to 260/280	19095Z-423
0.53	30	5.00	-60 to 260/280	19095Z-623
0.53	60	5.00	-60 to 260/280	19095Z-626



Structure of Diphenyldimethylpolysiloxane

DB-5

- (5%-Phenyl)-methylpolysiloxane
- Non-polar
- Excellent general purpose column
- Wide range of applications
- Low bleed
- High temperature limit
- Bonded and cross-linked
- Solvent rinsable
- Wide range of column dimensions available
- Equivalent to USP Phase G27

Similar Phases: HP-5, Ultra-2, SPB-5, CP-Sil 8CB, Rtx-5, BP-5, OV-5, 007-2(MPS-5), SE-52, SE-54, XTI-5, PTE-5, HP-5MS, ZB-5, AT-5, MDN-5, ZB-5

DB-5

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.10	10	0.10	-60 to 325/350	127-5012
0.10	10	0.17	-60 to 325/350	127-501E
0.10	10	0.33	-60 to 325/350	127-501N
0.10	10	0.40	-60 to 325/350	127-5013
0.10	20	0.10	-60 to 325/350	127-5022
0.10	20	0.40	-60 to 325/350	127-5023
0.15	10	1.20	-60 to 300/320	12A-5015

DB-5 (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	10	0.18	-60 to 325/350	121-5012
0.18	10	0.18	-60 to 325/350	121-5012E*
0.18	10	0.40	-60 to 325/350	121-5013
0.18	20	0.18	-60 to 325/350	121-5022
0.18	20	0.18	-60 to 325/350	121-5022E*
0.18	20	0.40	-60 to 325/350	121-5023
0.18	20	0.40	-60 to 325/350	121-5023E*
0.18	40	0.18	-60 to 325/350	121-5042
0.20	12	0.33	-60 to 325/350	128-5012
0.20	15	0.20	-60 to 325/350	128-50H7
0.20	25	0.33	-60 to 325/350	128-5022
0.20	50	0.33	-60 to 325/350	128-5052
0.25	15	0.10	-60 to 325/350	122-5011
0.25	15	0.25	-60 to 325/350	122-5012
0.25	15	0.50	-60 to 325/350	122-501E
0.25	15	1.00	-60 to 325/350	122-5013
0.25	25	0.25	-60 to 325/350	122-5022
0.25	30	0.10	-60 to 325/350	122-5031
0.25	30	0.25	-60 to 325/350	122-5032
0.25	30	0.50	-60 to 325/350	122-503E
0.25	30	1.00	-60 to 325/350	122-5033
0.25	50	0.25	-60 to 325/350	122-5052
0.25	60	0.10	-60 to 325/350	122-5061
0.25	60	0.25	-60 to 325/350	122-5062
0.25	60	0.50	-60 to 325/350	122-506E
0.25	60	1.00	-60 to 325/350	122-5063
0.32	15	0.10	-60 to 325/350	123-5011
0.32	15	0.25	-60 to 325/350	123-5012
0.32	15	1.00	-60 to 325/350	123-5013
0.32	25	0.17	-60 to 325/350	123-502D
0.32	25	0.25	-60 to 325/350	123-5022
0.32	25	0.52	-60 to 325/350	123-5026
0.32	25	1.05	-60 to 325/350	123-502F
0.32	30	0.10	-60 to 325/350	123-5031
0.32	30	0.25	-60 to 325/350	123-5032
0.32	30	0.50	-60 to 325/350	123-503E
0.32	30	1.00	-60 to 325/350	123-5033
0.32	30	1.50	-60 to 325/350	123-503B
0.32	50	0.25	-60 to 325/350	123-5052
0.32	50	0.52	-60 to 325/350	123-5056
0.32	50	1.00	-60 to 325/350	123-5053
0.32	60	0.25	-60 to 325/350	123-5062
0.32	60	1.00	-60 to 325/350	123-5063
0.45	15	1.27	-60 to 300/320	124-5012
0.45	30	0.42	-60 to 300/320	124-5037
0.45	30	1.27	-60 to 300/320	124-5032

DB-5 (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.45	15	1.27	-60 to 300/320	124-5012
0.45	30	0.42	-60 to 300/320	124-5037
0.45	30	1.27	-60 to 300/320	124-5032
0.53	10	2.65	-60 to 260/280	125-50HB
0.53	15	0.25	-60 to 300/320	125-501K
0.53	15	0.50	-60 to 300/320	125-5017
0.53	15	1.00	-60 to 300/320	125-501J
0.53	15	1.50	-60 to 300/320	125-5012
0.53	25	5.00	-60 to 260/280	125-5025
0.53	30	0.25	-60 to 300/320	125-503K
0.53	30	0.50	-60 to 300/320	125-5037
0.53	30	0.88	-60 to 300/320	125-503D
0.53	30	1.00	-60 to 300/320	125-503J
0.53	30	1.50	-60 to 300/320	125-5032
0.53	30	2.65	-60 to 260/280	125-503B
0.53	30	3.00	-60 to 260/280	125-5034
0.53	30	5.00	-60 to 260/280	125-5035
0.53	60	1.50	-60 to 300/320	125-5062
0.53	60	5.00	-60 to 260/280	125-5065

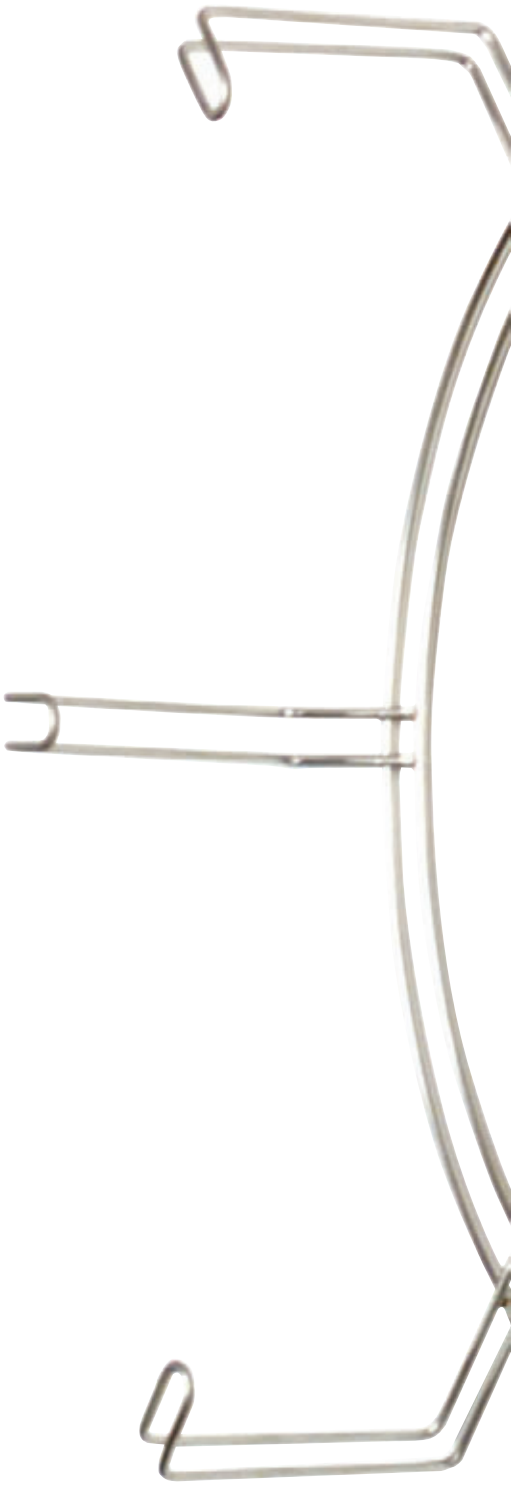
HP-5

- (5%-Phenyl)-methylpolysiloxane
- Non-polar
- Excellent general purpose column
- Wide range of applications
- High temperature limit
- Bonded and cross-linked
- Solvent rinsable
- Wide range of column dimensions available
- Equivalent to USP Phase G27

Similar Phases: DB-5, Ultra-2, SPB-5, CP-Sil 8 CB, Rtx-5, BP-5, OV-5, 007-2(MPS-5), SE-52, SE-54, XTI-5, PTE-5, HP-5MS, ZB-5, AT-5, MDN-5, ZB-5

HP-5

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	-60 to 325/350	19091J-577
0.20	12	0.33	-60 to 325/350	19091J-101
0.20	25	0.11	-60 to 325/350	19091J-002
0.20	25	0.33	-60 to 325/350	19091J-102
0.20	25	0.50	-60 to 325/350	19091J-202
0.20	50	0.11	-60 to 325/350	19091J-005
0.20	50	0.33	-60 to 325/350	19091J-105
0.20	50	0.50	-60 to 325/350	19091J-205
0.25	5	0.10	-60 to 325/350	19091J-330
0.25	15	0.25	-60 to 325/350	19091J-431
0.25	15	1.00	-60 to 325/350	19091J-231
0.25	30	0.10	-60 to 325/350	19091J-333
0.25	30	0.25	-60 to 325/350	19091J-433
0.25	30	1.00	-60 to 325/350	19091J-233
0.25	60	0.25	-60 to 325/350	19091J-436
0.25	60	1.00	-60 to 325/350	19091J-236
0.32	15	0.25	-60 to 325/350	19091J-411
0.32	25	0.17	-60 to 325/350	19091J-012
0.32	25	0.52	-60 to 325/350	19091J-112
0.32	25	1.05	-60 to 325/350	19091J-212
0.32	30	0.10	-60 to 325/350	19091J-313
0.32	30	0.25	-60 to 325/350	19091J-413
0.32	30	0.50	-60 to 325/350	19091J-113
0.32	30	1.00	-60 to 325/350	19091J-213
0.32	50	0.17	-60 to 325/350	19091J-015
0.32	50	0.52	-60 to 325/350	19091J-115
0.32	50	1.05	-60 to 325/350	19091J-215
0.32	60	0.25	-60 to 325/350	19091J-416
0.32	60	1.00	-60 to 325/350	19091J-216
0.53	10	2.65	-60 to 260/280	19095J-121
0.53	15	1.50	-60 to 300/320	19095J-321
0.53	15	5.00	-60 to 260/280	19095J-621
0.53	30	0.88	-60 to 300/320	19095J-023
0.53	30	1.50	-60 to 300/320	19095J-323
0.53	30	2.65	-60 to 260/280	19095J-123
0.53	30	5.00	-60 to 260/280	19095J-623



Ultra 1

- Non-polar
- 100% Dimethylpolysiloxane
- Equivalent to HP-1 with tighter specifications for retention index and capacity factors
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: DB-1, HP-1, SPB-1, CP-Sil 5 CB, Rtx-1, BP-1, 007-1(MS)

Ultra 1

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.20	12	0.33	-60 to 325/350	19091A-101
0.20	25	0.11	-60 to 325/350	19091A-002
0.20	25	0.33	-60 to 325/350	19091A-102
0.20	50	0.11	-60 to 325/350	19091A-005
0.20	50	0.33	-60 to 325/350	19091A-105
0.32	25	0.17	-60 to 325/350	19091A-012
0.32	25	0.52	-60 to 325/350	19091A-112
0.32	50	0.17	-60 to 325/350	19091A-015
0.32	50	0.52	-60 to 325/350	19091A-115

Ultra 2

- Non-polar
- (5%-Phenyl)-methylpolysiloxane
- Equivalent to HP-5 with tighter specifications for retention index and capacity factors
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: DB-5, HP-5, SPB-5, CP-Sil 8 CB, Rtx-5, BP-5, CB-5, 007-5, 2B-5

Ultra 2

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.20	12	0.33	-60 to 325/350	19091B-101
0.20	25	0.11	-60 to 325/350	19091B-002
0.20	25	0.33	-60 to 325/350	19091B-102
0.20	50	0.11	-60 to 325/350	19091B-005
0.20	50	0.33	-60 to 325/350	19091B-105
0.32	25	0.17	-60 to 325/350	19091B-012
0.32	25	0.52	-60 to 325/350	19091B-112
0.32	50	0.17	-60 to 325/350	19091B-015
0.32	50	0.52	-60 to 325/350	19091B-115

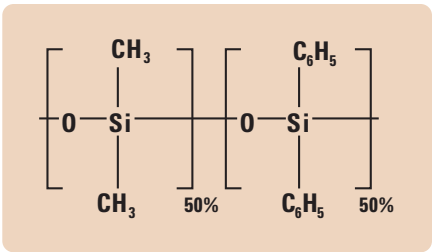
DB-35

- (35%-Phenyl)-methylpolysiloxane
- Midpolarity – slightly more polar than HP-35
- Low bleed
- Inert to active solutes
- Ideal for confirmational analyses
- Bonded and cross-linked
- Solvent rinsable
- Equivalent to USP Phase G42

Similar Phases: Rtx-35, SPB-35, AT-35, Sup-Herb, HP-35, BPX-35

DB-35

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	30	0.25	40 to 300/320	122-1932
0.25	60	0.25	40 to 300/320	122-1962
0.32	30	0.25	40 to 300/320	123-1932
0.32	30	0.50	40 to 300/320	123-1933
0.53	15	1.00	40 to 280/300	125-1912
0.53	30	0.50	40 to 280/300	125-1937
0.53	30	1.00	40 to 280/300	125-1932



Structure of Diphenyldimethylpolysiloxane

DB-17

- (50%-Phenyl)-methylpolysiloxane
- Midpolarity – slightly more polar than HP-50+
- Excellent for confirmational analyses
- Bonded and cross-linked
- Solvent rinsable
- Equivalent to USP Phase G3

Similar Phases: HP-50+, Rtx-50, CP-Sil 24 CB, 007-17(MPS-50), HP-17, SP-2250, SPB-50, ZB-50, AT-50

DB-17

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.05	10	0.10	40 to 280/300	126-1713
0.10	10	0.10	40 to 280/300	127-1712
0.10	10	0.20	40 to 280/300	127-1713
0.10	20	0.10	40 to 280/300	127-1722
0.18	20	0.18	40 to 280/300	121-1722
0.18	20	0.30	40 to 280/300	121-1723
0.25	15	0.15	40 to 280/300	122-1711
0.25	15	0.25	40 to 280/300	122-1712
0.25	15	0.50	40 to 280/300	122-1713
0.25	30	0.15	40 to 280/300	122-1731
0.25	30	0.25	40 to 280/300	122-1732
0.25	30	0.50	40 to 280/300	122-1733
0.25	60	0.25	40 to 280/300	122-1762
0.32	15	0.15	40 to 280/300	123-1711
0.32	15	0.25	40 to 280/300	123-1712
0.32	15	0.50	40 to 280/300	123-1713
0.32	30	0.15	40 to 280/300	123-1731
0.32	30	0.25	40 to 280/300	123-1732
0.32	30	0.50	40 to 280/300	123-1733
0.32	60	0.25	40 to 280/300	123-1762
0.53	5	2.00	40 to 280/300	125-1704
0.53	15	0.25	40 to 260/280	125-1711
0.53	15	0.50	40 to 260/280	125-1717

