



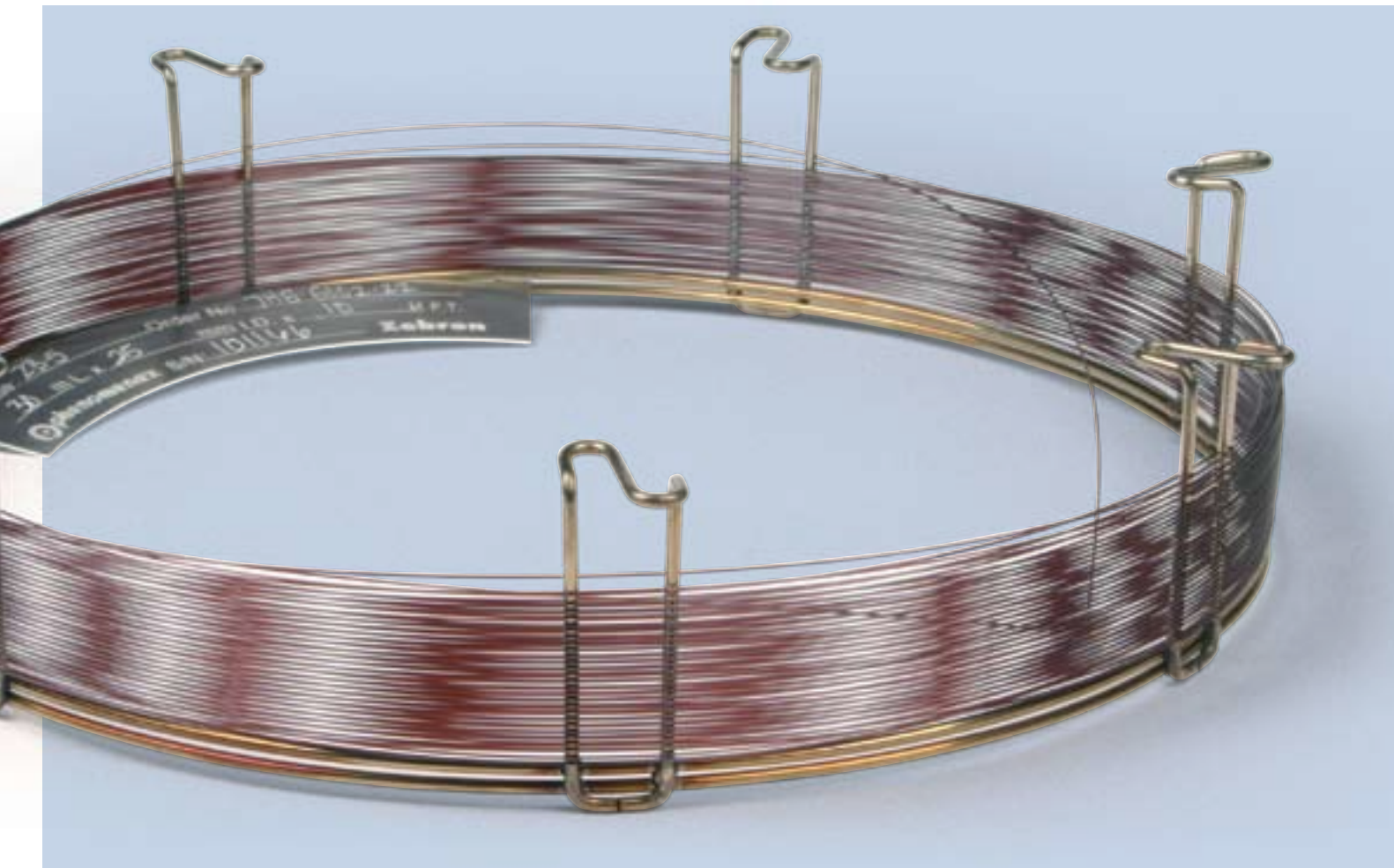
Zebbron™ Inferno™

430 °C Stable

Unsurpassed High Temperature GC Analysis



Recognized as one
of the top 100 most
technologically significant
products of 2007



430 °C

In the field of gas chromatography, not much has changed in the last 15 years. Chemists running high temperature applications have been resigned to either using inflexible and problematic metal columns or constantly replacing their fused silica column when it becomes brittle and spontaneously breaks.

To meet the needs of today's chemists, Phenomenex® has developed the Zebron™ Inferno™ columns for high temperature analysis. Recognized as the most technologically significant GC column in 2007, Zebron Inferno columns revolutionize the meaning of high temperature gas chromatography and provide chemists with peak performance up to 430 °C.

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- Saves Time and Money
- Increase Productivity by Speeding Up Run Time
- Allow For Low Level Analysis
- High Temperature Bake Outs
- Perfectly Compatible with Existing MS Systems
- Allows for Analysis of High Molecular Weight Compounds Analysis
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Inferior Alternatives

Traditional GC Capillary Columns Fall Short in High Temperature Analysis

Various GC analyses require a capillary GC column capable of withstanding high oven temperatures. However, finding such a column has been difficult. Gas chromatographers using traditional polyimide columns for high temperature analysis face many challenges:

- **Traditional Polyimide Columns Break**

After prolonged exposure to temperatures above 360 °C, traditional polyimide columns become brittle, inflexible, and are prone to breakage.

- **Costly to Replace**

Constantly replacing broken or brittle columns is inconvenient and expensive.

- **Inhibit Productivity**

Analysts spend too much time performing system maintenance and column changes due to column brittleness and breakage.

- **Problems Separating High Molecular Weight Compounds**

Analyzing high molecular weight compounds, such as long-chained hydrocarbons, heavy PAHs, and triglycerides, requires capillary GC columns that perform well at high GC oven temperatures. Traditional polyimide columns aren't tough enough to withstand such conditions.



Figure 1. Traditional capillary columns easily break with prolonged exposure to GC oven temperatures above 360 °C.

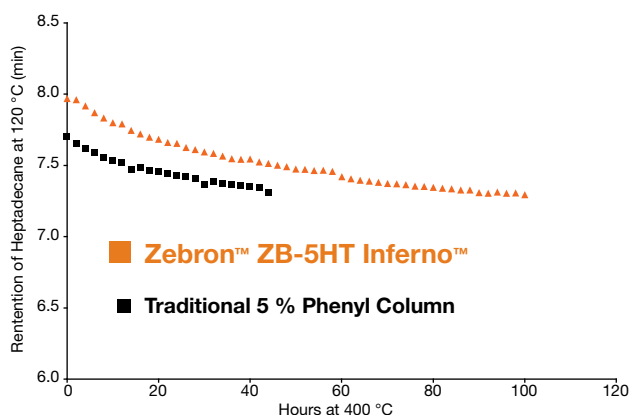


Figure 2. Comparison of retention of Heptadecane between the Zebtron ZB-5HT Inferno column versus a traditional 5 % Phenyl - 95 % - dimethylpolysiloxane column. Note that the 5 % Phenyl column died around 40 hours at 400 °C whereas the Zebtron ZB-5HT Inferno column maintained great retention of Pentadecane over 100 hours.

Metal GC Columns Present Tough Challenges

When working at high temperatures, the only other alternative to using traditional capillary columns is using a metal column. Metal columns, however, have several major drawbacks:

- **Hard to Use**

Metal columns inflexible and require special tubing cutters for installation.

- **Develop Leaks**

Metal columns develop leaks due to expansion and contraction when heating.

- **High Column Activity for Acids and Bases**

It's difficult to get good peak shape with acids and bases using metal columns due to their high activity for these compounds.

- **Incompatible with MS Detectors**

Metal columns are incompatible with Mass Spectrometer (MS) detectors.

Zebtron™ Inferno™

One of the 100 most technologically significant products of 2007



Winner 2007

Zebtron Inferno columns have been recognized as one of the 100 most technologically significant products introduced into the marketplace over the past year. Further, they are the only GC columns in history ever to have received such an award. This is a significant accomplishment and a true testament to their stability and performance.

