GC Column Selection Guidelines

Zebron™ GC Columns

The Master Resolution Equation

How do you choose a column? Do you reach into a cabinet of mystery columns, look to your favorite 5 % phenyl phase, or borrow one from a colleague? Understanding how column paramaters impact key elements of the master resolution equation will help you quickly make the right column selection for successful separations.

$$R_s = \left[\frac{\sqrt{N}}{4}\right] \times \left[\frac{\alpha - 1}{\alpha}\right] \times \left[\frac{k}{k+1}\right]$$

	Efficiency Term	Selectivity Term	Retention Term
	Column Length Column ID	Column Phase	Column ID Film Thickness
Other considerations:	Carrier Gas Linear Velocity	Temperature	Temperature

Internal Diameter

Column internal diameter (ID) has a major impact on both resolution and sample capacity. Smaller ID columns may actually lead to faster run times, as the narrower ID will increase the column's efficiency, allowing for shorter lengths of column.

Narrow — **Wide**

0.10, 0.18, 0.20 mm

Applications
- Complex samples

Advantages
- Faster run times
- Better resolution

Disadvantages
- Lower sample capacity
- Easily overloaded

Good Starting ID

0.25 mm

0.32, 0.53 mm

Applications
- Dirty samples
- Highly concentrated samples

Advantages
- Increased sample capacity
- Increased sample

Disadvantages
- Decreased efficiency
- May need higher flow rates unsuitable for GC/MS

Film Thickness

Film thickness determines solute retention and plays an important role in column sample capacity. Thin film columns are faster and provide higher resolution, but lower sample capacity. In most instances, choose the thinnest film possible that still provides adequate retention. When working with active samples, a slightly thicker film can significantly improve peak shape.

Thin — **Thick**

0.10, 0.18 µm

Applications
- High boilers
- GC/MS applications

Advantages
- Faster run times
- Higher temp. limits
- Lower bleed
- Higher efficiency

Disadvantages
- Less inert
- Limited retention

Good Starting Film

0.25 µm

0.50 µm or more

Applications
- Low boilers
- Gases, solvents, purgeables, volatiles
- Purity testing

Advantages
- Better inertness
- Higher capacity

Disadvantages
- Slower run times
- Lower temp. limits
- Higher bleed

Length

Longer columns can improve resolution, but will also increase run times. Under isothermal conditions, doubling the column length will double your run time, but will only increase resolution by 41%, but doubles the run time! Choose a column length that balances efficiency with acceptable run times.

Short — **Long**

15 m or less

Applications
- High boilers
- GC/MS applications

Advantages
- Faster run times
- Higher temp. limits
- Lower bleed
- Higher efficiency

Disadvantages
- Less inert
- Limited retention

Good Starting Length

30 m

60 m or more

Applications
- Complex samples with closely eluting peaks
- Low boilers
- Less active samples
- Complex temperature ramps

Advantages
- Better resolution

Disadvantages
- Slow run times

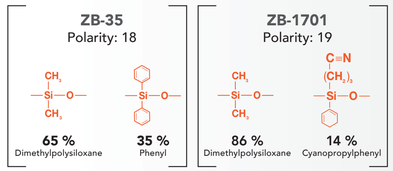
Column Phase

Selectivity Has the Biggest Impact on Resolution

Resolution between two analytes is mainly determined by the selectivity of the stationary phase. By increasing the resolution between two compounds, the total analysis time can often be reduced significantly!

Selectivity vs. Polarity

Polarity provides a general guideline for sample capacity and separation, which can affect peak shape and resolution. However, two columns may have similar polarity but show different separation profiles due to dissimilar phase chemistries. For example, ZB-35 and ZB-1701 are close in polarity, but the cyanopropyl group makes ZB-1701 very different from ZB-35 in terms of selectivity.



Selected Zebron Polarities

See full selection chart on the right

5	ZB-1*PLUS* ZB-1HT Inferno ZB-1XT SimDist
8	ZB-5*PLUS* ZB-5MS ZB-5MS*PLUS* ZB-5HT Inferno ZB-SemiVolatiles
9	ZB-XLB ZB-XLB-HT Inferno
11	ZB-MultiResidue-1
13	ZB-624 ZB-624*PLUS* ZB-MultiResidue-2
18	ZB-35 ZB-35HT Inferno
19	ZB-1701 ZB-1701P
24	ZB-50
52	ZB-WAX*PLUS*
57	ZB-WAX
58	ZB-FFAP

For Non-Polar Analytes
- Alkanes
- Aromatics
- Oils
- Boiling Point separations

For Slightly Polar Analytes
- Volatiles
- Drugs
- Pesticides

For Very Polar Analytes
- Polar Volatiles
- Alcohols
- Phenols
- Acids

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. . . breaking with tradition™

For additional column selection and optimization resources, visit
www.phenomenex.com/GC