DB-17 (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.53	15	1.00	40 to 260/280	125-1712
0.53	15	1.50	40 to 260/280	125-1713
0.53	30	0.25	40 to 260/280	125-1731
0.53	30	0.50	40 to 260/280	125-1737
0.53	30	1.00	40 to 260/280	125-1732
0.53	30	1.50	40 to 260/280	125-1733
0.53	60	1.00	40 to 260/280	125-1762

HP-50+

- (50%-Phenyl)-methylpolysiloxane
- Midpolarity-slightly less polar than DB-17
- Excellent for confirmational analyses
- Bonded and cross-linked
- Solvent rinsable
- Equivalent to USP Phase G3

Similar Phases: DB-17, Rtx-50, CP-Sil 24 CB, 007-17(MPS-50), SP-2250, SPB-50, ZB-50, AT-50

HP-50+

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	40 to 280/300	19091L-577
0.20	12	0.31	40 to 280/300	19091L-101
0.25	5	0.15	40 to 280/300	19091L-330
0.25	15	0.25	40 to 280/300	19091L-431
0.25	30	0.15	40 to 280/300	19091L-333
0.25	30	0.25	40 to 280/300	19091L-433
0.25	30	0.50	40 to 280/300	19091L-133
0.32	15	0.50	40 to 280/300	19091L-111
0.32	30	0.25	40 to 280/300	19091L-413
0.32	30	0.50	40 to 280/300	19091L-113
0.32	60	0.25	40 to 280/300	19091L-416
0.53	15	1.00	40 to 260/280	19095L-021
0.53	30	0.50	40 to 260/280	19095L-523
0.53	30	1.00	40 to 260/280	19095L-023

DB-1301 and DB-1701

- DB-1301: (6%-Cyanopropyl-phenyl) methylpolysiloxane
- DB-1301: Equivalent to USP Phase G43
- DB-1701: (14%-Cyanopropyl-phenyl)-methylpolysiloxane
- Low/midpolarity
- Bonded and cross-linked
- Exact replacement of HP-1301 and HP-1701
- Solvent rinsable

Similar Phases: Rtx-1301, PE-1301
DB-1701: SPB-1701, CP-Sil 19 CB, Rtx-1701, BP-10, OV-1701, 007-1701, ZB-1701

DB-1301

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	30	0.25	-20 to 280/300	122-1332
0.25	30	1.00	-20 to 280/300	122-1333
0.25	60	0.25	-20 to 280/300	122-1362
0.25	60	1.00	-20 to 280/300	122-1363
0.32	30	0.25	-20 to 280/300	123-1332
0.32	30	1.00	-20 to 280/300	123-1333
0.32	60	1.00	-20 to 280/300	123-1363
0.53	15	1.00	-20 to 260/280	125-1312
0.53	30	1.00	-20 to 260/280	125-1332
0.53	30	1.50	-20 to 260/280	125-1333

DB-1701

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.10	20	0.10	-20 to 280/300	127-0722
0.10	20	0.40	-20 to 280/300	127-0723
0.18	10	0.40	-20 to 280/300	121-0713
0.25	15	0.25	-20 to 280/300	122-0712
0.25	15	1.00	-20 to 280/300	122-0713
0.25	30	0.15	-20 to 280/300	122-0731
0.25	30	0.25	-20 to 280/300	122-0732
0.25	30	1.00	-20 to 280/300	122-0733
0.25	60	0.15	-20 to 280/300	122-0761
0.25	60	0.25	-20 to 280/300	122-0762
0.25	60	0.50	-20 to 280/300	122-0766
0.25	60	1.00	-20 to 280/300	122-0763
0.32	15	0.25	-20 to 280/300	123-0712

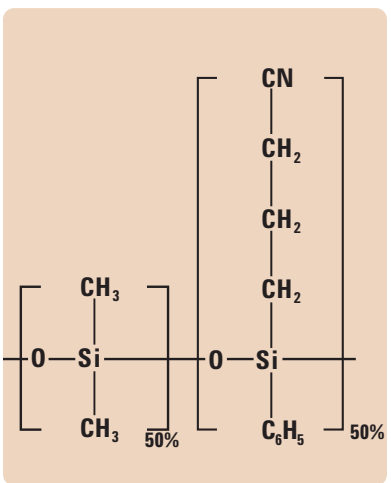
DB-1701

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	15	1.00	-20 to 280/300	123-0713
0.32	30	0.15	-20 to 280/300	123-0731
0.32	30	0.25	-20 to 280/300	123-0732
0.32	30	1.00	-20 to 280/300	123-0733
0.32	50	1.00	-20 to 280/300	123-0753
0.32	60	0.25	-20 to 280/300	123-0762
0.32	60	1.00	-20 to 280/300	123-0763
0.53	15	1.00	-20 to 260/280	125-0712
0.53	30	0.25	-20 to 260/280	125-0731
0.53	30	0.50	-20 to 260/280	125-0737
0.53	30	1.00	-20 to 260/280	125-0732
0.53	30	1.50	-20 to 260/280	125-0733
0.53	60	1.00	-20 to 260/280	125-0762

DB-225

- (50%-Cyanopropylphenyl)-dimethylpolysiloxane
- Mid/high polarity
- Excellent for separations of cis- and trans-fatty acid methyl esters (FAMEs)
- Bonded and cross-linked
- Solvent rinsable
- Exact replacement of HP-225
- Close equivalent to USP Phase G7

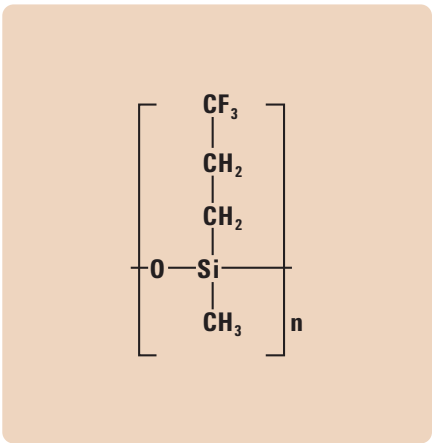
Similar Phases: SP-2330, CP-Sil 43 CB, Rtx-225, BP-225, OV-225, 007-225, AT-225



Structure of cyanopropylphenylmethylpolysiloxane

DB-225

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.10	20	0.10	40 to 220/240	127-2222
0.18	20	0.20	40 to 220/240	121-2223
0.25	15	0.25	40 to 220/240	122-2212
0.25	30	0.15	40 to 220/240	122-2231
0.25	30	0.25	40 to 220/240	122-2232
0.32	30	0.25	40 to 220/240	123-2232
0.53	15	1.00	40 to 200/220	125-2212
0.53	30	0.50	40 to 200/220	125-2237
0.53	30	1.00	40 to 200/220	125-2232



Structure of trifluoropropylmethylpolysiloxane

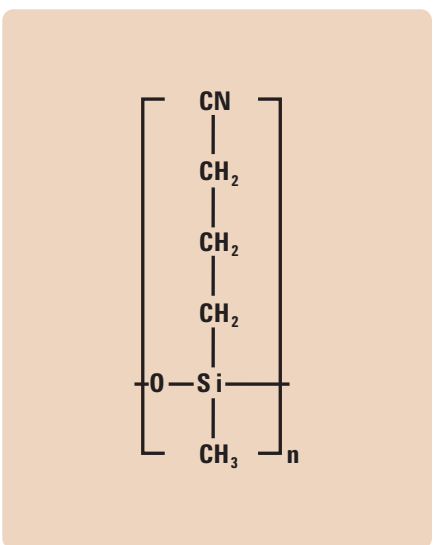
DB-200

- (35% Trifluoropropyl)-methylpolysiloxane
- 300/320°C temperature limit
- Midpolarity (more polar than DB-1701 or DB-17)
- Ideal for difficult to separate positional isomers
- Unique interactions with compounds containing nitro, halogen and carbonyl groups
- Low ECD bleed
- Unique selectivity
- Close equivalent to USP Phase G6

Similar Phases: Rtx-200

DB-200

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	30	0.25	30 to 300/320	122-2032
0.25	30	0.50	30 to 300/320	122-2033
0.32	30	0.25	30 to 300/320	123-2032
0.32	30	0.50	30 to 300/320	123-2033
0.53	30	1.00	30 to 280/300	125-2032



Structure of cyanpropylmethylpolysiloxane

DB-23

- (50%-Cyanopropyl)-methylpolysiloxane
- High polarity
- Designed for separation of fatty acid methyl esters (FAMEs)
- Excellent resolution for cis- and trans-isomers
- Bonded and cross-linked
- Solvent rinsable
- Replaces HP-23
- Close equivalent to USP Phase G5

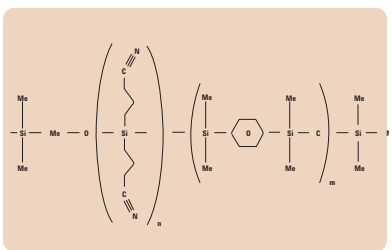
Similar Phases: SP-2330, Rtx-2330, 007-23, AT-Silar, BPX-70, SP-2340

DB-23

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.20	40 to 250/260	121-2323
0.25	15	0.25	40 to 250/260	122-2312
0.25	30	0.15	40 to 250/260	122-2331
0.25	30	0.25	40 to 250/260	122-2332
0.25	60	0.15	40 to 250/260	122-2361
0.25	60	0.25	40 to 250/260	122-2362
0.32	30	0.25	40 to 250/260	123-2332
0.32	60	0.25	40 to 250/260	123-2362
0.53	15	0.50	40 to 230/240	125-2312
0.53	30	0.50	40 to 230/240	125-2332

HP-88

- (88%-cyanopropyl)aryl-polysiloxane
- 250/320°C upper temperature limits
- High Polarity
- Designed for separation of cis/trans fatty acid methyl esters (FAMEs)
- Even better separation than DB-23 of cis-trans isomers



Structure of cyanopropylaryl-polysiloxane

Similar Phases: CP-Sil 88, SP-2560, SP-2340, SP-2330, BPX-70, BPX-90

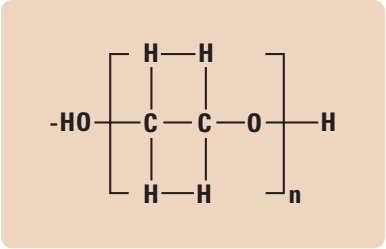
Because HP-88 is not bonded or cross-linked, we do not recommend solvent rinsing.

HP-88

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	100	0.20	0 to 250/260	112-88A7
0.25	60	0.20	0 to 250/260	112-8867
0.25	30	0.20	0 to 250/260	112-8837

Polyethylene Glycol (PEG) Columns

Agilent offers a full range of PEG columns. Even though each phase is based on the polyethylene glycol polymer, strict control of the cross-linking and deactivation processes result in a variety of unique phase characteristics to meet the varying analysis needs of your laboratory.



Structure of Polyethylene glycol

PEG Column	Features	Benefits
DB-WAX DB-WaxFF	Lowest operating temperature limit Most similar to Carbowax 20M Available in 0.10 mm ID Highly inert	Analyze low boiling point analytes Transfer older methods to bonded phase Used for Fast GC for high sample throughput Broad analyte compatibility
DB-WAXetr	Middle operating temperature range	Compromise for high and low boiling analytes
HP-INNOWax	Highest upper temperature limit Wide chemical compatibility Lowest bleed at elevated temperatures Highly inert	Analyze high boiling point compounds Excellent general purpose column Best choice for MS use Broad analyte compatibility
DB-FFAP, HP-FFAP	Acid modified	Can inject organic acids without derivization
CAM	Base modified Non-bonded	Good peak shape for basic compounds Cannot be solvent rinsed

DB-WAX and DB-WaxFF

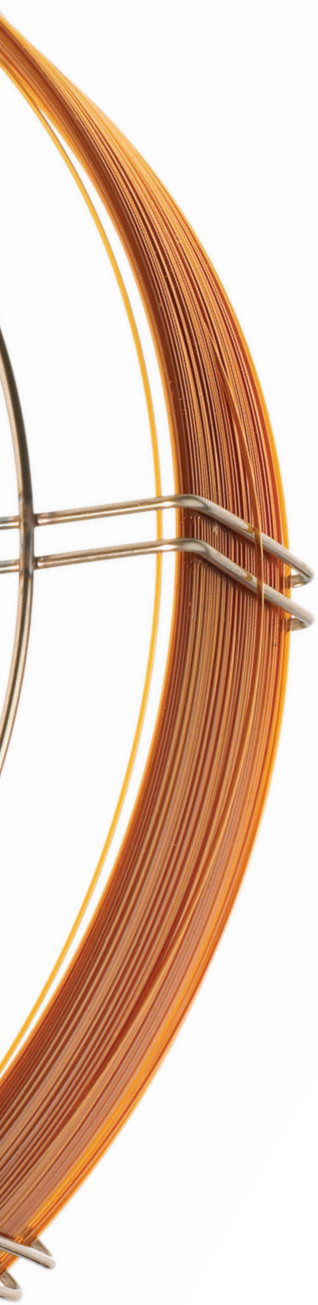
- Polyethylene glycol (PEG)
- Equivalent to USP Phase G16
- High polarity
- Lower temperature limit of 20°C is the lowest of any bonded PEG phase; improves resolution of low boiling point analytes
- Column-to-column reproducibility
- Bonded and cross-linked
- Exact replacement of HP-WAX
- Solvent rinsable
- DB-WaxFF is a highly reproducible, specially tested microbore DB-Wax for fragrance analysis

Similar Phases: HP-20M, SUPELCOWAX 10, CP-WAX 52 CB, SUPEROX II, CB-WAX, Stabilwax, BP-20, 007-CW, Carbowax, HP-INNOWax, Rtx-WAX, ZB-WAX

DB-WAX and DB-WaxFF

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
DB-WAX				
0.05	10	0.05	20 to 250/260	126-7012
0.05	10	0.10	20 to 240/250	126-7013
0.10	10	0.10	20 to 250/260	127-7012
0.10	10	0.20	20 to 240/250	127-7013
0.10	20	0.10	20 to 250/260	127-7022
0.10	20	0.20	20 to 240/250	127-7023
0.18	10	0.18	20 to 250/260	121-7012
0.18	20	0.18	20 to 250/260	121-7022
0.18	20	0.30	20 to 240/250	121-7023
0.18	40	0.18	20 to 250/260	121-7042
0.18	40	0.30	20 to 240/250	121-7043
0.20	25	0.20	20 to 250/260	128-7022
0.20	30	0.20	20 to 250/260	128-7032
0.20	50	0.20	20 to 250/260	128-7052
0.25	15	0.25	20 to 250/260	122-7012
0.25	15	0.50	20 to 240/250	122-7013
0.25	30	0.15	20 to 250/260	122-7031
0.25	30	0.25	20 to 250/260	122-7032
0.25	30	0.50	20 to 240/250	122-7033
0.25	60	0.15	20 to 250/260	122-7061
0.25	60	0.25	20 to 250/260	122-7062
0.25	60	0.50	20 to 240/250	122-7063

Only Agilent liners are designed for the precise tolerances of Agilent GC inlets. Learn more at **www.agilent.com/chem/liners**.