Zebron™ Inferno™

Providing Unsurpassed Performance For High Temperature Analysis

The Zebron ZB-1HT and ZB-5HT Inferno columns have durable stationary phases and a polyimide coating that is more robust than conventional columns, providing the highest thermal stability of any capillary columns. This enhanced technology makes them the ideal columns for doing high temperature analysis because they are:

- **More Rugged and Provide Longer Lifetime**

The Zebron Inferno columns are specially manufactured for rugged high temperature analysis. At temperatures above 380 °C, conventional fused silica tubing will become brittle and randomly break. At 380 °C, we're just warming up.

- **Save Time and Money**

Zebron Inferno columns' durability will reduce the need to change columns, thus saving time and cutting the cost of analysis.

- **Increase Productivity by Speeding Up Run Time**

Increase productivity and reduce run time by using the Zebron Inferno columns to run standard analysis at higher temperatures.

- **Allow for Low Level Analysis**

Engineered Self Cross-linking™ (ESC) Technology provides enhanced column durability and low bleed levels for maximum sensitivity.

- **High Temperature Bake Outs**

Zebron Inferno columns allow for more aggressive column bake outs to remove persistent contaminants and prevents run-to-run carryovers of analytes.

- **Perfectly Compatible with MS Systems**

Unlike metal columns, which are incompatible with MS detectors, the Zebron Inferno columns can be used with existing MS systems.

- **Allow for the Analysis of High Molecular Weight Compounds**

The Zebron Inferno column's high temperature stability is suited for the analysis of less volatile samples.

- **Alternative to Inflexible and Problematic Metal Columns**

At high temperatures, the Zebron Inferno columns remain flexible and resilient. This allows applications to be run at high temperature without having to resort to inflexible and problematic metal columns.

- **Suited for a Wide Range of Applications**

The Zebron Inferno columns are ideal for a wide range of applications, such as long-chained hydrocarbons, biodiesel, heavy PAHs, triglycerides, motor oils, surfactants, crown ethers, waxes, polymers and plastics, and tars.

Still Flexible After 23 Hours at 430 °C

430 °C TPGC Stability Test*

At temperatures above 380 °C, conventional fused silica tubing will become brittle and randomly break. Our special new tubing is manufactured using a novel High Temperature Polyimide Resin material that shows minimal thermal degradation even at programmed temperatures up to 430 °C.

*Evaluated by performing 185 programmed temperature runs, total 23 hours at 430 °C. Polyimide tubing was still flexible as shown here.

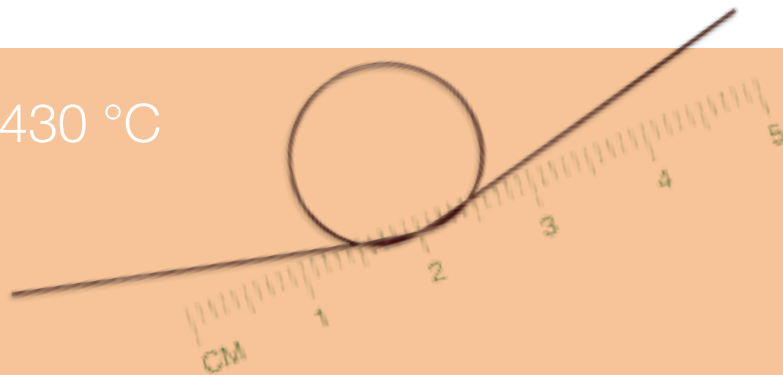


Figure 3. Zebron Inferno columns remain amazingly flexible even after extreme conditions.

Outperforms Agilent J&W DB-5ht

Lifetime Comparison†

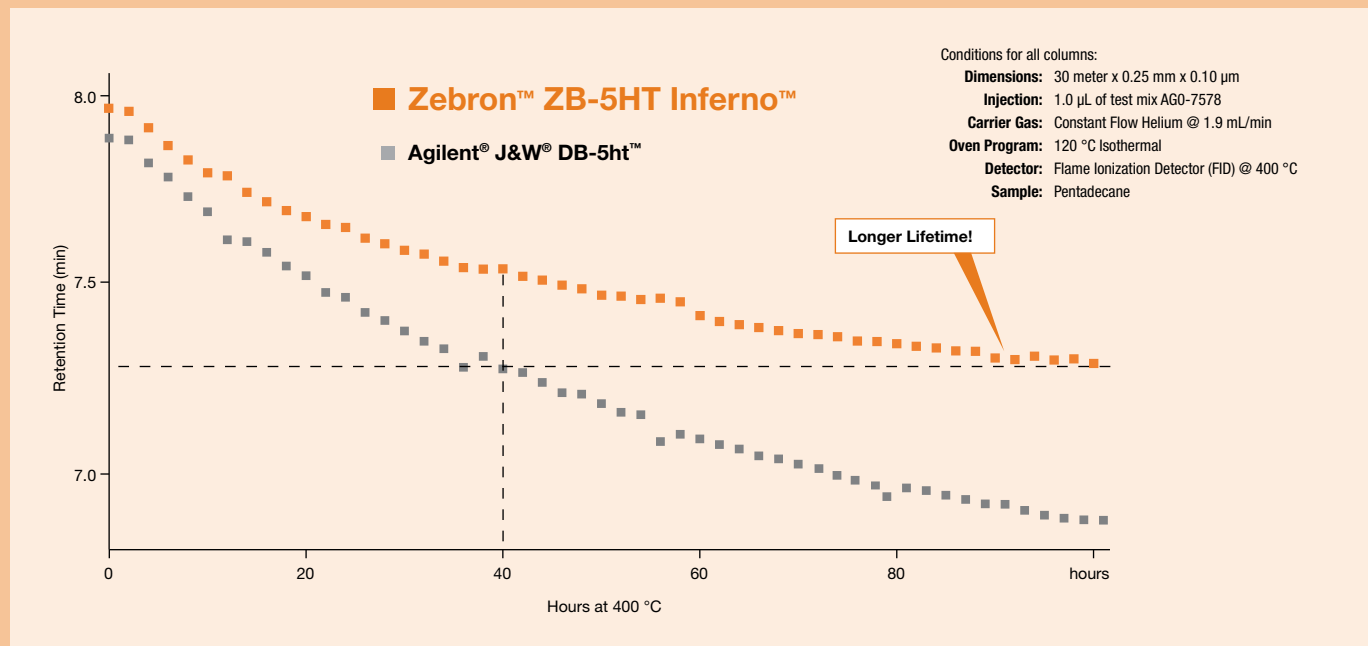


Figure 4. Zebtron ZB-5HT outperforms Agilent J&W DB-5ht. Columns were held at 400 °C for 2 hours, then the oven was lowered to 120 °C for Pentadecane analysis.

Bleed Profile†

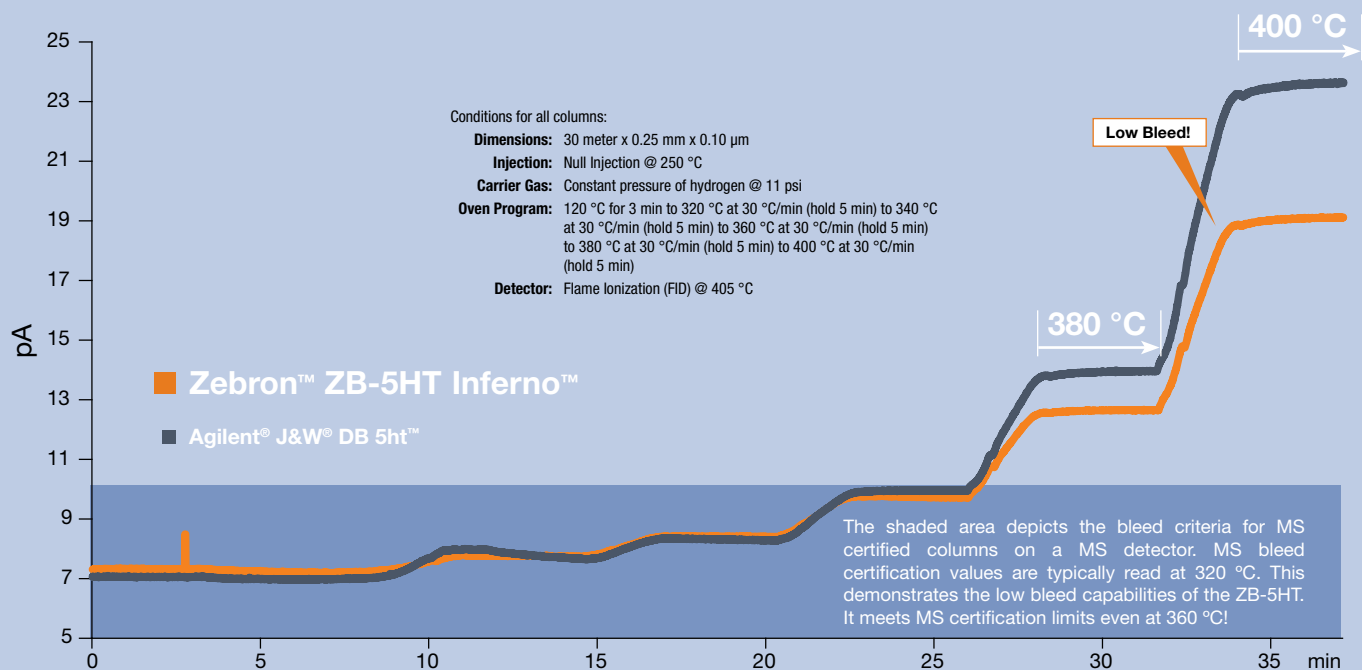
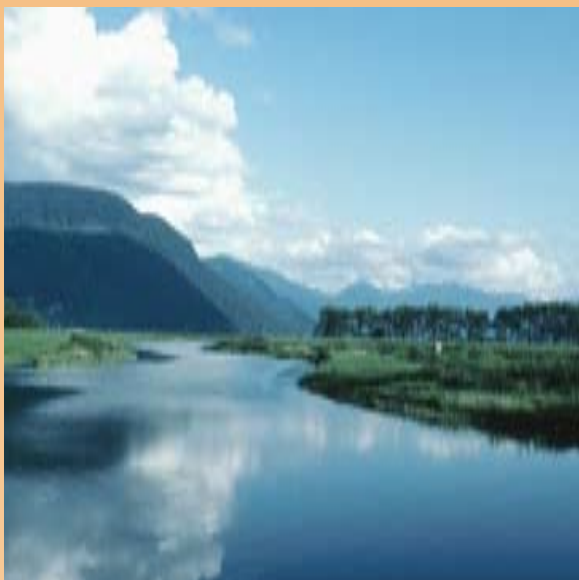


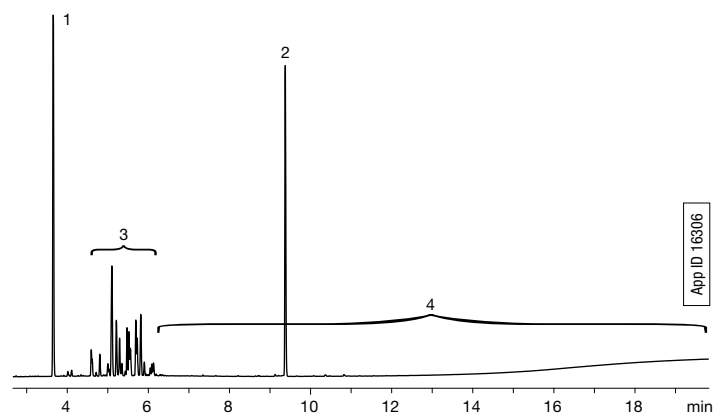
Figure 5. Column bleed profile comparison of an Agilent J&W DB-5ht column versus a Zebtron ZB-5HT Inferno column.

† All columns were new, never used, prior to this testing and purchased either directly from the original manufacturer or through an authorized distributor. All testing was carefully controlled to ensure conditions were similar for all columns involved. The comparative data is not representative of every application.



Improved Lifetime with Enhanced Endurance and Extended Temperature Range

The enhanced endurance and extended temperature range of the Zebtron Inferno™ columns allows for more aggressive column baking steps to remove persistent contaminants, thus prolonging column lifetimes. The chromatogram below shows PCBs contaminated with 10 % mineral oil. Since the ECD does not respond to hydrocarbons, it is difficult to know when samples contain potentially harmful compounds. If these contaminants are not removed, it will shorten column lifetime. With the Zebron Inferno column, the contamination is easily removed using a high temperature column bake out at 420 °C.



Aroclor 1016 in Mineral Oil

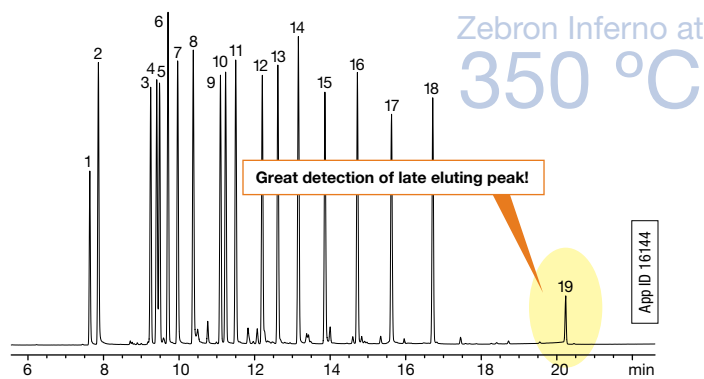
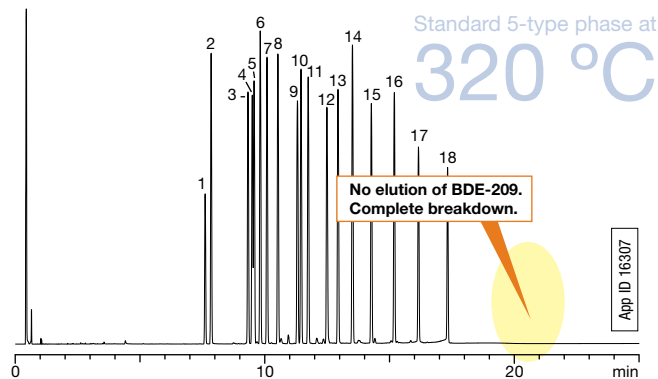
Column: Zebtron ZB-5HT Inferno
Dimensions: 30 meter x 0.32 mm x 0.1 µm
Part No: 7HM-G015-02
Oven Program: 150 °C for 2 min to 420 °C @ 20 °C/min for 4.5 min
Carrier Gas: Constant Flow Helium, 1.9 mL/min
Injection: Split 52:1, 1 µL @ 330 °C
Detector: ECD @ 380 °C
Sample: 1. TCMX
2. DCOB
3. Aroclor 1016
4. Mineral Oil

Note: Aroclor 1016 @ 100 ppb; Mineral Oil @ 1% in iso-Octane

Increased Sensitivity for Late Eluting Compounds

Analyzing Polybrominated Diphenyl Ethers (BDEs) with a traditional non-metal column can be challenging, if not impossible. Late eluting BDEs often break down and become difficult to detect. The Zebtron Inferno columns have increased sensitivity for late eluting

compounds and thus can easily detect these formerly troublesome analytes. In addition, the Zebtron Inferno columns allow analysis to be run at elevated temperatures, resulting in faster elution and thus higher peaks.