DB-WAX and DB-WaxFF (Continued)

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	15	0.25	20 to 250/260	123-7012
0.32	15	0.50	20 to 240/250	123-7013
0.32	30	0.15	20 to 250/260	123-7031
0.32	30	0.25	20 to 250/260	123-7032
0.32	30	0.50	20 to 240/250	123-7033
0.32	60	0.25	20 to 250/260	123-7062
0.32	60	0.50	20 to 240/250	123-7063
0.45	30	0.85	20 to 230/240	124-7032
0.53	15	0.50	20 to 230/240	125-7017
0.53	15	1.00	20 to 230/240	125-7012
0.53	30	0.25	20 to 230/240	125-7031
0.53	30	0.50	20 to 230/240	125-7037
0.53	30	1.00	20 to 230/240	125-7032
0.53	60	1.00	20 to 230/240	125-7062
DB-WaxFF				
0.10	20	0.20	20 to 240/250	127-7023FF

DB-WAXetr

- Polyethylene glycol (PEG)
- Extended Temperature Range (etr)
- High polarity
- Excellent column-to-column repeatability
- Bonded and cross-linked
- Solvent rinsable
- Equivalent to USP Phase G16

Similar Phases: HP-20M, SUPELCOWAX 10, CP-WAX 52 CB, SUPEROX II, CB-WAX, Stabilwax, BP-20, 007-CW, Carbowax, HP-INNOWax, ZB-WAX

DB-WAXetr

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.20	25	0.40	30 to 250/260	128-7323
0.25	30	0.25	30 to 260/280	122-7332
0.25	30	0.50	30 to 250/260	122-7333
0.25	60	0.25	30 to 260/280	122-7362
0.25	60	0.50	30 to 250/260	122-7363
0.32	15	0.25	30 to 260/280	123-7312
0.32	15	1.00	30 to 250/260	123-7314
0.32	30	0.25	30 to 260/280	123-7332
0.32	30	0.50	30 to 250/260	123-7333
0.32	30	1.00	30 to 250/260	123-7334
0.32	50	1.00	30 to 250/260	123-7354
0.32	60	0.25	30 to 260/280	123-7362
0.32	60	0.50	30 to 250/260	123-7363
0.32	60	1.00	30 to 250/260	123-7364
0.53	15	1.00	30 to 240/260	125-7312
0.53	15	2.00	50 to 230/250	125-7314
0.53	30	1.00	30 to 240/260	125-7332
0.53	30	1.50	30 to 230/240	125-7333
0.53	30	2.00	50 to 230/250	125-7334
0.53	60	1.00	30 to 240/260	125-7362

HP-INNOWax

- Polyethylene glycol (PEG)
- High polarity
- Highest upper temperature limits of the bonded PEG phases
- Column-to-column repeatability
- Bonded and cross-linked
- Solvent rinsable
- Close equivalent to USP Phase G16

Similar Phases: HP-20M, SUPELCOWAX 10, CP-WAX 52 CB, SUPEROX II, CB-WAX, Stabilwax, BP-20, 007-CW, Carbowax, DB-WAXetr, ZB-WAX

HP-INNOWax

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	40 to 260/270	19091N-577
0.20	25	0.20	40 to 260/270	19091N-102
0.20	25	0.40	40 to 260/270	19091N-202
0.20	50	0.20	40 to 260/270	19091N-105
0.20	50	0.40	40 to 260/270	19091N-205
0.25	4	0.25	40 to 260/270	19091N-130
0.25	5	0.15	40 to 260/270	19091N-030
0.25	15	0.25	40 to 260/270	19091N-131
0.25	15	0.50	40 to 260/270	19091N-231
0.25	30	0.15	40 to 260/270	19091N-033
0.25	30	0.25	40 to 260/270	19091N-133
0.25	30	0.50	40 to 260/270	19091N-233
0.25	60	0.15	40 to 260/270	19091N-036
0.25	60	0.25	40 to 260/270	19091N-136
0.25	60	0.50	40 to 260/270	19091N-236
0.32	15	0.25	40 to 260/270	19091N-111
0.32	30	0.15	40 to 260/270	19091N-013
0.32	30	0.25	40 to 260/270	19091N-113
0.32	30	0.50	40 to 260/270	19091N-213
0.32	60	0.25	40 to 260/270	19091N-116
0.32	60	0.50	40 to 260/270	19091N-216
0.53	15	1.00	40 to 240/250	19095N-121
0.53	30	1.00	40 to 240/250	19095N-123
0.53	60	1.00	40 to 240/250	19095N-126

DB-FFAP

- Nitroterephthalic acid modified polyethylene glycol
- High polarity
- Temperature range from 40° to 250°C
- Designed for the analysis of volatile fatty acids and phenols
- Replaces OV-351
- Bonded and cross-linked
- Solvent rinsable
- Close equivalent to USP Phase G35

We do not recommend the use of water or methanol to rinse DB-FFAP GC columns.

Similar Phases: Stabilwax-DA, HP-FFAP, Nukol, 007-FFAP, BP21, CP-Wax 58 (FFAP) CB, AT-1000, OV-351, CP-FFAP-CB

DB-FFAP

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	15	0.25	40 to 250	122-3212
0.25	30	0.25	40 to 250	122-3232
0.25	30	0.50	40 to 250	122-3233
0.25	60	0.25	40 to 250	122-3262
0.25	60	0.50	40 to 250	122-3263
0.32	15	0.25	40 to 250	123-3212
0.32	25	0.50	40 to 250	123-3223
0.32	30	0.25	40 to 250	123-3232
0.32	30	0.50	40 to 250	123-3233
0.32	30	1.00	40 to 250	123-3234
0.32	50	0.50	40 to 250	123-3253
0.32	60	0.25	40 to 250	123-3262
0.32	60	0.50	40 to 250	123-3263
0.32	60	1.00	40 to 250	123-3264
0.45	30	0.85	40 to 250	124-3232
0.53	10	1.00	40 to 250	125-32H2
0.53	15	0.50	40 to 250	125-3217
0.53	15	1.00	40 to 250	125-3212
0.53	30	0.25	40 to 250	125-3231
0.53	30	0.50	40 to 250	125-3237
0.53	30	1.00	40 to 250	125-3232
0.53	30	1.50	40 to 250	125-3233
0.53	60	1.00	40 to 250	125-3262

HP-FFAP

- Nitroterephthalic acid modified polyethylene glycol
- High polarity
- Temperature range from 60° to 240/250°C (230/240°C for 0.53 mm)
- Designed for the analysis of volatile fatty acids and phenols
- Replaces OV-351
- Bonded and cross-linked
- Solvent rinsable
- Close equivalent to USP Phase G35

We do not recommend the use of water or methanol to rinse HP-FFAP GC columns.

Similar Phases: Stabilwax-DA, DB-FFAP, Nukol, 007-FFAP, BP21, CP-WAX 58 (FFAP) CB, AT-1000, OV-351, CP-FFAP-CB

HP-FFAP

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.20	25	0.30	60 to 240/250	19091F-102
0.20	50	0.30	60 to 240/250	19091F-105
0.25	30	0.25	60 to 240/250	19091F-433
0.32	25	0.50	60 to 240/250	19091F-112
0.32	30	0.25	60 to 240/250	19091F-413
0.32	50	0.50	60 to 240/250	19091F-115
0.53	10	1.00	60 to 240	19095F-121
0.53	15	1.00	60 to 240	19095F-120
0.53	30	1.00	60 to 240	19095F-123

CAM

- Base deactivated polyethylene glycol
- Specifically designed for amine analysis
- Excellent peak shape for primary amines
- Replaces HP-Basicwax

Similar Phases: Stabilwax-DB, Carbowax Amine

Because the CAM is not bonded or cross-linked, we do not recommend solvent rinsing.

CAM

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	15	0.25	60 to 220/240	112-2112
0.25	30	0.25	60 to 220/240	112-2132
0.25	30	0.50	60 to 220/240	112-2133
0.25	60	0.25	60 to 220/240	112-2162
0.32	30	0.25	60 to 220/240	113-2132
0.32	30	0.50	60 to 220/240	113-2133
0.53	30	1.00	60 to 200/220	115-2132

Specialty Columns

Agilent offers a wide variety of specialty columns for high-temperature, pesticide, petroleum, semivolatile, volatile, and life science applications. This guide features some of the most popular selections. For a complete listing of Agilent's GC columns, see Agilent's Essential Chromatography and Spectroscopy Catalog or contact your local Agilent representative.

High Temperature

DB-1ht

- 100% Dimethylpolysiloxane
- Non-polar
- Specially processed for extended temperature limit of 400°C
- High temperature, polyimide-coated, fused silica tubing
- Excellent peak shape and faster elution times for high boilers
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: Stx-1ht

DB-1ht

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	15	0.10	-60 to 400	122-1111
0.25	30	0.10	-60 to 400	122-1131
0.32	15	0.10	-60 to 400	123-1111
0.32	30	0.10	-60 to 400	123-1131

DB-5ht

- (5%-Phenyl)-methylpolysiloxane
- Non-polar
- Specially processed for extended temperature limit of 400°C
- High temperature, polyimide-coated, fused silica tubing
- Excellent peak shape and faster elution times for high boilers
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: HT5, Stx-5ht

DB-5ht

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	15	0.10	-60 to 400	122-5711
0.25	30	0.10	-60 to 400	122-5731
0.32	15	0.10	-60 to 400	123-5711
0.32	30	0.10	-60 to 400	123-5731

DB-17ht

- (50%-Phenyl)-methylpolysiloxane
- Midpolarity
- Extended upper temperature limit of 365°C
- High temperature, polyimide-coated, fused silica tubing
- Excellent peak shape and faster elution times for high boilers
- Improved resolution for triglycerides
- Ideal for confirmational analyses
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: Rtx-65TG, BPX50, CP-TAP CB

DB-17ht

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	15	0.15	40 to 340/365	122-1811
0.25	30	0.15	40 to 340/365	122-1831
0.32	15	0.15	40 to 340/365	123-1811
0.32	30	0.15	40 to 340/365	123-1831
0.32	60	0.15	40 to 340/365	123-1861

Pesticides

Agilent J&W low bleed columns are ideal for the analysis of pesticides. Not only do they possess less bleed than a standard polymer, which improves the signal to noise ratio and minimum detectable quantities, but they also have higher upper temperature limits which allow for faster run times. Agilent also offers several common phases with additional pesticide specific testing to ensure performance for your application.

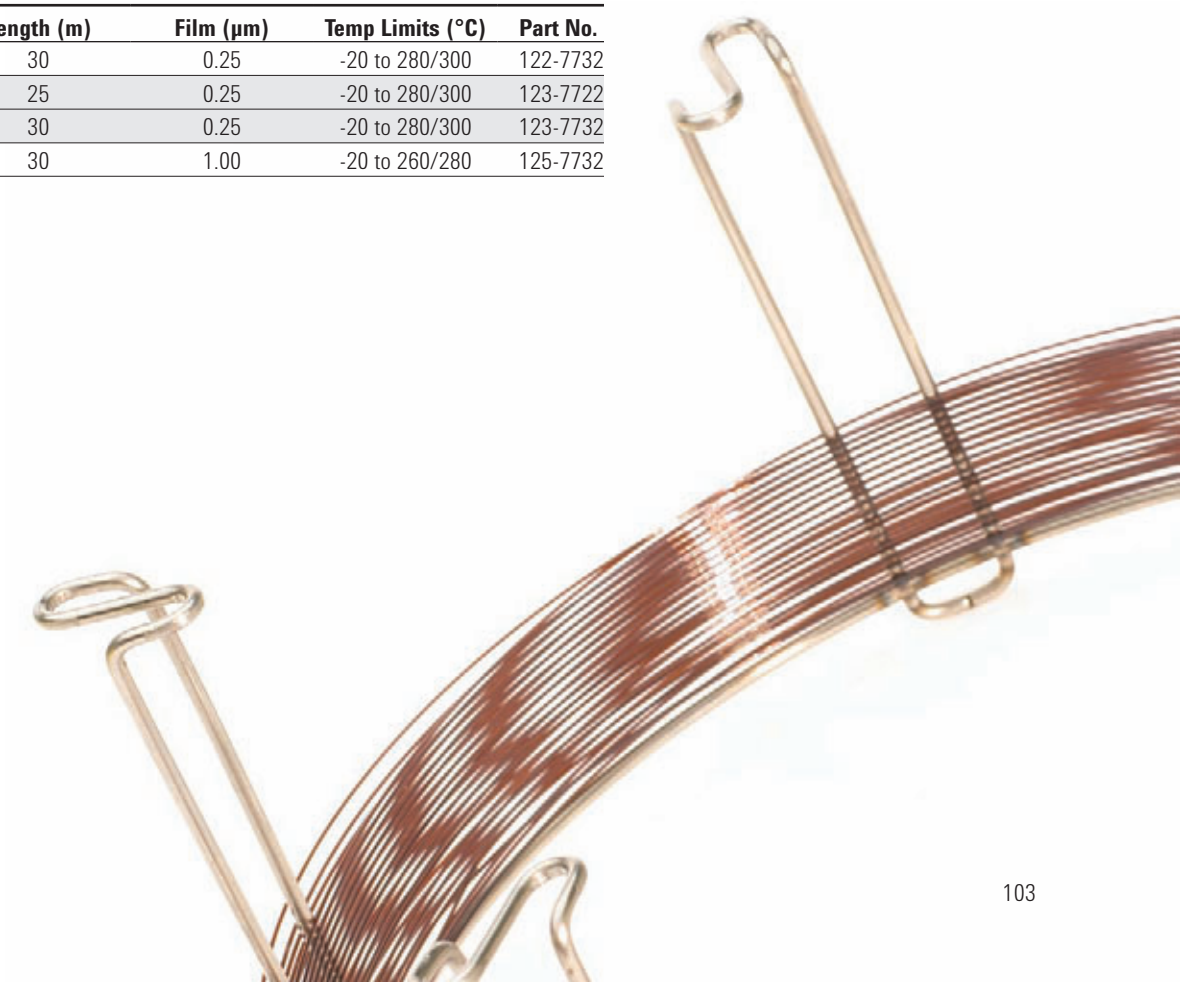
DB-1701P

- Low/midpolarity
- Exact replacement of HP-PAS1701
- Specifically designed and processed for the analysis of organochlorine pesticides
- ECD tested to assure minimal pesticide breakdown and low ECD bleed
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: SPB-1701, CP-Sil 19CB, Rtx-1701, BP-10, CB-1701, OV-1701, 007-1701

DB-1701P

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	30	0.25	-20 to 280/300	122-7732
0.32	25	0.25	-20 to 280/300	123-7722
0.32	30	0.25	-20 to 280/300	123-7732
0.53	30	1.00	-20 to 260/280	125-7732



DB-608

- Specifically designed for the analysis of chlorinated pesticides and PCBs
- U.S. EPA Methods: 608, 508, 8080
- Excellent inertness and recoveries without pesticide breakdown
- Bonded and cross-linked
- Solvent rinsable
- Exact replacement of HP-608

Similar Phases: SPB-608, NON-PAKD Pesticide, 007-608

DB-608

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	40 to 280/300	121-6822
0.25	30	0.25	40 to 280/300	122-6832
0.32	30	0.50	40 to 280/300	123-1730
0.45	30	0.70	40 to 260/280	124-1730
0.53	15	0.83	40 to 260/280	125-1710
0.53	30	0.50	40 to 260/280	125-6837
0.53	30	0.83	40 to 260/280	125-1730

Agilent's certified vials are manufactured with the same high-quality design, technical expertise, and exacting specifications that go into every Agilent instrument. Learn more at **www.agilent.com/chem/vials**.