PolyBrominated Diphenyl Ethers (PBDE)

Column: Standard 5-type phase
Dimensions: 15 meter x 0.25 mm x 0.1 μm
Oven Program: 70 °C to 160 °C @ 25 °C/min to 320 °C @ 10 °C/min hold 10 min
Carrier Gas: Constant Pressure Helium, 3.4 mL/min
Injection: On-Column 0.5 μL @ 73 °C
Detector: ECD @ 340 °C
Note: PBDE Standard @ 2.5 ppm in iso-octane

Sample: 1. BDE-25 11. BDE-99
 2. BDE-28 12. BDE-85
 3. BDE-75 13. BDE-154
 4. BDE-49 14. BDE-153
 5. BDE-71 15. BDE-138
 6. BDE-47 16. BDE-183
 7. BDE-66 17. BDE-190
 8. BDE-77 18. BDE-203
 9. BDE-100
 10. BDE-119

PolyBrominated Diphenyl Ethers (PBDEs)

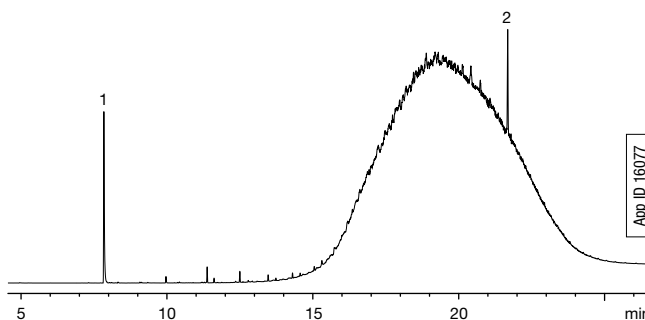
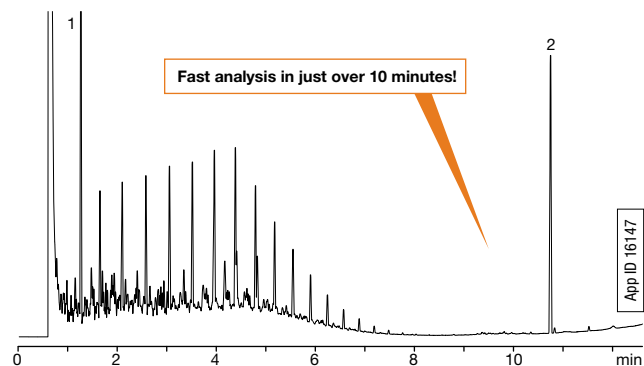
Column: Zebtron ZB-5HT Inferno
Dimensions: 15 meter x 0.25 mm x 0.10 μm
Part No.: 7EG-G015-02
Injection: On-Column @ 73 °C, 0.5 μL
Carrier Gas: Helium @ 1.5 mL/min (constant flow)
Oven Program: 70 °C to 160 °C @ 25 °C/min to 350 °C @ 10 °C/min for 5 min
Detector: ECD @ 400 °C
Note: Sample was 2.5 ppm in iso-octane.

Sample: 1. BDE-25 11. BDE-99
 2. BDE-28 12. BDE-85
 3. BDE-75 13. BDE-154
 4. BDE-49 14. BDE-153
 5. BDE-71 15. BDE-138
 6. BDE-47 16. BDE-183
 7. BDE-66 17. BDE-190
 8. BDE-77 18. BDE-203
 9. BDE-100 19. BDE-209
 10. BDE-119

Increase High-Throughput

High thermal stability enhances many analyses, such as the determination of extractable hydrocarbons. This method, often referred to as diesel range organics (DRO), is outlined by the U.S. EPA method 8015, or international methods such as Germany's DIN

H53, or the United Kingdom's TPH analysis. When using a Zebtron Inferno column, you can use high temperatures to reduce run times and increase lab throughput.



Fast H53 Analysis of Diesel Fuel

Column: Zebtron ZB-5HT Inferno
Dimensions: 15 meter x 0.32 mm x 0.10 μm
Part No.: 7EM-G015-02
Injection: On-Column @ 63 °C, 0.1 μL
Carrier Gas: Helium @ 2.7 mL/min (constant flow)
Oven Program: 60 °C to 375 °C @ 25 °C/min
Detector: FID @ 400 °C
Note: Diesel fuel was 200 ppm in dichloromethane with internal standards at 50 ppm.

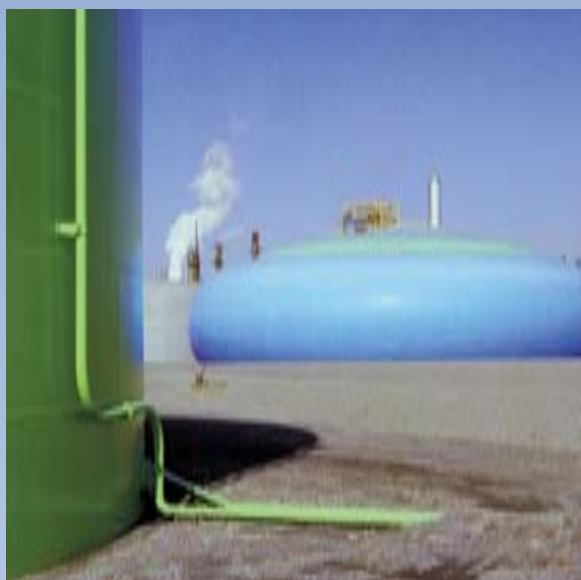
Sample: 1. Decane (C10)
 2. Tetracontane (C40)

Mineral Oil Using H-53 Conditions

Column: Zebtron ZB-5HT
Dimensions: 30 meter x 0.25 mm x 0.1 μm
Part No.: 7HG-G015-02
Oven Program: 50 °C for 6 min to 400 °C @ 20 °C/min for 15 min
Carrier Gas: Constant Flow Helium, 1.3 mL/min
Injection: On-Column 0.1 μL @ 53 °C
Detector: FID @ 415 °C
Note: Fuel was 10 mg/mL in dichloromethane with 50 ppm markers

Sample: 1. Decane (C10)
 2. Tetracontane (C40)

PETROCHEMICALS



Stable and Durable Even When Pushed to 430 °C

To demonstrate the ultra-high temperature performance of the Zebtron™ Inferno™ columns, we tested the Zebtron ZB-5HT under the extreme conditions (23 hours at 430 °C) and compared the difference in retention time. Under these harsh conditions, the difference in retention of pentacontane between the first and 125th chromatograms was only 1.5 %! With the Zebtron Inferno column's improved endurance and extended temperature range, expect to get precise, dependable results for extended periods.

Simulated Distillation Analysis Made Easy

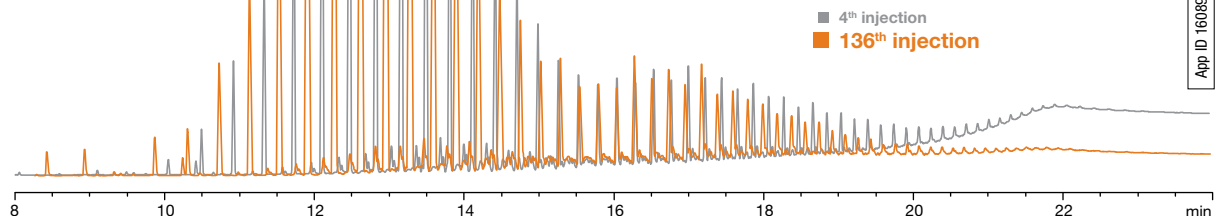
ASTM D2887 and D6352 both set standard test methods for boiling range determination of petroleum fractions by GC. While ASTM D2887 is used for products having a final boiling point of 538 °C or lower, ASTM D6352 is used for determining petroleum distillate fractions with a boiling point (BP) up to 700 °C.

The Zebtron Inferno columns make simulated distillation analysis easier and less expensive. Normally, you would have to use a traditional fused silica column for ASTM D2887 and a metal column for ASTM D6352. Zebtron Inferno columns provide a robust solution for both analyses.