Petroleum

Petroleum applications vary greatly in character. From the noble gases to simulated distillation, Agilent offers a broad range of columns designed to meet the needs of the petroleum/ petrochemical chromatographer. Refer to the PLOT column section for columns for the analysis of light gases.

DB-2887

- 100% Dimethylpolysiloxane
- Specifically designed for simulated distillation using ASTM Method D2887
- Rapid conditioning, fast run time and low bleed when compared to packed columns
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: HP-1, Petrocol EX2887, MXT-2887, MXT-1

DB-2887

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.53	10	3.00	-60 to 350	125-2814

DB-HT SimDis

- 100% dimethylpolysiloxane
- "Boiling point" phase for high temperature simulated distillation
- Durable stainless steel tubing
- 430ºC upper temperature limit
- Distillation range of C6 to C110+
- Low bleed – even at 430ºC!
- Bonded and cross-linked
- Solvent rinsable

Similar Phases: Petrocol EX2887, CP-SimDist Ultimetal, MXT-2887, Rtx-2887, AC Controls High Temp Sim Dist, AT-2887

DB-HT SimDis

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.53	5	0.15	-60 to 400/430	145-1001

Semivolatiles

Semivolatiles are usually extracted from soil samples or other environmental matrices. GC columns with precise retention time reproducibility and good mass spectrometer performance are key enablers for these often demanding analyses.

DB-5.625

- Close equivalent to a (5%-Phenyl)-methylpolysiloxane
- Non-polar
- Specially processed to exhibit excellent inertness for EPA Semivolatiles Methods 625, 1625, 8270 and CLP protocols*
- Surpasses EPA performance criteria for semivolatiles
- Inert for base, neutral and acidic compounds
- High temperature limit with excellent thermal stability and low bleed
- Bonded and cross-linked
- Solvent rinsable

* Pentachlorophenol, 2,4-Dinitrophenol, Carbazole, and N-Nitrosodiphenylamine used to test response factors.

Similar Phases: XTI-5, Rtx-5, PTE-5, BPX-5

DB-5.625

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	0.18	-60 to 325/350	121-5621
0.18	20	0.36	-60 to 325/350	121-5622
0.25	30	0.25	-60 to 325/350	122-5631
0.25	30	0.50	-60 to 325/350	122-5632
0.25	30	1.00	-60 to 325/350	122-5633
0.25	60	0.25	-60 to 325/350	122-5661
0.32	30	0.25	-60 to 325/350	123-5631
0.32	30	0.50	-60 to 325/350	123-5632

Volatiles

Agilent offers a selection of advanced polymer chemistries for the increasingly demanding volatiles applications. Whether for a primary analytical column or as a complementary confirmation column, Agilent J&W capillaries are chromatographers' first choice.

DB-VRX

- Unique selectivity engineered for optimum resolution of volatiles analysis: U.S. EPA Methods 502.2, 524.2 and 8260
- 0.45 mm ID columns provide more plates per meter compared to 0.53 mm ID columns for the fewest coelutions for GC method (an industry first)**
- No subambient cooling required to resolve the six "gases"
- Fast run time:
  < 30 minutes for optimum sample throughput
  < 8 minutes with 0.18 mm ID
- Low polarity
- Excellent peak shape
- Bonded and cross-linked
- Solvent rinsable

**Two coelutions: 1) m- and p-xylene, for which U.S. EPA does not require separation, and 2) 1,1,2,2-tetrachloroethane and o-xylene which are separated by detectors PID and ELCD, respectively. Note to GC/MS analysts: These coeluting compounds have different primary characteristic ions of 83 and 106, respectively.

Similar Phases: VOCOL, NON-PAKD, Rtx-Volatiles, PE-Volatiles, 007-624, HP-624, CP-624, Rtx-VRX, Rtx-VGC

DB-VRX

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	1.00	-10 to 260	121-1524
0.18	40	1.00	-10 to 260	121-1544
0.25	30	1.40	-10 to 260	122-1534
0.25	60	1.40	-10 to 260	122-1564
0.32	30	1.80	-10 to 260	123-1534
0.32	60	1.80	-10 to 260	123-1564
0.45	30	2.55	-10 to 260	124-1534
0.45	75	2.55	-10 to 260	124-1574

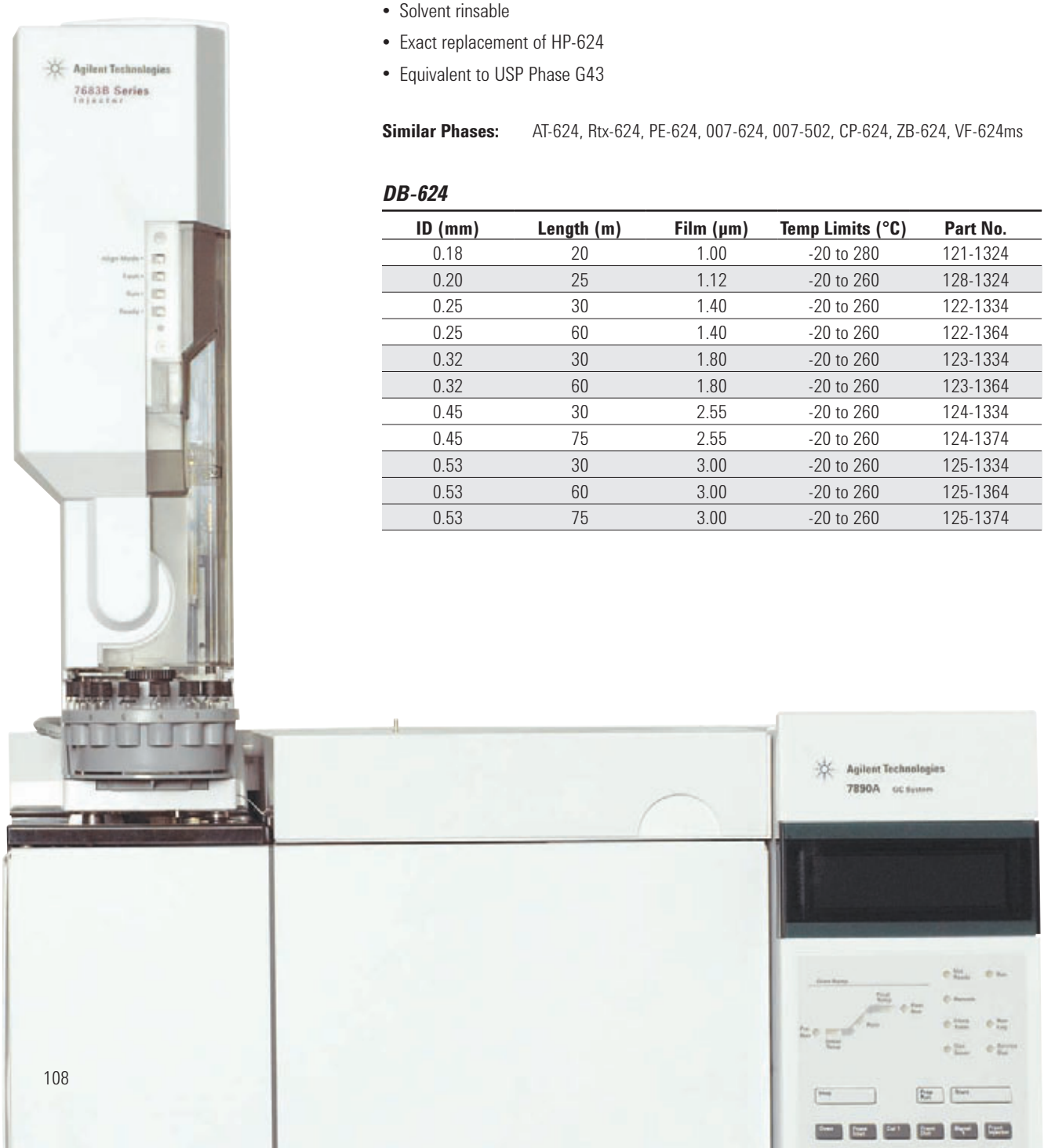
DB-624

- Specifically designed for the analysis of volatile priority pollutants
- No cryogenics needed for U.S. EPA Method 502.2
- Excellent for U.S. EPA Methods: 501.3, 502.2, 503.1, 524.2, 601, 602, 8010, 8015, 8020, 8240, 8260
- Excellent inertness for active compounds
- Bonded and cross-linked
- Solvent rinsable
- Exact replacement of HP-624
- Equivalent to USP Phase G43

Similar Phases: AT-624, Rtx-624, PE-624, 007-624, 007-502, CP-624, ZB-624, VF-624ms

DB-624

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.18	20	1.00	-20 to 280	121-1324
0.20	25	1.12	-20 to 260	128-1324
0.25	30	1.40	-20 to 260	122-1334
0.25	60	1.40	-20 to 260	122-1364
0.32	30	1.80	-20 to 260	123-1334
0.32	60	1.80	-20 to 260	123-1364
0.45	30	2.55	-20 to 260	124-1334
0.45	75	2.55	-20 to 260	124-1374
0.53	30	3.00	-20 to 260	125-1334
0.53	60	3.00	-20 to 260	125-1364
0.53	75	3.00	-20 to 260	125-1374



Life Sciences

The life sciences offer some difficult challenges to capillary GC chromatographers. These include complex sample matrices, the necessity for low level detection and the chemically active characteristics of many of the samples. In response to this, Agilent offers a line of columns which are designed specifically for drugs of abuse testing.

Agilent high-purity graphite ferrules are free from sulfur and other contaminants that can interfere with your detector. Learn more at **www.agilent.com/chem/ferrules**.

DB-ALC1 and DB-ALC2

- Reliable blood alcohol analysis
- Optimized primary and confirmation column pair for U.S. blood alcohol analysis
- Faster GC run times
- Improved resolution of key ethanol/acetone peaks
- Available in 0.32 and 0.53 mm ID
- Bonded and cross-linked

Similar Phases: Rtx-BAC1, Rtx-BAC2

DB-ALC1 and DB-ALC2

Description	ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
DB-ALC1	0.32	30	1.80	20 to 260/280	123-9134
DB-ALC1	0.53	30	3.00	20 to 260/280	125-9134
DB-ALC2	0.32	30	1.20	20 to 260/280	123-9234
DB-ALC2	0.53	30	2.00	20 to 260/280	125-9234

HP-Fast Residual Solvent

- Equivalent to USP Phase G43
- Thinner film reduces run time by 2.5 times and increases Minimum Detection Limit (MDL) by 2 times compared to standard film thickness used for this method
- Bonded and cross-linked

Similar Phases: DB-624, PE-624, 007-624, 007-502, CP-624, ZB-624

HP-Fast Residual Solvent

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.53	30	1.00	-20 to 260	19095V-420

PLOT Columns

PLOT columns are ideal for separating compounds that are gases at room temperatures. Agilent Technologies offers a comprehensive line of PLOT columns for analysis of fixed gases, low molecular weight hydrocarbon isomers, volatile polar compounds and reactive analytes such as sulfur gases, amines and hydrides. Our PLOT phases are offered in dimensions from 0.25 to 0.53 mm ID, allowing for easy column selection for various detector and system requirements. For GC/MS systems, we offer several small diameter columns with truly bonded and immobilized stationary phases, eliminating potential detector fouling due to particle generation.

PLOT Column Application Recommendations

Column	Stationary Phase	Typical Applications
HP-PLOT Molesieve	5Å molecular sieve zeolite	Permanent and noble gases. Thick and thin films available. Thick film column will resolve argon and oxygen at 35°C.
HP-PLOT Al_2O_3 KCl	Aluminum oxide deactivated with KCl	Least "polar" Alumina phase. Lowest retention of olefins relative to comparable paraffin. C_1 to C_8 hydrocarbon isomers. Column of choice for accurate quantitation of dienes, especially propadiene and butadiene from ethylene and propylene streams.
HP-PLOT Al_2O_3 S	Aluminum oxide deactivated with sodium sulfate	Excellent general use Alumina column for light hydrocarbons: C_1 to C_8 isomers. Best for resolving acetylene from butane and propylene from isobutane.
GS-Alumina	Aluminum oxide with proprietary deactivation	Most "polar" of the Alumina columns. Highest retention of olefins relative to comparable paraffin. Excellent general use Alumina column for light hydrocarbons: C_1 to C_8 isomers. Best for resolving cyclopropane from propylene. Good stability and recovery from water saturation.
HP-PLOT Q	Polystyrene-divinylbenzene	C_1 to C_3 isomers, alkanes to C_{12}, CO_2, methane, air/CO, water, oxygenated compounds, sulfur compounds, solvents.
HP-PLOT U	Divinylbenzene/ethylene	More polar than HP-PLOT Q and GS-Q. C_1 to C_7 hydrocarbons, CO_2, methane, air/CO, water, glycol dimethacrylate oxygenates, amines, solvents, alcohols, ketones, aldehydes.
GS-GasPro	Proprietary, bonded silica-based	C_1 to C_{12} hydrocarbons, CO_2, trace-level sulfurs, hydride gases, inorganic gases, halocarbons, SF_6, oxygen/nitrogen separation at -80°C.
GS-CarbonPLOT	Bonded, monolithic carbon layer	C_1 to C_5 hydrocarbons, CO_2, air/CO, trace acetylene in ethylene, methane.
GS-OxyPLOT	High selectivity adsorbent	High retention for oxygenated hydrocarbons (Methanol retention index +1400). Useful for alcohols, ketones, and ethers in gasoline, diesel, and C_1 to C_4 hydrocarbon streams.

GS-OxyPLOT

- Excellent selectivity for C_1 to C_{10}
- Suitable for ASTM oxygenate methods
- Useful for alcohols, ketones, and ethers in gasoline

Similar Phases: CP-LowOX

GS-OxyPLOT

ID (mm)	Length (m)	Temp Limits (°C)	Part No.
0.53	10	350	115-4912

HP-PLOT Al_2O_3 KCl

- Least "polar" Alumina phase
- Aluminum oxide deactivated with KCl
- Standard column choice for light hydrocarbon analysis: C_1 to C_8 hydrocarbon isomers
- Low retention of olefins relative to comparable paraffin
- Excellent for quantitation of dienes, especially propadiene and butadiene from ethylene and propylene streams
- Recommended phase for many ASTM methods
- Preferred KCl deactivated Alumina

Similar Phases: CP-Al_2O_3/KCl PLOT, Rt-Alumina PLOT, Alumina PLOT, Al_2O_3/KCl

HP-PLOT Al_2O_3 KCl

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	30	5.00	-60 to 200	19091P-K33
0.32	50	8.00	-60 to 200	19091P-K15
0.53	30	15.00	-60 to 200	19095P-K23
0.53	50	15.00	-60 to 200	19095P-K25

With Capillary Flow Technology, Agilent's new Deans Switch makes heart cutting more practical and reliable.