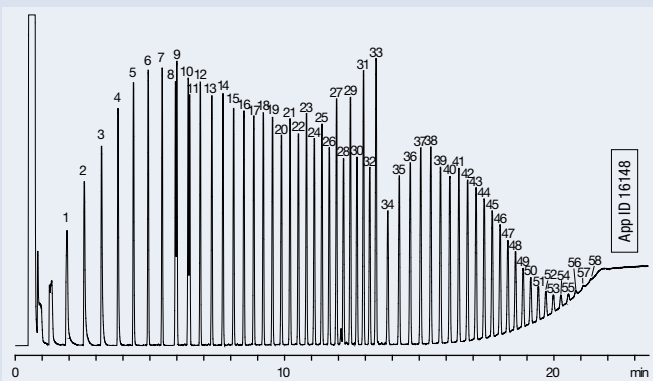
Only 1.5 % retention difference after 23 hours in extreme conditions

Paraffin Wax

Column: Zebron™ ZB-5HT Inferno™
Dimensions: 15 meter x 0.32 mm x 0.10 µm
Part No.: 7EM-G015-02
Injection: Direct on column @ 43 °C, 0.1 µL
Carrier Gas: Helium @ 1.9 mL/min (35 cm/sec) (constant flow)
Oven Program: 40 °C for 2 min to 430 °C @ 20 °C for 10 min
Detector: FID @ 430 °C
Sample: Paraffin Wax

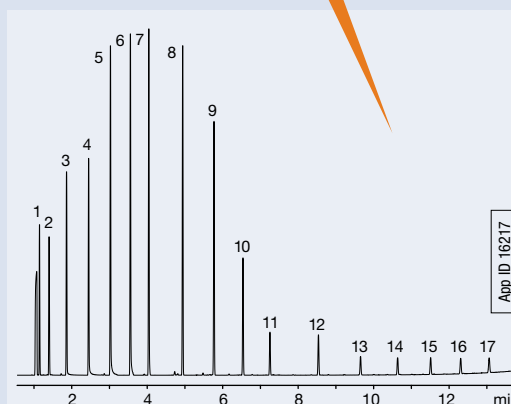


App ID 16089



App ID 16148

Stable analysis for standard high temperature simulated distillation analysis



App ID 16217

ASTM 6352

Column: Zebron ZB-1HT Inferno
Dimensions: 5 meter x 0.53 mm x 0.10 µm
Part No.: 7AK-G014-02
Oven Program: 40 °C for 0.5 min to 430 °C @ 20 °C/min for 10 min
Carrier Gas: Constant Flow Helium, 4.4 mL/min
Injection: On-Column 0.1 µL @ 43 °C
Detector: FID @ 430 °C

Note: Sample was a combination of PolyWax 655 and retention time markers C8-C40 in CS2/Chloroform

Sample:					
1. C10	11. Phytane	21. C28	31. C38	41. C56	51. C76
2. C11	12. C19	22. C29	32. C39	42. C58	52. C78
3. C12	13. C20	23. C30	33. C40	43. C60	53. C80
4. C13	14. C21	24. C31	34. C42	44. C62	54. C82
5. C14	15. C22	25. C32	35. C44	45. C64	55. C84
6. C15	16. C23	26. C33	36. C46	46. C66	56. C86
7. C16	17. C24	27. C34	37. C48	47. C68	57. C88
8. C17	18. C25	28. C35	38. C50	48. C70	58. C90
9. Pristane	19. C26	29. C36	39. C52	49. C72	
10. C18	20. C27	30. C37	40. C54	50. C74	

ASTM Method D 2887-97: Boiling Range Distribution of Petroleum Fractions

Column: Zebron ZB-1HT Inferno
Dimensions: 15 meter x 0.53 mm x 0.15 µm
Part No.: 7EK-G014-05
Injection: On-Column @ 38 °C, 0.1 µL
Carrier Gas: Helium @ 10 mL/min (constant flow)
Oven Program: 35 °C for 1 min to 360 °C @ 25 °C/min
Detector: FID @ 375 °C

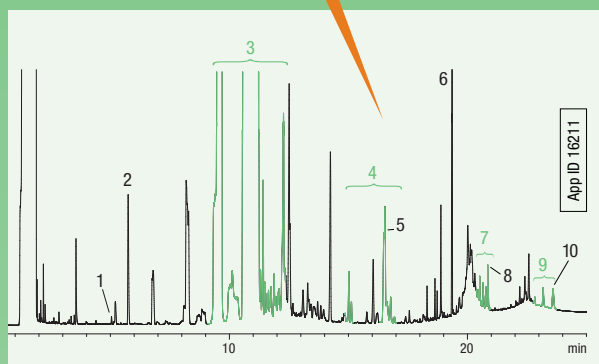
Sample:

1. Hexane	10. Octadecane
2. Heptane	11. Eicosane
3. Octane	12. Tetracosane
4. Nonane	13. Octacosane
5. Decane	14. n-Dotriacontane
6. Undecane	15. n-Hexatriacontane
7. Dodecane	16. Tetracontane
8. Tetradecane	17. Tetratriacontane
9. Hexadecane	

BIODIESEL



Improved Glycerol Resolution
High Sensitivity for Triolein
Ultra Low Bleed at 380 °C



ASTM D 6584: Free and Total Glycerin in B-100 Biodiesel Methyl Esters

Column: Zebtron ZB-5HT Inferno

Dimensions: 15 meter x 0.32 mm x 0.10 μ m + 2 meter x 0.53 mm Z-Guard

Part No.: 7EM-G015-02

Injection: On-Column @ 53 °C, 1 μ L

Carrier Gas: Helium @ 3.0 mL/min (constant flow)

Oven Program: 50 °C for 1 min to 180 °C @ 15 °C/min to 230 °C @ 7 °C/min to 380 °C @ 30 °C/min for 10 min

Detector: FID @ 380 °C

- Sample:**
1. Glycerol
 2. Butanetriol (ISTD1)
 3. Esters
 4. Monoglycerides
 5. 1-Monooleoyl-rac-glycerol
 6. Tricarpin (ISTD2)
 7. Diglycerides
 8. 1,3-Diolein
 9. Triglycerides
 10. Triolein

Note: A 2.0 m x 0.53 mm Guard Column was connected to the analytical column per ASTM method requirements.

Reliable Determination of Glycerin Biodiesel

Biodiesel has emerged as a significant fuel source worldwide in the past decade. As there are many advantages to converting from petroleum fuel to biodiesel, its use will only increase in the future. Aside from being an economic alternative to the rising prices of diesel fuel, biodiesel is easily produced from common feedstocks, reduces exhaust pollutants, and is a renewable source of energy.

During biodiesel production, or transesterification, oils or fats are reacted with methanol in the presence of a catalyst to produce glycerol and fatty esters. Glycerin contaminant in the final product can lead to severe operational problems such as engine deposits, filter clogging, or fuel deterioration. Therefore new regulations require that the level of glycerin be measured before any final product is sold commercially to ensure product quality.

Both the United States (US) and Europe have set limits on free glycerin and glycerides levels in biodiesel oil products. The US American Society for Testing and Materials (ASTM) method D6584 and European EN14105 methods both outline the high temperature GC procedures for biodiesel oil analysis.

The Zebtron ZB-1HT and ZB-5HT Inferno columns specifically address the challenges of analyzing glycerin in biodiesel products. Their high temperature stability is ideal for biodiesel analysis because they can withstand the elevated temperatures needed to remove high boiling triglycerides.

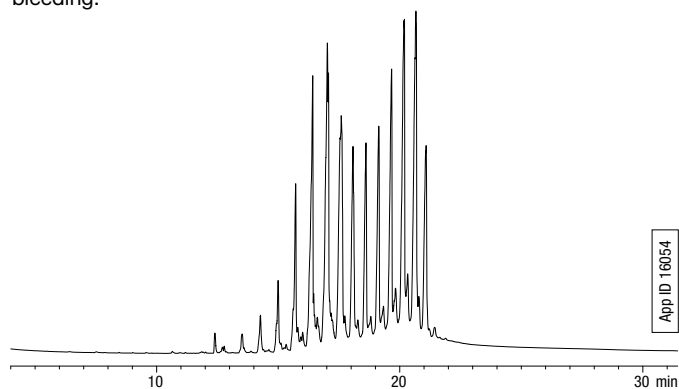
In addition, the Zebtron Inferno columns are guaranteed to give reliable biodiesel purity checks. While standard polyimide resin degrades at temperatures above 380 °C, the Zebtron Inferno columns utilize a polyimide resin material that shows minimal thermal degradation, even at programmed temperatures up to 430 °C – the highest thermal stability of any non-metal GC column!