GS-Alumina KCl

- Least "polar" Alumina phase
- Aluminum oxide deactivated with KCl
- Good choice for light hydrocarbon analysis
- Good resolution of propadiene and butadiene from ethylene and propylene streams

Similar Phases: CP-Al_2O_3/KCl PLOT, Rt-Alumina PLOT, Alumina PLOT, Al_2O_3/KCl

GS-Alumina KCl

ID (mm)	Length (m)	Temp Limits (°C)	Part No.
0.53	30	-60 to 200	115-3332
0.53	50	-60 to 200	115-3352

HP-PLOT Al_2O_3 S

- Middle range of "polarity" for Alumina phases
- Aluminum oxide deactivated with sodium sulfate
- Excellent general use column for light hydrocarbon analysis: C_1 to C_8 hydrocarbon isomers
- Best for resolving acetylene from butane and propylene from isobutane

Similar Phases: GS-Alumina

HP-PLOT Al_2O_3 S

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.25	30	5.00	-60 to 200	19091P-S33
0.32	25	8.00	-60 to 200	19091P-S12
0.32	50	8.00	-60 to 200	19091P-S15
0.53	15	15.00	-60 to 200	19095P-S21
0.53	30	15.00	-60 to 200	19095P-S23
0.53	50	15.00	-60 to 200	19095P-S25

GS-Alumina

- Most "polar" Alumina phase
- Aluminum oxide with proprietary deactivation
- Excellent general use column for light hydrocarbon analysis: C_1 to C_8 hydrocarbon isomers
- Separates C_1 to C_4 saturated and unsaturated hydrocarbons
- Best for resolving cyclopropane from propylene
- Faster, more efficient and provides more sensitivity than packed equivalents
- Minimal conditioning time required
- Preferred substitution for sodium sulfate deactivated Alumina because of its regenerative nature

Similar Phases: Al_2O_3/KCl, Al_2O_3/Na_2SO_4, Rt-Alumina PLOT, Alumina PLOT

Note: Alumina columns have a tendency to adsorb water and CO_2 which, over time, results in changes in retention time. We use an advanced, proprietary deactivation process which allows for rapid regeneration. Fully water saturated GS-Alumina columns regenerate in 7 hours or less at 200ºC.

GS-Alumina

ID (mm)	Length (m)	Temp Limits (°C)	Part No.
0.53	30	-60 to 200	115-3532
0.53	50	-60 to 200	115-3552

HP-PLOT Al_2O_3 M

- Most "polar" Alumina phase (similar to GS-Alumina)
- Aluminum oxide deactivated with proprietary deactivation
- Good general use column for light hydrocarbon analysis: C_1 to C_8 hydrocarbon isomers
- Good for resolving acetylene from butane and propylene from isobutane

Similar Phases: GS-Alumina

HP-PLOT Al_2O_3 M

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	50	8.00	-60 to 200	19091P-M15
0.53	30	15.00	-60 to 200	19095P-M23
0.53	50	15.00	-60 to 200	19095P-M25

GS-GasPro

- Unique bonded silica PLOT column technology
- Excellent choice for light hydrocarbons and sulfur gases
- Retention stability not affected by water
- Separates CO and CO_2 on a single column
- Ideal PLOT column for GC/MS – no particles

Similar Phases: CP-Silica PLOT

GS-GasPro

ID (mm)	Length (m)	Temp Limits (°C)	Part No.
0.32	5	-80 to 260/300	113-4302
0.32	15	-80 to 260/300	113-4312
0.32	30	-80 to 260/300	113-4332
0.32	60	-80 to 260/300	113-4362

GS-CarbonPLOT

- High stability, bonded carbon layer stationary phase
- Unique selectivity for inorganic and organic gases
- Extended temperature limit of 360ºC

Similar Phases: Carbopack, CLOT, Carboxen-1006 PLOT, CP-CarboPLOT P7

GS-CarbonPLOT

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	15	1.50	0 to 360	113-3112
0.32	30	1.50	0 to 360	113-3132
0.32	30	3.00	0 to 360	113-3133
0.32	60	1.50	0 to 360	113-3162
0.53	15	3.00	0 to 360	115-3113
0.53	30	3.00	0 to 360	115-3133

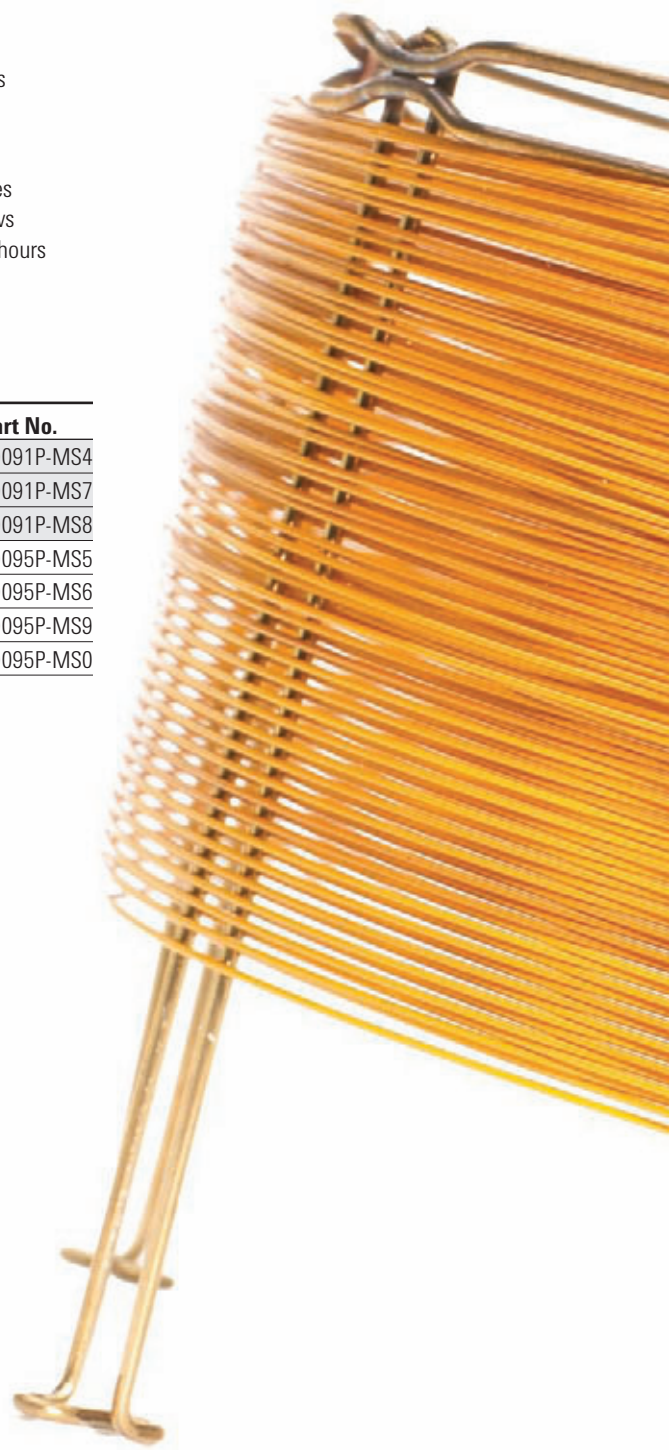
HP-PLOT Molesieve

- A PLOT column for the analysis of permanent gases
- O_2, N_2, CO and CH_4 resolve in less than 5 minutes
- Durable molecular sieve 5Å coating minimizes baseline spiking and damage to multiport valves
- Select a thick film for Ar/O_2 separation without cryogenic cooling
- Select thin film HP-PLOT Molesieve columns for routine air monitoring applications
- Replaces GS-Molesieve

Note: Molecular sieve columns will absorb water which, over time, results in changes in retention time. We use an advanced, proprietary deactivation process which allows for rapid regeneration. Fully saturated HP-PLOT Molesieve columns regenerate in 7 hours or less at 200ºC.

HP-PLOT Molesieve

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	30	12.00	-60 to 300	19091P-MS4
0.32	15	25.00	-60 to 300	19091P-MS7
0.32	30	25.00	-60 to 300	19091P-MS8
0.53	15	25.00	-60 to 300	19095P-MS5
0.53	30	25.00	-60 to 300	19095P-MS6
0.53	15	50.00	-60 to 300	19095P-MS9
0.53	30	50.00	-60 to 300	19095P-MS0



HP-PLOT Q

- Bonded polystyrene-divinylbenzene based column
- A PLOT column with polarity between Porapak-Q and Porapak-N
- Excellent column for C_1 to C_3 isomers and Alkanes to C_{12}, CO_2, methane, air/CO, oxygenated compounds, sulfur compounds and solvents
- A PLOT column to replace packed gas-solid columns
- Separates ethane, ethylene and ethyne (acetylene)
- Improved resolution in less time than conventional packed columns
- Minimal conditioning time required – 1 hour
- Preferred "Q" column due to its robust nature
- Replacement column for GS-Q

Similar Phases: CP PoraPLOT Q, CP PoraPLOT Q-HT, Rt-QPLOT, SupelQ PLOT, GS-Q

HP-PLOT Q

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	15	20.00	-60 to 270/290	19091P-Q03
0.32	30	20.00	-60 to 270/290	19091P-Q04
0.53	15	40.00	-60 to 270/290	19095P-Q03
0.53	30	40.00	-60 to 270/290	19095P-Q04

HP-PLOT U

- Bonded divinylbenzene/ethylene glycol dimethacrylate
- More polar than HP-PLOT Q
- Excellent column for C_1 to C_7 hydrocarbons, CO_2, methane, air/CO, water, oxygenates, amines, solvents, alcohols, ketones, and aldehydes
- Improved resolution in less time than conventional packed columns

Similar Phases: PoraPlot U, RTU PLOT

HP-PLOT U

ID (mm)	Length (m)	Film (µm)	Temp Limits (°C)	Part No.
0.32	30	0.10	-60 to 190	19091P-U04
0.53	15	0.20	-60 to 190	19095P-U03
0.53	30	0.20	-60 to 190	19095P-U04

Column Installation and Troubleshooting

Quick reference guides and tips to ensure peak performance.

Agilent J&W GC columns are backed by decades of chromatography experience, so you can count on superior quality and dependability. And you can help ensure maximum performance, efficiency, and column life by implementing the most current installation and troubleshooting procedures.

In this section, you'll discover tips, techniques, and easy-reference guides that will help you...

- Confidently install any capillary column.
- Condition and test new columns.
- Alleviate and avoid column performance degradation due to thermal damage, oxygen damage, and other factors.
- Pinpoint and fix the most common column problems.

So you'll expand your hours of continuous operation, decrease downtime, and get the reproducible results that your lab demands.

Capillary Column Installation Quick Reference Guide

For more detailed installation information, refer to the GC Column Installation Guide which is provided with your column, or visit **www.agilent.com/chem/columninstall**.

Tips & Tools

Find all the tools you need for column installation in Agilent's Column Installation Kit, p/n 430-2000.

Precolumn Installation Check List

1. Replace oxygen, moisture, and hydrocarbon traps as needed.
2. Clean the injection port, replace critical injection port seals, replace injection port liners, and change septa as needed.
3. Check detector seals, and replace as necessary. Clean or replace detector jets as necessary.
4. Carefully inspect the column for damage or breakage.
5. Check your GC manufacturer's gas pressure requirements and verify gas cylinder delivery pressures to ensure that an adequate supply of carrier, makeup, and fuel gases are available. Minimum recommended carrier gas purity percentages are: Helium 99.995% and Hydrogen 99.995%, with H_20 < 1ppm and O_2 < 0.5ppm.
6. Gather the necessary installation tools: You will need a column cutter, column nuts, column nut wrench, ferrules, a magnifying loupe, and typewriter correction fluid.

Table 6:
Ferrule Sizes

Column ID	Ferrule ID (mm)
0.10	0.4
0.18	0.4
0.20	0.4
0.25	0.4
0.32	0.5
0.45	0.8
0.53	0.8

Installing the Column

1. Uncoil approximately 0.5 m of tubing (1 coil ~ 0.5 m) from the column basket at both ends of the column for injector and detector installation. Avoid using sharp bends in the tubing.
2. Mount the column in the oven. Use a handling bracket if available.
3. Install the column nut and graphite/Vespel or graphite ferrule at each column end; pull the nut and ferrule down the tubing approximately 15 cm. (**Table 6**)
4. Score (scratch) the column. Use a light touch to score the column about 4 to 5 cm from each end.

5. Make a clean break. Grasp the column between the thumb and forefinger as close to the score point as possible. Gently pull and bend the column. The column should part easily. If the column does not break easily, do not force it. Score the column again in a different place (farther from the end than before) and try again for a clean break.

6. Use a magnifying loupe to inspect the cut. Make sure the cut is square across the tubing with no polyimide or "glass" fragments at the end of the tube.

7. Install the column in the inlet. Check the GC manufacturer's instrument manual for the correct insertion distance in the injection port type being used. Slide the column nut and ferrule to the proper distance and then mark the correct distance on the column with typewriter correction fluid just behind the column nut. Allow the fluid to dry. Insert the column into the injector. Finger tighten the column nut until it starts to grab the column, and then tighten the nut and additional 1/4 to 1/2 turn, so that the column cannot be pulled from the fitting when gentle pressure is applied. Verify that the correct column insertion distance has been maintained by looking at the typewriter correction fluid mark.

8. Turn on the carrier gas and establish the proper flow rate. Set head pressure, split flow, and septum purge flow to appropriate levels. See **Table 7** for nominal head pressures. If fusing a split/splitless inlet, check that the purge (split) valve is "on" (open).

9. Confirm carrier gas flow through the column. Immerse the end of the column in a vial of solvent and check for bubbles.

10. Install the column into the detector. Check the instrument manufacturer's manual for the proper insertion distance.

11. Check for leaks. **This is very important**. Do not heat the column without thoroughly checking for leaks.

12. Establish proper injector and detector temperatures.

13. Establish proper makeup and detector gas flows. Ignite or turn "on" the detector.

14. Purge the column for a minimum of 10 minutes at ambient temperature. Add the appropriate additional purge time following inlet or trap maintenance.

15. Inject non-retained substance to check for proper injector installation. Examples: butane or methane (FID), headspace vapors from Acetonitrile (NPD), headspace vapors from methylene chloride (ECD), air (TCD), argon (mass spectrometer). Proper installation is indicated by a symmetrical non-retained peak. If tailing is observed, reinstall the column into the inlet.