Optimized for High Molecular Weight Analysis

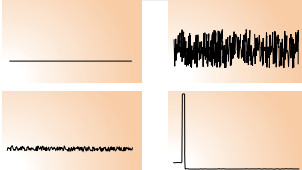
The Zebtron Inferno columns easily handle the challenges of analyzing high-molecular weight compounds that require higher temperature programs. To analyze these compounds, a thermally stable capillary column with low bleed is needed. However, traditional non-metal columns become brittle with extended use at temperatures above 380 °C, which leads to excessive bleeding and short column lifetimes. Since the Zebtron Inferno columns are thermally stable up to 430 °C, you can reliably analyze high molecular compounds, such as butter triglycerides, olive oil, peanut oil, and canola oil, without having to worry about the column breaking or bleeding.

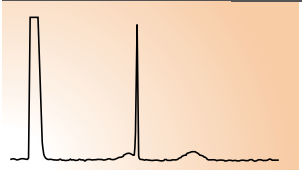


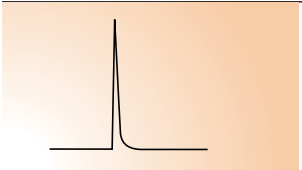
Butter Triglycerides


Column: Zebtron ZB-5HT Inferno
Dimensions: 15 meter x 0.32 mm x 0.10 μ m
Part No.: 7EM-G015-02
Injection: On-Column @ 103 °C, 2 μ L
Carrier Gas: Helium @ 1.8 mL/min (constant flow)
Oven Program: 100 °C to 400 °C @ 14 °C/min for 10 min
Detector: FID @ 400 °C


GC TROUBLESHOOTING

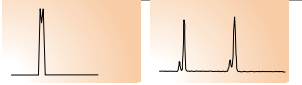
		Possible Cause:	Suggested Remedy:
 <p>No Peaks</p>	SYSTEM		
	Clogged syringe	Clean or replace syringe.	
	Leaks	Check injector for leaks; make sure column is properly installed in detector.	
	No carrier gas	Turn on carrier gas.	
	Detector OFF or not lit	Ignite or turn on detector; reduce sample size or gas flows if solvent blew out detector.	
	Wrong injection port	Verify correct injection port.	
	Clogged inlet sleeve	Replace inlet liner.	
	COLUMN		
	Broken column	Inspect column and verify flow at column outlet.	
	Plugged column	Cut off 5-10 cm of column ends and reinstall column. Verify flow at column outlet.	

 <p>Ghost Peaks</p>	SYSTEM		
	Septum bleed	Replace septum with high-temperature, low-bleed septum.	
	Carry over	Increase final temperature and hold; rinse syringe better.	
	Dirty inlet	Replace inlet liner.	
	Contaminated gas	Replace filters, scrubbers, or service purifiers; use higher purity gasses.	
	Outgassing from traps	Replace traps.	
	Contaminated gas lines	Replace or clean gas lines.	
	COLUMN		
	Sample contaminated	Cut 50-100 cm from injector side of column; perform an extended conditioning step; solvent rinse column; use glass wool in liner or decrease injection temperature; or replace column.	
	SAMPLE		
Contaminated sample	Remake sample with higher purity/fresh solvents and clean glassware.		
Contaminated flush solvent	Replace syringe flush solvent with fresh/pure solvent.		
Possible sample degradation	Make new sample; store samples using proper procedures; reduce introduction of catalysts or reactive analytes in sample; store samples in opaque or dark containers.		

 <p>Tailing Peaks</p>	Contaminated or active injector liner or column	Clean or replace injector liner. Don't use glass wool in the liner. Solvent rinse or replace the column.
	Dead volume due to poorly installed liner or column	Confirm by injecting inert peak (methane); if it tails, column is not properly installed. Reinstall liner and column as necessary.
	Ragged column end	Score the tubing lightly with a sapphire scribe or a ceramic scoring wafer before breaking it. Examine the end. If the break is not clean and the end square, cut the column again. Point the end down while breaking it, and reinstall the column while installing a nut and ferrule. This will prevent fragments from entering the column.
	A bad match between the polarities of stationary phase and the solvent	Change the stationary phase. Usually polar analytes tail on non-polar columns, or dirty columns.
	A cold region in the sample flow path	Remove any cold zones in the flow path.
	Debris in the liner or column	Clean or replace the liner. Cut 10 cm off the end of the column and reinstall it.
	Injection takes too long	Improve injection technique.
	Split ratio is too low	Increase split ratio to at least 20:1.
	Overloading the inlet	Decrease the sample volume or dilute sample.
	Some types of compounds such as alcoholic amines and carboxylic acids tend to tail	Try a more polar column. Make a derivative of the sample.

 <p>Broad Solvent Fronts</p>	Bad column installation	Reinstall column.
	Injector leak	Find and fix leak.
	Injection volume too large	Decrease sample size or dilute 1:10.
	Injection temperature too low	Increase injection temperature so the entire sample is vaporized "instantly". An injection temperature higher than the temperature limit of the column will not damage the column.
	Split ratio is too low	Increase split ratio.
	Column temperature too low	Increase column temperature. Use a lower boiling point solvent.
	Initial column temperature too high for splitless injection	Decrease the initial column temperature. Use a less volatile solvent so the initial column temperature is at least 10 °C below the boiling point of the solvent. Use a shorter purge activation time.
	Purge time too long (splitless injection)	Use a shorter purge activation time.

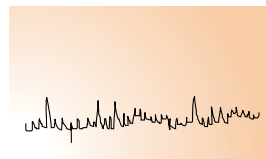
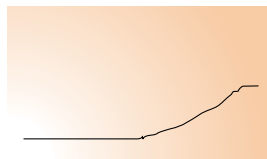
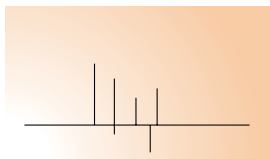
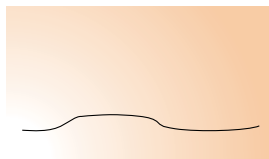
 <p>Fronting Peaks</p>	Column overloading	Reduce the injection volume (increasing sensitivity, if necessary), increase split ratio, or use a column with greater capacity. Columns with larger diameters or thicker stationary phase coatings generally have larger sample capacities; however, resolution may be reduced.
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 <p>Split Peaks</p>	Poor (jerky or erratic) injections	Use smooth, steady plunger depression. Use autosampler.
	Bad column installation	Reinstall column.
	Fluctuations in column temperature	Repair temperature control system. Calibrate GC oven.
	Mixed sample solvent for splitless or on-column injections	Use single solvent.
<p>When using injection techniques that require "solvent effect" refocusing such as splitless injection, the solvent must form a compact, continuous flooded zone in the column. If the solvent does not wet the stationary phase (column lining) sufficiently, as might be the case for methanol used with a nonpolar stationary phase, the solvent flooded zone may be several meters long and not of uniform thickness. This will result in broad and distorted peaks because the solutes will not be refocused into a narrow band near the beginning of the column.</p>		Installing a retention gap (5 meters of uncoated but deactivated column) ahead of the chromatographic column may reduce or eliminate this problem.

GC TROUBLESHOOTING

Possible Causes For Baseline Instability

System	Column	Sample
<ul style="list-style-type: none"> Leaks, O₂ influx Column bleed Septum bleed Contaminated gases Unequilibrated 	<ul style="list-style-type: none"> Dirty detector Dirty inlet Improper flow rates Pneumatic temperature change 	<ul style="list-style-type: none"> Bleed contamination Liquid leak detector contamination
<ul style="list-style-type: none"> Carry over Depolymerization agents (HCl, KOH, etc.) 		