Tips & Tools

To accurately calculate pressure settings and flow rates through a capillary GC column, download free GC Pressure/ Flow Calculator software at **www.agilent.com/chem/gccalc**.

Conditioning and Testing the Column

1. Set oven temperature 20°C above the maximum temperature of the analysis or at the maximum temperature of the column (whichever is lower) for 2 hours. If after 10 minutes at the upper temperature the background does not begin to fall, immediately cool the column and check for leaks.

2. If you are using Vespel or graphite/Vespel ferrules, recheck column nut tightness after the conditioning process.

3. Confirm final proper average linear velocity by injecting a non-retained substance again.

Table 7:
Approximate Head Pressures (psig)

Column Length (m)	Column ID (mm)					
	0.18	**0.2**	**0.25**	**0.32**	**0.45**	**0.53**
10	5-10					
12		10-15				
15			8-12	5-10		1-2
20	10-20					
25		20-30				
30			15-25	10-20	3-5	2-4
40	20-40					
50		40-60				
60			30-45	20-30	6-10	4-8
75					8-14	5-10
105						7-15

Causes of Column Performance Degradation

Column Breakage

Fused silica columns break wherever there is a weak point in the polymide coating. The polymide coating protects the fragile but flexible fused silica tubing. The continuous heating and cooling of the oven, vibrations caused by the oven fan, and being wound on a circular cage all place stress on the tubing. Eventually breakage occurs at a weak point. Weak spots are created where the polymide coating is scratched or abraded. This usually occurs when a sharp point or edge is dragged over the tubing. Column hangers and tags, metal edges in the GC oven, column cutters, and miscellaneous items on the lab bench are just some of the common sources of sharp edges or points.

It is rare for a column to spontaneously break. Column manufacturing practices tend to expose any weak tubing and eliminate it from use in finished columns. Larger diameter columns are more prone to breakage. This means that greater care and prevention against breakage must be taken with 0.45-0.53 mm I.D. tubing than with 0.18-0.32 mm I.D. tubing.

A broken column is not always fatal. If a broken column was maintained at a high temperature either continuously or with multiple temperature program runs, damage to the column is very likely. The back half of the broken column has been exposed to oxygen at elevated temperatures which rapidly damages the stationary phase. The front half is fine since carrier gas flowed through this length of column. If a broken column has not been heated or only exposed to high temperatures or oxygen for a very short time, the back half has probably not suffered any significant damage.

A union can be installed to repair a broken column. Any suitable union will work to rejoin the column. Problems with dead volume (peak tailing) may occur with improperly installed unions.

Thermal Damage

Exceeding a column's upper temperature limit results in accelerated degradation of the stationary phase and tubing surface. This results in the premature onset of excessive column bleed, peak tailing for active compounds and/or loss of efficiency (resolution). Fortunately, thermal damage is a slower process, thus prolonged times above the temperature limit are required before significant damage occurs. Thermal damage is greatly accelerated in the presence of oxygen. Overheating a column with a leak or high oxygen levels in the carrier gas results in rapid and permanent column damage.

Setting the GC's maximum oven temperature at or only a few degrees above the column's temperature limit is the best method to prevent thermal damage. This prevents the accidental overheating of the column. If a column is thermally damaged, it may still be functional. Remove the column from the detector. Heat the column for 8-16 hours at its isothermal temperature limit. Remove 10-15 cm from the detector end of the column. Reinstall the column and condition as usual. The column usually does not return to its original performance; however, it is often still functional. The life of the column will be reduced after thermal damage.

Oxygen Damage

Oxygen is an enemy to most capillary GC columns. While no column damage occurs at or near ambient temperatures, severe damage occurs as the column temperature increases. In general, the temperature and oxygen concentration at which significant damage occurs is lower for polar stationary phases. It is constant exposure to oxygen that is the problem. Momentary exposure such as an injection of air or a very short duration septum nut removal is not a problem.

A leak in the carrier gas flow path (e.g., gas lines, fittings, injector) is the most common source of oxygen exposure. As the column is heated, very rapid degradation of the stationary phase occurs. This results in the premature onset of excessive column bleed, peak tailing for active compounds and/or loss of efficiency (resolution). These are the same symptoms as for thermal damage. Unfortunately, by the time oxygen damage is discovered, significant column damage has already occurred. In less severe cases, the column may still be functional but at a reduced performance level. In more severe cases, the column is irreversibly damaged.

Agilent offers a conveniently designed, pencil-shaped tool and a ceramic wafer that allow you to make clean, easy cuts in fused silica, glass and aluminum-clad capillary columns.

Maintaining an oxygen and leak free system is the best prevention against oxygen damage. Good GC system maintenance includes periodic leak checks of the gas lines and regulators, regular septa changes, using high quality carrier gases, installing and changing oxygen traps, and changing gas cylinders before they are completely empty.

Chemical Damage

There are relatively few compounds that damage stationary phases. Introducing nonvolatile compounds (e.g., salts) in a column often degrades performance, but damage to the stationary phase does not occur. These residues can often be removed and performance returned by solvent rinsing the column.

Inorganic or mineral bases and acids are the primary compounds to avoid introducing into a column. The acids include hydrochloric (HCl), sulfuric (H_2SO_4), nitric (HNO_3), phosphoric (H_3PO_4), and chromic (CrO_3). The bases include potassium hydroxide (KOH), sodium hydroxide (NaOH), and ammonium hydroxide (NH_4OH). Most of these acids and bases are not very volatile and accumulate at the front of the column. If allowed to remain, the acids or bases damage the stationary phase. This results in the premature onset of excessive column bleed, peak tailing for active compounds and/or loss of efficiency (resolution). The symptoms are very similar to thermal and oxygen damage. Hydrochloric acid and ammonium hydroxide are the least harmful of the group. Both tend to follow any water that is present in the sample. If the water is not or only poorly retained by the column, the residence time of the HCl and NH_4OH in the column is short. This tends to eliminate or minimize any damage by these compounds. Thus, if HCl or NH_4OH are present in a sample, using conditions or a column with no water retention will render these compounds relatively harmless to the column.

The only organic compounds that have been reported to damage stationary phases are perfluoroacids. Examples include trifluoroacetic, pentafluoropropanoic, and heptafluorobutyric acid. They need to be present at high levels (e.g., 1% or higher). Most of the problems are experienced with splitless or Megabore direct injections where large volumes of the sample are deposited at the front of the column.

Since chemical damage is usually limited to the front of the column, trimming or cutting 0.5-1 meter from the front of the column often eliminates any chromatographic problems. In more severe cases, five or more meters may need to be removed. The use of a guard column or retention gap will minimize the amount of column damage; however, frequent trimming of the guard column may be necessary. The acid or base often damages the surface of the deactivated fused silica tubing which leads to peak shape problems for active compounds.

Column Contamination

Column contamination is one of the most common problems encountered in capillary GC. Unfortunately, it mimics a very wide variety of problems and is often misdiagnosed as another problem. A contaminated column is usually not damaged, but it may be rendered useless.

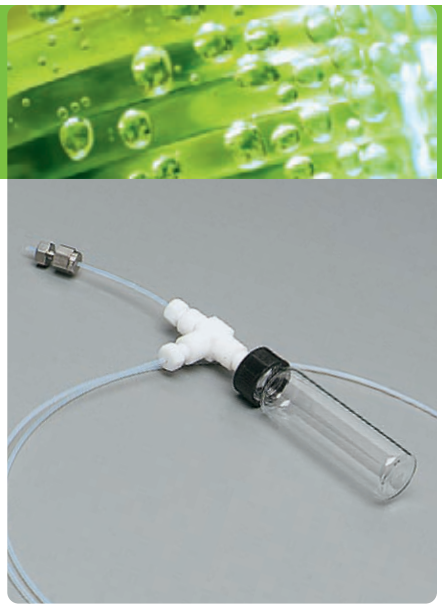
There are two basic types of contaminants: nonvolatile and semivolatile. Nonvolatile contaminants or residues do not elute and accumulate in the column. The column becomes coated with these residues which interfere with the proper partitioning of solutes in and out of the stationary phase. Also, the residues may interact with active solutes resulting in peak adsorption problems (evident as peak tailing or loss of peak size). Active solutes are those containing a hydroxyl (-OH) or amine (-NH) group, and some thiols (-SH) and aldehydes. Semivolatile contaminants or residues accumulate in the column, but eventually elute. Hours to days may elapse before they completely leave the column. Like nonvolatile residues, they may cause peak shape and size problems, and, in addition, are usually responsible for many baseline problems (instability, wander, drift, ghost peaks, etc.).

Contaminants originate from a number of sources, with injected samples being the most common. Extracted samples are among the worst types. Biological fluids and tissues, soils, waste and ground water, and similar types of matrices contain high amounts of semivolatile and nonvolatile materials. Even with careful and thorough extraction procedures, small amounts of these materials are present in the injected sample. Several to hundreds of injections may be necessary before the accumulated residues cause problems. Injection techniques such as on-column, splitless, and Megabore direct place a large amount of sample into the column, thus column contamination is more common with these injection techniques.

Occasionally, contaminants originate from materials in gas lines and traps, ferrule and septa particles, or anything coming in contact with the sample (vials, solvents, syringes, pipettes, etc.). These types of contaminants are probably responsible when a contamination problem suddenly develops and similar samples in previous months or years did not cause any problems.

Minimizing the amount of semivolatile and nonvolatile sample residues is the best method to reduce contamination problems. Unfortunately, the presence and identity of potential contaminants are often unknown. Rigorous and thorough sample cleanup is the best protection against contamination problems. The use of a guard column or retention gap often reduces the severity or delays the onset of column contamination induced problems. If a column becomes contaminated, it is best to solvent rinse the column to remove the contaminants.

Maintaining a contaminated column at high temperatures for long periods of time (often called baking-out a column) is not recommended. Baking-out a column may convert some of the contaminating residues into insoluble materials that cannot be solvent rinsed from the column. If this occurs, the column cannot be salvaged in most cases. Sometimes the column can be cut in half and the back half may still be useable. Baking-out a column should be limited to 1-2 hours at the isothermal temperature limit of the column.



Solvent Rinse Kit, P/N 430-3000

Solvent Rinsing Columns

Solvent rinsing columns involves removing the column from the GC and passing milliliters of solvent through the column. Any residues soluble in the rinse solvents are washed from the column. Injecting large volumes of solvent while the column is still installed is not rinsing and doing so will not remove any contaminants from the column. **A capillary GC column must have a bonded and cross-linked stationary phase before it can be solvent rinsed.** Solvent rinsing a nonbonded stationary phase results in severe damage to the column.

A column rinse kit is used to force solvent through the column (**see picture**). The rinse kit is attached to a pressurized gas source (N_2 or He), and the column is inserted into the rinse kit. Solvent is added to the vial, and the vial is pressurized using the gas source. The pressure forces solvent to flow through the column. Residues dissolve into the solvent and are backflushed out of the column with the solvent. The solvent is then purged from the column, and the column is properly conditioned.

Before rinsing a column, cut about 0.5 meter from the front (i.e., injector end) of the column. Insert the detector end of the column into the rinse kit. Multiple solvents are normally used to rinse columns. Each successive solvent must be miscible with the previous one. High boiling point solvents should be avoided especially as the last solvent. The sample matrix solvent(s) is often a good choice.

Agilent's GC Buddy multi-purpose lab tool has everything you need. P/N 5182-9765

Methanol, methylene chloride and hexane are recommended and work very well for the majority of cases. Acetone can be substituted for methylene chloride to avoid using halogenated solvents; however, methylene chloride is one of the best rinsing solvents. If aqueous based samples (e.g., biological fluids and tissues) were injected, use water before the methanol. Some residues originating from aqueous based samples are only soluble in water and not organic solvents. Water and alcohols (e.g., methanol, ethanol, isopropanol) should be used to rinse bonded polyethylene glycol based stationary phases (e.g., DB-WAX, DB-WAXetr, DB-FFAP, HP-Innowax) **only as a last resort**.

Table 8 lists the suggested solvent volumes for different diameter columns. Using larger solvent volumes is not harmful, but rarely better and merely wasteful. After adding the first solvent, pressurize the rinse kit, but stay below 20 psi. Use the highest pressure that keeps the solvent flow rate below 1 ml/min. Except for most 0.53 mm I.D. columns, the rinse kit pressure will reach 20 psi before the flow rate reaches 1 ml/min. Longer rinse times are required when using heavy or viscous solvents, and for longer or smaller diameter columns. When all or most of the first solvent has entered the column, add the next solvent. The previous solvent does not have to vacate the column before the next solvent is started through the column.

After the last solvent has left the column, allow the pressurizing gas to flow through the column for 5-10 minutes. Install the column in the injector and turn on the carrier gas. Allow the carrier gas to flow through the column for 5-10 minutes. Attach the column to the detector (or leave it unattached if preferred). Using a temperature program starting at 40-50°C, heat the column at 2-3°/min until the upper temperature limit is reached. Maintain this temperature for 1-4 hours until the column is fully conditioned.

Table 8:
Solvent Volumes for Rinsing Columns

Column ID (mm)	Solvent Volume (ml)
0.18-0.2	3-4
0.25	4-5
0.32	6-7
0.45	7-8
0.53	10-12

Using larger volumes will not damage the column

Column Storage

Capillary columns should be stored in their original box when removed from the GC. Place a GC septa over the ends to prevent debris from entering the tubing. Upon reinstallation of the column, the column ends need to be trimmed by 2-4 cm to ensure that a small piece of septa is not lodged in the column.

If a column is left in a heated GC, there should always be carrier gas flow. The carrier gas flow can be turned off only if the oven, injector, detector and transfer lines are turned off (i.e., not heated). Without carrier gas flow, damage to the heated portion of the column occurs.

Evaluating the Problem

The first step in any troubleshooting effort is to step back and evaluate the situation. Rushing to solve the problem often results in a critical piece of important information being overlooked or neglected. In addition to the problem, look for any other changes or differences in the chromatogram. Many problems are accompanied by other symptoms. Retention time shifts, altered baseline noise or drift, or peak shape changes are only a few of the other clues that often point to or narrow the list of possible causes. Finally, make note of any changes or differences involving the sample. Solvents, vials, pipettes, storage conditions, sample age, extraction, preparation techniques, or any other factor influencing the sample environment can be responsible.

Checking the Obvious

A surprising number of problems involve fairly simple and often overlooked components of the GC system or analysis. Many of these items are transparent in the daily operation of the GC and are often taken for granted ("set it and forget it"). The areas and items to check include:

- Gases: pressures, carrier gas average linear velocity, and flow rates (detector, split vent, septum purge)
- Temperatures: column, injector, detector, and transfer lines
- System parameters: purge activation times, detector attenuation and range, mass ranges, etc.
- Gas lines and traps: cleanliness, leaks, and expiration
- Injector consumables: septa, liners, O-rings, and ferrules
- Sample integrity: concentration, degradation, solvent, and storage
- Syringes: handling technique, leaks, needle sharpness, and cleanliness
- Data system: settings and connections

The Most Common Problems

Ghost Peaks or Carryover

System contamination is responsible for most ghost peaks or carryover problems. If the extra ghost peaks are similar in width to the sample peaks (with similar retention times), the contaminants were likely introduced into the column at the same time as the sample. The extra compounds may be present in the injector (i.e., contamination) or in the sample itself. Impurities in solvents, vials, caps and syringes are only some of the possible sources. Injecting sample and solvent blanks may help to find possible sources of the contaminants. If the ghost peaks are much broader than the sample peaks, the contaminants were most likely already in the column when the injection was made. These compounds were still in the column when a previous GC run was terminated. They elute during a later run and are often very broad. Sometimes numerous ghost peaks from multiple injections overlap and elute as a hump or blob. This often takes on the appearance of baseline drift or wander.

Increasing the final temperature or time in the temperature program is one method to minimize or eliminate a ghost peak problem. Alternatively, a short bake-out after each run or series of runs may remove the highly retained compounds from the column before they cause a problem.

Condensation Test

Use this test whenever injector or carrier gas contamination problems are suspected (e.g., ghost peaks or erratic baseline).

1. Leave the GC at 40-50°C for 8 or more hours.
2. Run a blank analysis (i.e., start the GC, but with no injection) using the normal temperature conditions and instrument settings.
3. Collect the chromatogram for this blank run.
4. Immediately repeat the blank run as soon as the first one is completed. Do not allow more than 5 minutes to elapse before starting the second blank run.
5. Collect the chromatogram for the second blank run and compare it to the first chromatogram.
6. If the second chromatogram contains a substantially larger amount of peaks and baseline instability, the incoming carrier gas line or the carrier gas is contaminated.
7. If the second chromatogram contains few peaks or very little baseline drift, the carrier gas and incoming carrier gas lines are relatively clean.

Troubleshooting Guides

Excessive Baseline Noise

Possible Cause	Solution	Comments
Injector contamination	Clean the injector; replace liner, gold seal	Try a condensation test; gas lines may also need cleaning
Column contamination	Bake-out the column	Limit the bake-out to 1-2 hours
	Solvent rinse the column	Only for bonded and cross-linked phases
		Check for inlet contamination
Detector contamination	Clean the detector	Usually the noise increases over time and not suddenly
Contaminated or low quality gases	Use better grade gases; also check for expired gas traps or leaks	Usually occurs after changing a gas cylinder
Column inserted too far into the detector	Reinstall the column	Consult GC manual for proper insertion distance
Incorrect detector gas flow rates	Adjust the flow rates to the recommended values	Consult GC manual for proper flow rates
Leak when using an MS, ECD, or TCD	Find and eliminate the leak	Usually at the column fittings or injector
Old detector filament, lamp or electron multiplier	Replace appropriate part	
Septum degradation	Replace septum	For high temperature applications use an appropriate septum

Baseline Instability or Disturbances

Possible Cause	Solution	Comments
Injector contamination	Clean the injector	Try a condensation test; gas lines may also need cleaning
Column contamination	Bake-out the column	Limit a bake-out to 1-2 hours
Unequilibrated detector	Allow the detector to stabilize	Some detectors may require up to 24 hours to fully stabilize
Incompletely conditioned column	Fully condition the column	More critical for trace level analyses
Change in carrier gas flow rate during the temperature program	Normal in many cases	MS, TCD and ECD respond to changes in carrier gas flow rate

Tailing Peaks

Possible Cause	Solution	Comments
Column contamination	Trim the column	Remove 0.5-1 meter from the front of the column
	Solvent rinse the column	Only for bonded and cross-linked phases
		Check for inlet contamination
Column activity	Irreversible. Replace the column	Only affects active compounds
Solvent-phase polarity mismatch	Change sample solvent to a single solvent	More tailing for the early eluting peaks or those closest to the solvent front
	Use a retention gap	3-5 meter retention gap is sufficient
Solvent effect violation for splitless or on-column injections	Decrease the initial column temperature	Peak tailing decreases with retention
Too low of a split ratio	Increase the split ratio	Flow from split vent should be 20 ml/min or higher
Poor column installation	Reinstall the column	More tailing for the early eluting peaks
Some active compounds always tail	None	Most common for amines and carboxylic acids

Split Peaks

Possible Cause	Solution	Comments
Injection technique	Change technique	Usually related to erratic plunger depression or having sample in the syringe needle. Use an auto injector.
Mixed sample solvent	Change sample solvent to a single solvent	Worse for solvents with large differences in polarity or boiling points
Poor column installation	Reinstall the column	Usually a large error in the insertion distance
Sample degradation in the injector	Reduce the injector temperature	Peak broadening or tailing may occur if the temperature is too low
	Change to an on-column injection	Requires an on-column injector
Poor sample focusing	Use a retention gap	For splitless and on-column injection

Retention Time Shift

Possible Cause	Solution	Comments
Change in carrier gas velocity	Check the carrier gas velocity	All peaks will shift in the same direction by approximately the same amount
Change in column temperature	Check the column temperature	Not all peaks will shift by the same amount
Change in column dimension	Verify column identity	
Large change in compound concentration	Try a different sample concentration	May also affect adjacent peaks. Sample overloading is corrected with an increase split ratio or sample dilution.
Leak in the injector	Leak check the injector	A change in peak size usually occurs also
Blockage in a gas line	Clean or replace the plugged line	More common for the split line; also check flow controllers and solenoids
Septum leak	Replace septum	Check for needle barb
Sample solvent incompatibility	Change sample solvent Use a retention gap	For splitless injection

Change in Peak Size

Possible Cause	Solution	Comments
Change in detector response	Check gas flows, temperatures and settings	All peaks may not be equally affected
	Check background level or noise	May be caused by system contamination and not the detector
Change in the split ratio	Check split ratio	All peaks may not be equally affected
Change in the purge activation time	Check the purge activation line	For splitless injection
Change in injection volume	Check the injection technique	Injection volumes are not linear
Change in sample concentration	Check and verify sample concentration	Changes may also be caused by degradation, evaporation, or variances in sample temperature or pH
Leak in the syringe	Use a different syringe	Sample leaks passed the plunger or around the needle; leaks are not often readily visible
Column contamination	Trim the column	Remove 0.5-1 meter from the front of the column
	Solvent rinse the column	Only for bonded and cross-linked phases
Column activity	Irreversible	Only affects active compounds
Coelution	Change column temperature or stationary phase	Decrease column temperature and check for the appearance of a peak shoulder or tail
Change in injector discrimination	Maintain the same injector parameters	Most severe for split injections
Sample flashback	Inject less, use a larger liner, reduce the inlet temperature	Less solvent and higher flow rates are most helpful
Decomposition from inlet contamination	Clean the injector; replace liner, gold seal	Only use deactivated liners and glass wool in the inlet

Loss of Resolution

Possible Cause	Solution	Comments
Decrease in separation		
Different column temperature	Check the column temperature	Differences in other peaks will be visible
Different column dimensions or phase	Verify column identity	Differences in other peaks will be visible
Coelution with another peak	Change column temperature	Decrease column temperature and check for the appearance of a peak shoulder or tail
Increase in peak width		
Change in carrier gas velocity	Check the carrier gas velocity	A change in the retention time also occurs
Column contamination	Trim the column	Remove 0.5-1 meter from the front of the column
	Solvent rinse the column	Only for bonded and cross-linked phases
Change in the injector	Check the injector settings	Typical areas: split ratio, liner, temperature, injection volume
Change in sample concentration	Try a different sample concentration	Peak widths increase at higher concentrations
Improper solvent effect, lack of focusing	Lower oven temperature, better solvent, sample phase polarity match, use a retention gap	For splitless injection

Basics of GC Method Development

How to develop a systematic, structured approach to GC method development.

From setting your equipment... to adjusting temperature and flow rates... effective method development practices are essential to achieving top performance and reliable results.

That's why we've put the most critical method-development procedures all in one place – and right at your fingertips. For example, we'll show you how to...

- Maximize resolution – and shorten your analysis time – by determining the best carrier gas average linear velocity.
- Select your default injector settings for various sample types – including volatile samples (such as solvents) and high-boiling samples (such as steroids, triglycerides, and surfactants).
- Determine whether a temperature program or an isothermal temperature condition is most suitable for your application.
- Perfect the latest techniques for developing a temperature program – including setting the initial temperature and hold time, adjusting the ramp rate to improve resolution of middle-eluting peaks, determining final temperature and time, and confirming peak identities.

By following the advice in this section, you can build productivity, quality, and cost-effectiveness into every method you develop.

Basics of Method Development

Finding the Best Carrier Gas Average Linear Velocity

Determining the best average linear velocity is fairy easy and only involves a small amount of trial and error. Hydrogen provides the best resolution in the shortest amount of time. Helium provides similar resolution, but at a longer analysis time. Nitrogen is not recommended for use with capillary columns due to the extremely long analysis times.

When using helium as the carrier gas, try an initial average linear velocity of 30 cm/sec. If better resolution is desired, reduce the velocity to no less than 25 cm/sec; however, the analysis time will be increased. If a shorter analysis time is desired, increase the velocity to 35 cm/sec up to 40 cm/sec. Beware of potential resolution losses at these higher linear velocities. Minor adjustment to the oven temperature may also be needed. Average linear velocities of 30-35 cm/sec are used for many analyses when using helium as a carrier gas.

When using hydrogen as the carrier gas, try an initial average linear velocity of 60 cm/sec. If better resolution is desired, reduce the velocity to no less than 50 cm/sec; however, the analysis time will be increased. If a shorter analysis time is desired, increase the velocity to 70 cm/sec up to 80 cm/sec. Be aware of potential resolution losses at these higher velocities. Minor adjustment to the oven temperature may also be needed. Average linear velocities of 60-70 cm/sec are used for many analyses when using hydrogen as a carrier gas.

Upon comparing the chromatograms at the various average linear velocities, retention and resolution differences will be noticeable. Sometimes different average linear velocities are best for different peaks within the same chromatogram. In these cases, a compromise velocity is usually selected. Except with nitrogen, small changes in the average linear velocity (<2 cm/sec) rarely result in significant changes in resolution. When experimenting with average linear velocities, try values that are different by at least 3-4 cm/sec.

Default Injector Settings

An injector temperature of 250°C is sufficient for nearly all samples. For volatile samples such as volatile solvents, an injector temperature of 150-200°C is recommended. For high boiling samples such as steroids, triglycerides or surfactants, an injector temperature of 275-300°C is recommended. Make sure the septum can tolerate the high injector temperature.

Most samples can be analyzed using a wide range of injector conditions or parameters. This results in a fairly standard set of injector conditions being suitable for most samples. Since the default or standard injector conditions are suitable for 80-90% of all samples, these conditions are a good place to start when developing a new method.

Default Injector Settings

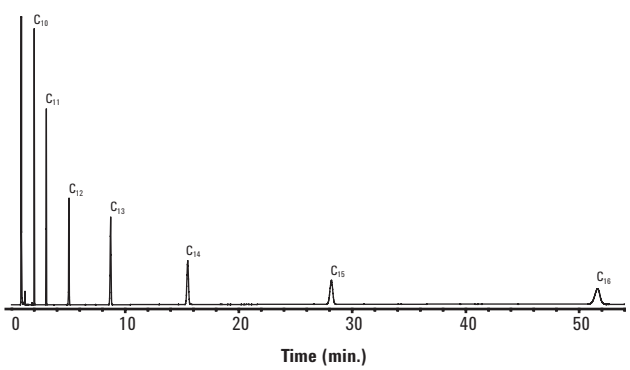
	Megabore Direct	Split	Splitless
Temperature:	250 °C	250 °C	250 °C
Liner:	Direct flash vaporization	Straight tube or hourglass shape	Straight tube with a bottom restriction
Injection:	1 µl	1 µl	1 µl
Split ratio:		1:50	
Purge activation time:			0.5 minutes

Oven Temperatures

Isothermal temperature condition involves maintaining a constant oven temperature throughout the GC run. Isothermal temperature conditions are used for solutes with similar retention. Retention differences for dissimilar solutes can be quite severe for isothermal temperature conditions. Peak widths rapidly increase with retention for isothermal conditions (**Figure 10a**). For these reasons, isothermal temperature conditions are only suitable for a limited number of analyses.

Figure 10a: Isothermal Condition

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **100°C isothermal**



A Warning When Adjusting Temperature Programs

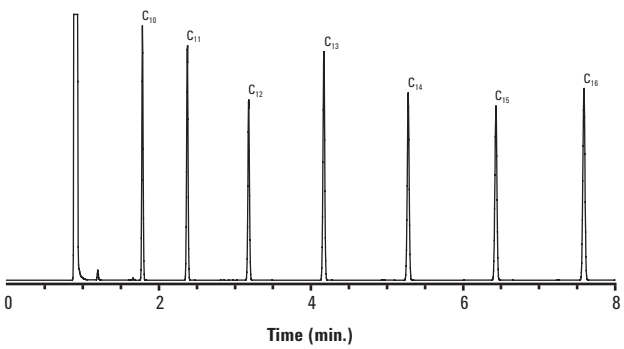
When changing a temperature program, confirmation of peak identities in the new chromatogram is essential. **Peak retention orders can shift upon a change in the temperature program (called peak inversions)**. Peak misidentifications or an apparent loss of a peak (actually co-eluting with another peak) are common results of undetected peak inversions. This is especially true for the most polar stationary phases.

Most analyses require the use of a temperature program. A temperature program involves heating the oven at a controlled rate during the run. This allows the faster analysis of solutes with dissimilar retention, and there is very little peak broadening with an increase in retention (**Figure 10b**). The primary disadvantages of a temperature program are the more difficult method development process and the longer GC oven cool down time between analyses. There are no secrets or tricks for finding the best temperature program for an analysis. Usually some trial and error is involved.

If numerous attempts at different temperature programs have not resulted in satisfactory peak resolution, a different approach may be necessary. Some compounds cannot be separated with a particular stationary phase with any reasonable temperature program, thus a different stationary phase may be necessary. Sometimes, improving efficiency may be the answer. Optimizing the carrier gas average linear velocity, improving injector efficiency, or using a more efficient column dimension may provide the desired resolution.

Figure 10b: Temperature Program Condition

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **60°C for 1 min, 60-180°C at 20°/min**



Developing a Temperature Program

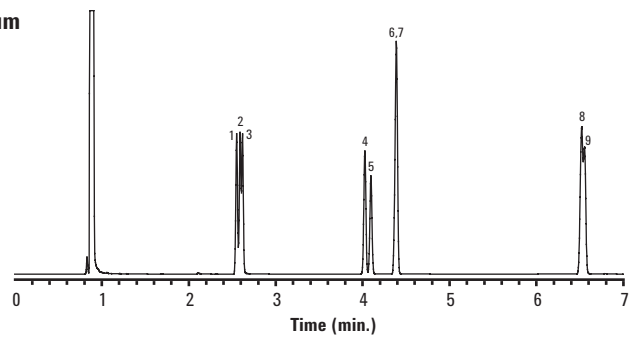
Using a Linear Temperature Program as a Starting Point

If previous analysis information is not available to use as a guide, the first program development step is to try a simple, linear temperature program. This provides information on the retention characteristics of the solutes. Start with an initial temperature of 50°C (or 10°C below the boiling point of your sample solvent), a ramp rate of 10°/min, a final temperature equal to the isothermal temperature limit of the column, and a final hold time of approximately 30 minutes. The long final hold time is used to ensure all of the solutes elute from the column. The program can be stopped several minutes after the last solute has eluted from the column. This may occur before the final temperature is reached (**Figure 11**). After obtaining a chromatogram using the simple, linear temperature program, the next steps are to adjust the various program components to obtain adequate resolution and the shortest analysis time.