Reference

Parameters	Unit	Symbols
Retention Time of an Unretained Solute	s	t_0
Retention Time, Measured from the Start	s	t_R
Adjusted Retention Time	s	$t_R^l = t_R - t_0$
Peak Width (Base)	s	W
Peak Width (Half Height)	s	$W_{1/2}$
Capacity Factor (Retention Factor)	-	$k = \frac{t_R^l}{t_0}$
Selectivity Factor	-	$\alpha = \frac{k_2}{k_1} = \frac{t_{R2}^l}{t_{R1}^l}$
Resolution	-	$R_s = 2 \left(\frac{t_{R2}^l - t_{R1}^l}{W_1 + W_2} \right)$
Number of Theoretical Plates	-	$N = 5.54 \left(\frac{t_R}{W_{1/2}} \right)^2 = 16 \left(\frac{t_R}{W} \right)^2$
Number of Effective Plates	-	$N_{eff} = 5.54 \left(\frac{t_R^l}{W_{1/2}} \right)^2 = 16 \left(\frac{t_R^l}{W} \right)^2$
Column Length	cm	L
Height Equivalent of a Theoretical Plate (Plate Height)	cm	$H = \frac{L}{N}$
Effective Plate Height	cm	$H_{eff} = \frac{L}{N_{eff}}$
Linear Velocity of the Mobile Phase	cm s ⁻¹	$U = \frac{L}{t_0}$
Pressure Conversions		1 bar = 100 kPa 1 atm = 101.3 kPa 1 psi = 6.9 kPa

How To Decrease Peak Width

- Use a More Efficient Column**
 - Packed - Smaller particles, packed more tightly
 - Capillary - Smaller ID, thinner film
- Optimize Method Parameters**
 - See van Deemter Plots for optimal flow rates of carrier gases
 - Optimize temperature profiles
- Reduce Sample Size**
 - To avoid column overloading
- Reduce Dead Volume in System**
 - Follow manufacturer's recommended installation instructions
 - Eliminate any leaks
 - Optimize detector flows

Non-reproducible Retention Times

Possible Cause:	Suggested Remedy:
SYSTEM	
Leaks	Check injector for leaks; make sure column is properly installed in detector.
Erratic flow controller	Verify flows. Fix/replace flow controller if necessary.
Unstable oven temperature	Calibrate oven; possibly replace thermocouple.
Pneumatic temperature change	Redirect oven exhaust; regulate room temperature.
Line pressure change	Install dual stage regulator.
Injection technique	Standardize a reproducible injection technique.
COLUMN	
Polarity changing from contamination	Cut 50-100 cm from injector side of column; perform an extended conditioning step; solvent rinse column; use glass wool in liner or decrease injection temperature; or replace column.
Adsorption	Increase final temperature in program with hold time; remove 50-100 cm from injector side of column.
SAMPLE	
Concentration solute/stationary phase insolubility	Use retention gap; change column phase.



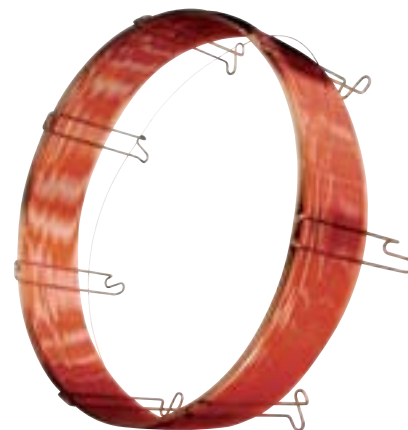
WANT TO LEARN MORE?

Contact Phenomenex
to get your FREE copy of our
GC Troubleshooting Guide

ORDERING INFORMATION

ZEBRON INFERNO GC COLUMNS

- Temperature Limits: -60 to 400/430 °C (Isothermal/TPGC)**
- Individually tested for low bleed, MS certified
- Rugged high temperature, polyimide coated, fused silica tubing
- Provides true boiling point separation for hydrocarbon distillation methods
- Low activity, provides good peak shape for acidic and basic samples
- Provides robust column performance for high temperature bake outs



Applications

- High boiling petroleum products
- Simulated distillation methods
- Long-chained hydrocarbons
- Polymers / Plastics
- High molecular weight waxes
- Diesel fuel
- Motor oils
- Triglycerides*
- Surfactants*

*ZB-5HT Inferno recommended for these applications

Specifications

ZB-1HT:	USP phase G2
ZB-5HT:	USP phase G27
Available lengths (meter):	15, 20, 30
Internal diameters (mm):	0.18, 0.25, 0.32, 0.53
Film thickness (µm):	0.10, 0.15, 0.18, 0.25
Guard Column:	Available with Guardian™ integrated guard columns

**0.53 mm ID columns are rated to 400 °C max operational temperature

ZB-1HT INFERNO™

100 % Dimethylpolysiloxane

ID (mm)	df (µm)	Temp. Limits °C	Part No.	Price
15-Meter				
0.25	0.10	-60 to 400/430	7EG-G014-02	\$ 325
0.32	0.10	-60 to 400/430	7EM-G014-02	350
0.32	0.25	-60 to 400/430	7EM-G014-11	350
0.53	0.15	-60 to 400	7EK-G014-05	350
20-Meter				
0.18	0.18	-60 to 400/430	7FD-G014-08	460
30-Meter				
0.25	0.10	-60 to 400/430	7HG-G014-02	530
0.25	0.25	-60 to 400/430	7HG-G014-11	530
0.32	0.10	-60 to 400/430	7HM-G014-02	570
0.32	0.25	-60 to 400/430	7HM-G014-11	570
0.53	0.15	-60 to 400	7HK-G014-05	625

ZB-5HT INFERNO™

5 %-Phenyl-95 %-Dimethylpolysiloxane

ID (mm)	df (µm)	Temp. Limits °C	Part No.	Price
15-Meter				
0.25	0.10	-60 to 400/430	7EG-G015-02	\$ 325
0.32	0.10	-60 to 400/430	7EM-G015-02	350
0.32	0.25	-60 to 400/430	7EM-G015-11	350
0.53	0.15	-60 to 400	7EK-G015-05	350
20-Meter				
0.18	0.18	-60 to 400/430	7FD-G015-08	460
30-Meter				
0.25	0.10	-60 to 400/430	7HG-G015-02	530
0.25	0.25	-60 to 400/430	7HG-G015-11	530
0.32	0.10	-60 to 400/430	7HM-G015-02	570
0.32	0.25	-60 to 400/430	7HM-G015-11	570
0.53	0.15	-60 to 400	7HK-G015-05	625

ORDERING INFORMATION

HT Z-GUARDS

- Individually QC tested to ensure the highest level of quality
- Extend column lifetime
- Improve separation and peak shapes (especially early elutors)
- Improve sensitivity and accuracy of quantitative results
- Available as individual guard columns or as complete kits with connectors

High Temperature Guard Columns

ID (mm)	Description	5-Meter		10-Meter	
		Part No.	Price	Part No.	Price
0.25	Guard Column	7AG-G000-00-GHO	\$ 95	7CG-G000-00-GHO	\$ 165
	Guard Column Kit	7AG-G000-00-GHK	140	7CG-G000-00-GHK	210
0.32	Guard Column	7AM-G000-00-GHO	110	7CM-G000-00-GHO	190
	Guard Column Kit	7AM-G000-00-GHK	150	7CM-G000-00-GHK	230
0.53	Guard Column	7AK-G000-00-GHO	145	7CK-G000-00-GHO	253
	Guard Column Kit	7AK-G000-00-GHK	190	7CK-G000-00-GHK	299

Z-Guard Column Kits include 5 or 10 meters of deactivated fused silica tubing, 5 universal connectors and 0.5 mL of high-temperature polyimide resin.