Figure 11: Simple, Linear Temperature Program

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **50-130°C at 10°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene



Adjusting the Initial Temperature and Hold Time

To improve the resolution of earlier eluting peaks, decrease the initial temperature or increase the initial hold time. Decreasing the initial temperature usually results in the largest resolution improvement, but analysis times are substantially increased (**Figure 12a**). In addition, cool down times between runs can be significantly increased especially when cooling below 50°C. It is often impossible to cool a GC oven below 35°C in most laboratory environments without using cryogenic oven cooling. The resolution of the later eluting peaks are minimally affected by lowering the initial temperature especially for longer length columns. If excessive resolution is obtained with the original linear temperature program, increase the initial temperature to reduce the resolution and analysis time. The resolution of later eluting peaks may also be reduced upon increasing the initial temperature.

Increasing the initial hold time often improves the resolution of the earlier eluting peaks; however, the improvement is smaller than those obtained with lowering the initial temperature (**Figures 12b and c**). The resolution of later eluting peaks is minimally affected with a change in the initial hold time. Lowering the initial temperature and increasing the initial hold time can be combined to improve the resolution of earlier eluting peaks (**Figure 12d**). Hold times should be limited to 5 minutes or less if possible. Peaks eluting during the later portion of the hold time may start to broaden, thus making resolution more difficult to achieve.

Figure 12a: Developing Temperature Programs: Decrease Initial Temperature

Column: **DB-1, 15 m x 0.32 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **40-130°C at 10°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene

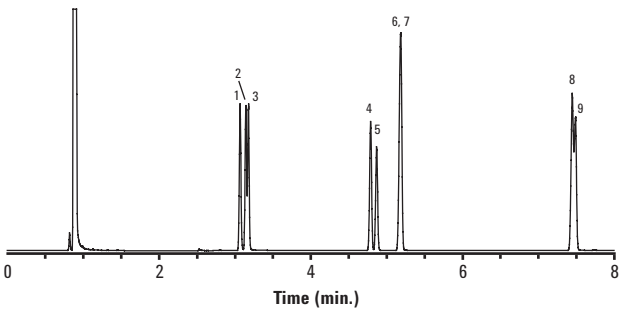


Figure 12b: Developing Temperature Programs: Increase Initial Hold Time

Column: **DB-1, 15 m x 0.32 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **50°C for 2 min, 50-130°C at 10°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene

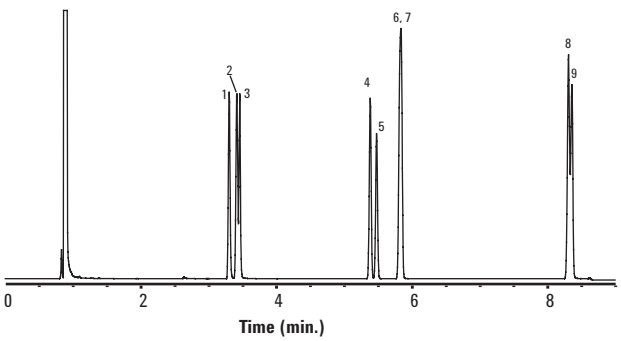


Figure 12c: Developing Temperature Programs: Increase Initial Hold Time

Column: **DB-1, 15 m x 0.32 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **50°C for 4 min, 50-130°C at 10°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene

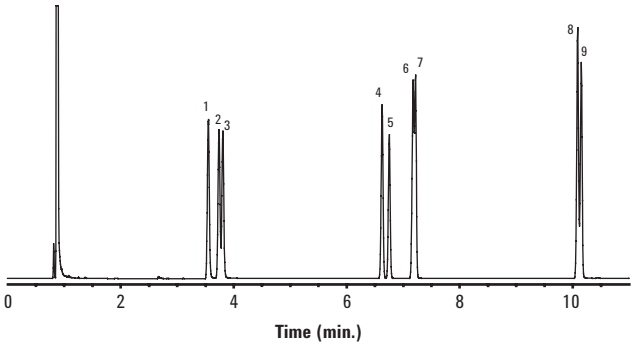
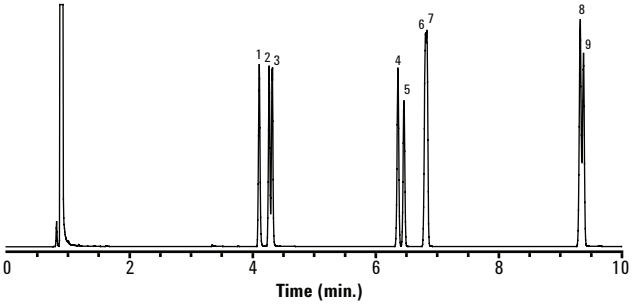


Figure 12d: Developing Temperature Programs: Decrease Initial Temperature and Increase Initial Hold Time

Column: **DB-1, 15 m x 0.32 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **40°C for 2 min, 40-130°C at 10°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene



Adjusting the Ramp Rate

The resolution of the peaks eluting in the middle of the chromatogram can be altered by changing the ramp rate. If there is excessive peak resolution, the ramp rate can be increased to reduce the resolution and the analysis time. If there is insufficient resolution, decrease the ramp rate, but there will be an increase in the analysis time (**Figure 13a**). Better resolution of later eluting peaks often occurs when decreasing the ramp rate. Only change the ramp rate by about 5°/min each time. Much larger or smaller alternations usually cause massive or insignificant changes, respectively. Changes in initial temperatures and times can be combined with ramp rate changes to affect a large section of the chromatogram (**Figure 13b**).

Figure 13a: Changing Ramp Rate

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **50-120°C at 5°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene

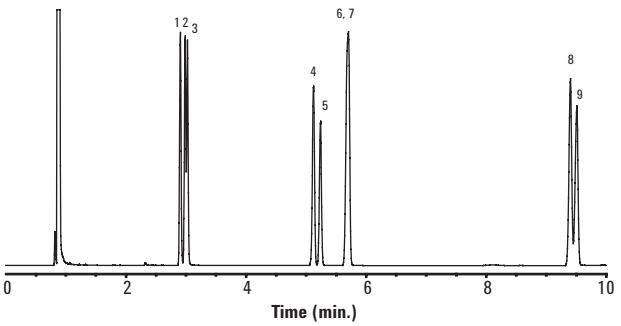
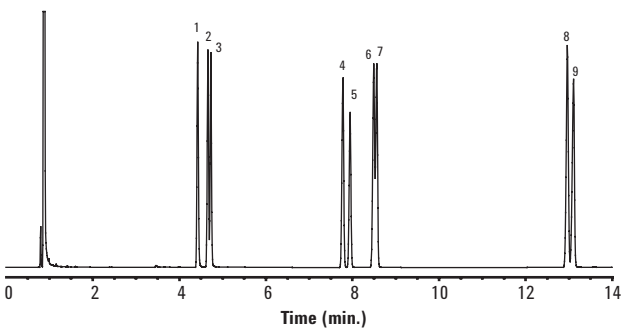


Figure 13b: Changing Ramp Rate

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **40°C for 2 min, 40-120°C at 5°/min**

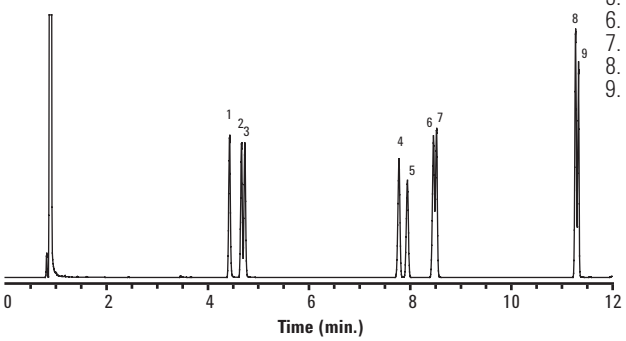
1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene



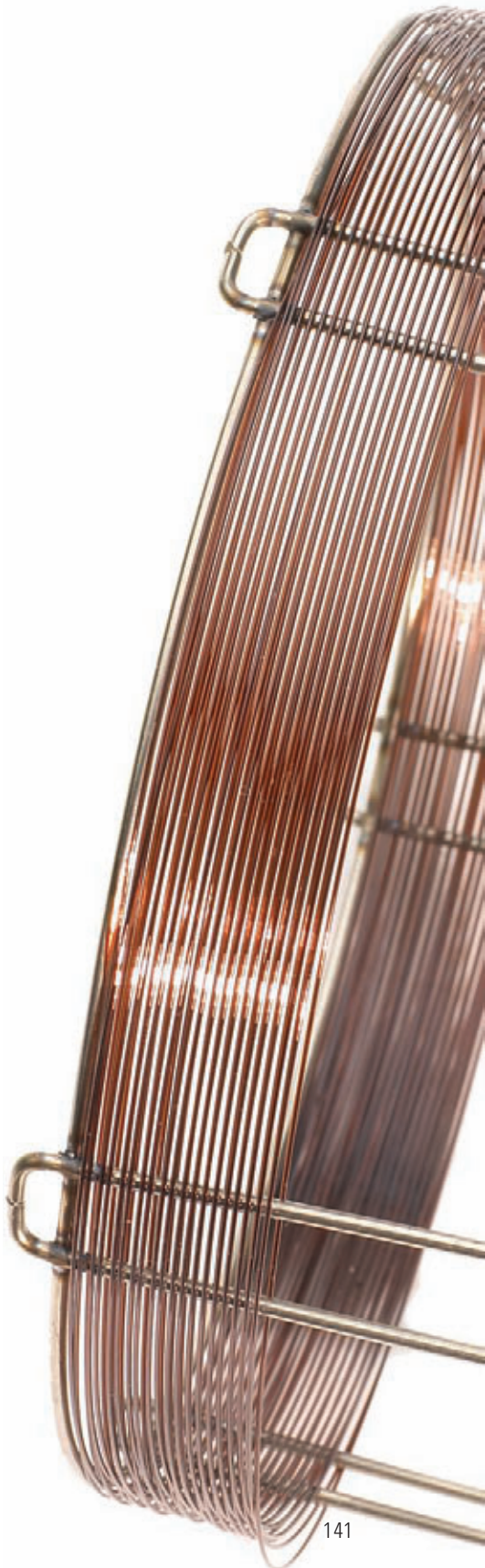
Multiple ramp rates can be used to affect smaller regions of the chromatogram. For example, if 5°/min was good for an earlier portion of the chromatogram and 15°/min was better for a later portion, then both ramp rates can be used within a single program (**Figure 14**).

Figure 14: Using Multiple Ramp Rates

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **40°C for 2 min, 40-70°C at 5°/min, 70-130°C at 15°/min**



1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene



Another option to alter resolution of peaks in the middle of a chromatogram is to use a mid ramp hold. A mid ramp hold is a several minute isothermal portion somewhere during a temperature ramp. For example, the temperature program of 50-100°C at 10°/min, 100°C for 3 min, 100-300°C at 10°/min contains a mid ramp hold. To determine a suitable hold temperature, calculate the oven temperature range when the first peak of interest is eluting. Use a hold temperature that is 20-30°C below this temperature. Hold times of 2-5 minutes are most effective. Shorter or longer times often have no, or detrimental, affect on peak resolution. Try several different temperatures and hold times since small changes in the times and temperatures can be significant (**Figures 15a and b**). Using a mid ramp hold only if other temperature program changes were not effective.

Figure 15a: Using Mid Ramp Holds

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **40-70°C at 10°/min, 70°C for 3 min, 70-120°C at 10°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene

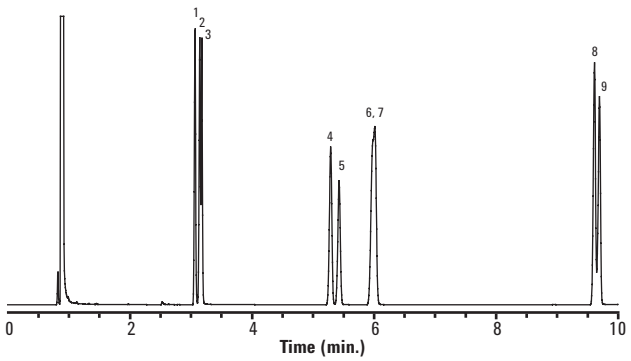
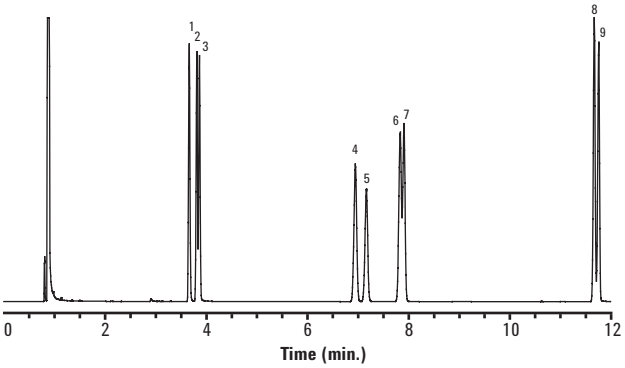


Figure 15b: Using Mid Ramp Holds

Column: **DB-1, 15 m x 0.25 mm I.D., 0.25 µm**
Carrier: **Helium at 30 cm/sec**
Oven: **40-60°C at 5°/min, 60°C for 3 min, 60-120°C at 5°/min**

1. 3-Heptanone
2. 2-Heptanone
3. Cyclohexanone
4. 1,3-Dichlorobenzene
5. 1,4-Dichlorobenzene
6. 1,2-Dichlorobenzene
7. Iodobenzene
8. Naphthalene
9. 3-Nitrobenzene



Final Temperature and Time

Stop the temperature program shortly after the last peak has eluted from the column. If the column's isothermal temperature limit is reached and peaks are still eluting, a final hold time is necessary. Only use a final hold time if the temperature limit is reached and compounds are still eluting. Any peaks that elute during isothermal temperature conditions will substantially increase in width as peak retention increases. If the column has a higher program maximum temperature, you can continue to ramp the GC oven to that temperature limit but should only hold at that temperature for less than 20 minutes.

Extracted samples often contain compounds that elute after the last solute of interest. The final temperature and/or hold time need to be large enough to ensure elution of these compounds. Higher final temperatures or longer hold times should be tried until it is certain that all solutes elute from the column for every run. Column contamination will occur if portions of previously injected samples remain in the column during later injections.

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