GUARDIAN™: INTEGRATED GUARD COLUMNS

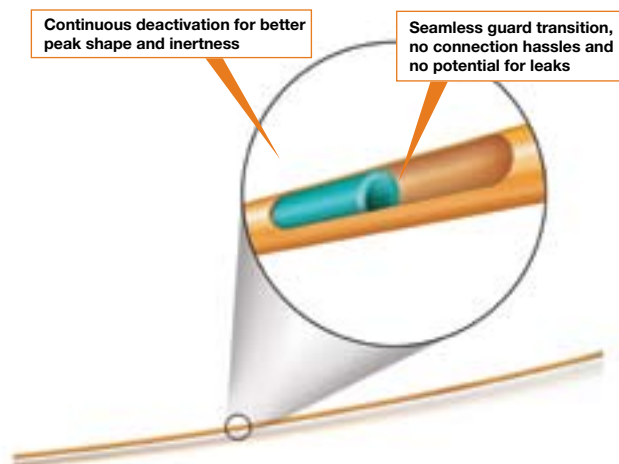
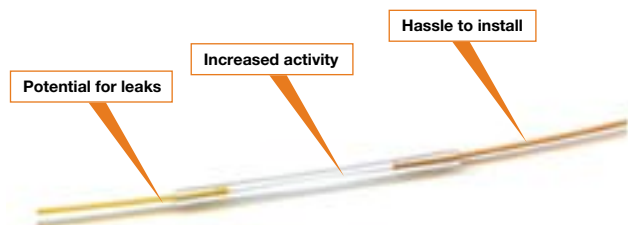
- Eliminates the potential for leaks
- Extends column life
- Improves analyte focusing for low boiling compounds
- Aggressively tested to ensure deactivation

GC Phase	Dimensions	5 m Guardian Part No.	Price
Zebron ZB-1HT	30 meter x 0.25 mm x 0.10 df (µm)	7HG-G014-02-GGA	\$ 590
Zebron ZB-5HT	30 meter x 0.25 mm x 0.10 df (µm)	7HG-G015-02-GGA	590

Traditional Union Connected Guard Column

VS.

Guardian Integrated Guard Column



ORDERING INFORMATION

ESSENTIAL ACCESSORIES FOR HIGH TEMPERATURE ANALYSIS



INLET BASE SEALS

- Prevents analyte adsorption
- Improves detection sensitivity
- Improves method reproducibility
- Fits all Agilent 5890/6890 systems

Part No.	Description	Similar to Mfr. No.*	Unit	Price
Standard, single groove for splitless applications, 0.8 mm dia. inlet hole				
AGO-7518	Gold Inlet Base Seal, splitless (single groove), 0.8 mm	18740-20885	2/pk	\$ 65
AGO-7519	Gold Inlet Base Seal, splitless (single groove), 0.8 mm	18740-20885	10/pk	269
High Split Flow, cross groove for split applications, 0.8 mm dia. inlet hole				
AGO-7520	Gold Inlet Base Seal, split (double groove/cross), 0.8 mm	5182-9652	2/pk	69
AGO-7521	Gold Inlet Base Seal, split (double groove/cross), 0.8 mm	5182-9652	10/pk	275
Replacement Inlet Seal Washers				
AGO-7522	Inlet Seal Washers, for Agilent GC injection port	5061-5869	12/pk	30

INJECTION PORT INLET LINERS

- Fit standard instrument manufacturers' inlets
- Popular designs at excellent prices
- Reduce analyte discrimination
- Improve reproducibility and results
- Clean, non-adsorptive/non-reactive surface



Description	GC Model No.	Dimensions ID x L x OD (mm)	Material* (deactivated)	Quartz Wool (Y/N)	Similar to Manufacturer Number **	Part No.	Unit	Price
Agilent Technologies (HP)								
Single Taper Direct Connect with Side Hole (top) 	5880/5980/6890	4 x 78.5 x 6.3	B (y)	N	21055	AGO-7850	5/pk	\$ 215
Single Taper Direct Connect with Side Hole (bottom) 	5880/5980/6890	4 x 78.5 x 6.3	B (y)	N	G1544-80730 20771	AGO-7851	5/pk	245
Split / Splitless Liner with wool 	5880/5890/6890	4 x 78.5 x 6.3	B (y)	Y	—	AGO-8174	5/pk	80
Shimadzu								
Splitless Liner 	9A/16A	3.4 x 139 x 5.0	B (y)	N	20749	AGO-4669	5/pk	139
Thermo Scientific (Finnigan)								
Splitless / Single Taper Liner Trace /Trace 	8000	5 x 105 x 8.0	B (y)	N	45350033	AGO-7852	5/pk	125

* B= Borosilicate; Deactivated = Yes (y) or No (n). ** Similar to but not always an exact equivalent to the original manufacturer's product.

ORDERING INFORMATION

SEPTA

Silicone Rubber Inlet Septa

- Advanced silicone formulations reduce coring and increase septum lifetime
- Enhanced durability and re-sealing capabilities
- Precision formed and cut to exacting specifications
- Reduced needle damage
- General purpose and specialty low bleed, high-temperature septa available

PhenoRed-400

Fire brick red, with a 50 durometer rating, this specially formulated high-temperature, low-bleed silicone rubber septum is designed and conditioned for high sensitivity analysis where the demands for low bleed and heat stability are critical. Say goodbye to ghost peaks! Temperature-rated to 400 °C.

PhenoGreen-400

Long life, high-temperature green septum, rated to 400 °C. GuideRight™ through-hole to guide the needle during injection.



Part No.	Description	Unit	Price
PhenoRed 3/16 in. (9.5 mm) Diameter			
AG0-4690	PhenoRed-400 Injector Septa	50/pk	\$ 69
AG0-4691	PhenoRed-400 Injector Septa	100/pk	125
PhenoRed 7/16 in. (11 mm)			
AG0-4696	PhenoRed-400 Injector Septa	50/pk	\$ 69
AG0-4697	PhenoRed-400 Injector Septa	100/pk	125

GUIDERIGHT™ INJECTION HOLE SEPTA

The GuideRight™ through-hole guides the needle during injection. Septum performance and lifetime increase while downtime due to bent needles or dirty injection ports decreases. Choose from either high-temperature PhenoGreen™ or PhenoRed™, both rated to 400 °C.

Part No.	Description	Unit	Price
PhenoGreen 3/16 in. (9.5 mm) Diameter			
AG0-7874	PhenoGreen™ 400 Injector Septa	50/pk	\$ 65
PhenoGreen 7/16 in. (11 mm) Diameter			
AG0-7875	PhenoGreen™ 400 Injector Septa	50/pk	65
PhenoRed 3/16 in. (9.5 mm) Diameter			
AG0-7916	PhenoRed™ 400 Injector Septa	50/pk	69
PhenoRed 7/16 in. (11 mm) Diameter			
AG0-7917	PhenoRed™ 400 Injector Septa	50/pk	69

LONG FERRULES

Graphite Ferrules

- High-purity graphite significantly reduces ferrule bleed
- Special construction minimizes "flaking"
- Stable to 450 °C - excellent for high temperature use
- Not for use with GC/MS transfer lines



Part No.	Description	Unit	Price
0.4 mm Ferrule ID			
AG0-4698	Graphite Ferrule 1/16 in. to 0.4 mm	10/pk	\$ 35
AG0-4699	Graphite Ferrule 1/16 in. to 0.4 mm	50/pk	129
0.5 mm Ferrule ID			
AG0-4701	Graphite Ferrule 1/16 in. to 0.5 mm	10/pk	35
AG0-4702	Graphite Ferrule 1/16 in. to 0.5 mm	50/pk	129
0.8 mm Ferrule ID			
AG0-4704	Graphite Ferrule 1/16 in. to 0.8 mm	10/pk	35
AG0-4705	Graphite Ferrule 1/16 in. to 0.8 mm	50/pk	129



If Zebron does not provide you with equivalent separations as compared to any other GC column of the same phase and comparable dimensions, send in your comparative data within 45 days and keep the Zebron column for FREE!

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Zebbron™ Inferno™

430 °C Stable

Unsurpassed High Temperature GC Analysis



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