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POLARITY	COMPOSITION	TEMP. LIMITS (Isothermal/TPGC)	GC/MS CERTIFIED	USP PHASE	APPLICATIONS	RECOMMENDED USE	FOR ALTERNATE RESULTS
5	**ZB-1** Non-polar phase suited for boiling point separations 100 % Dimethylpolysiloxane	**-60 to 360 / 370 °C** * Thicker films (≥ 1.0 µm) are rated to 340/360 °C	✓	G1, G2, G9, G38	Essential Oils, Ethanol, Gases (Refinery), Hydrocarbons, Mercaptans, MTBE, Natural Gas Odorants, Oxygenates and GROs, PCBs, Simulated Distillation, Solvent Impurities, Light Sulfur Compounds	• Excellent resolving power of critical pairs in complex petrochemical samples • Used for "fingerprinting" and routine quality control analyses (e.g., citrus oils)	Even lower bleed: ZB-1ms High temperatures: ZB-1HT Inferno
5	**ZB-1*PLUS*™** Low bleed phase for non-polar compounds 100 % Dimethylpolysiloxane	**-60 to 360/370 °C**	✓	G1, G2, G9, G38	Acids, Amines, Diesel Fuel, Drugs, Flavors & Fragrances, PCBs (EPA Method 1668), Pesticides	• Especially suited to high sensitivity GC/MS • Improved signal-to-noise ratio for better sensitivity and mass spectral integrity • Extremely inert for active compounds	Simulated distillation: ZB-1XT SimDist Metal High temperatures: ZB-1HT Inferno
5	**ZB-1HT Inferno™** RD 100 High temperature stability up to 430 °C for non-polar compounds 100 % Dimethylpolysiloxane	**-60 to 400/430 °C** * 0.53 mm ID columns are rated to 400 °C	✓	G1, G2, G9, G38	Diesel Fuel, High Boiling Petroleum Products, High Molecular Weight Waxes, Long-chained Hydrocarbons, Motor Oils, Polymers/Plastics, Simulated Distillation	• Rugged, high temperature stable (430 °C) • Robust performance for high temperature bakeouts • True boiling point separation for hydrocarbon distillation methods • Recommended for high boilers, contaminants, or carryovers	Simulated distillation: ZB-1XT SimDist Metal Alternate polarity: ZB-5HT, ZB-35HT, ZB-XLB-HT
5	**ZB-1XT SimDist Metal** Glass Infusion™ metal column technology for efficient, reproducible separations 100 % Dimethylpolysiloxane	**-60 to 450 °C** * Thicker film (2.65 µm) is rated to 400 °C	✓	G1, G2, G9, G38	ASTM Methods (D2887, D2887X, D3710, D6352, D7169), Crude Oil, Gasoline Fractions, Petroleum Distillates, Petroleum Fractions, Simulated Distillation, Vacuum Distillates	• Uniform Glass Infusion coating for sharp peaks and high efficiency • Individually tested for improved reproducibility • 45 – 70 % higher efficiency than other manufacturers • Improved resolution of C50/C52 hour after hour	Fused-silica alternative: ZB-1HT Inferno
8	**ZB-5** Low polarity phase for general purpose use 5 % Phenyl / 95 % Dimethylpolysiloxane	**-60 to 360/370 °C** * Thicker films (≥ 1.0 µm) are rated to 340/360 °C	✓	G27, G36, G41	Alkaloids, Dioxins, Drugs, Essential Oils/Flavors, FAMEs, Halo-hydrocarbons, PCBs/Aroclors, Pesticides/Herbicides, Phenols, Residual Solvents	• Versatile column recommended for a wide range of applications • Great column for unknown samples • Resilient to dirty samples – long column life	Even lower bleed: ZB-5MSi Enhanced aromatic selectivity: ZB-5ms
8	**ZB-5*PLUS*™** Versatile, low bleed, inert 5 % phenyl phase for multi-use applications 5 % Phenyl / 95 % Dimethylpolysiloxane	**-60 to 360/370 °C**	✓	G27, G36, G41	Drugs, EPA Methods, FAMEs, Nitrosamines, Pesticides, Phenols	• Highly inert for improved peak shape of acidic/basic compounds, drugs of abuse, and pesticides • Maximum sensitivity for GC/MS • 5 % phenyl selectivity with improved column-to-column performance	SVOCs, PAHs, or PBDEs: ZB-SemiVolatiles Drugs of abuse: ZB-Drug-1
8	**ZB-5MS*PLUS*™** The next generation of inertness for specialty chemical, forensic, toxicology, and food testing applications 5% Phenyl-Arylene / 95% Dimethylpolysiloxane	**-60 to 325/350 °C**	✓	G27, G36, G41	Acids, Alkaloids, Amines, Drugs, Essential Oils/ Flavours, Halo-hydrocarbons, Phenols, Residual Solvents, Solvent Impurities, Pesticides/ Herbicides	• Specialized deactivation for versatile 5% Phenyl-Arylene selectivity with improved sensitivity • Low bleed (MS Certified) and well-suited to high sensitivity GC/MS and GC/MS/MS work	SVOCs, PAHS, or PBDEs: ZB-SemiVolatiles Alternate phenyl selectivity: ZB-5*PLUS*
8	**ZB-5HT Inferno** RD 100 High temperature stability (up to 430 °C) for high boiling point compounds 5 % Phenyl / 95 % Dimethylpolysiloxane	**-60 to 400/430 °C** * 0.53 mm ID columns are rated to 400 °C	✓	G27, G36, G41	Diesel Fuels, High Boiling Petroleum Products, High Molecular Weight Waxes, Long-chained Hydrocarbons, Motor Oils, Polymers/Plastics, Simulated Distillation, Surfactants, Triglycerides	• Rugged, high temperature stable (430 °C) • Robust performance for high temperature bakeouts • True boiling point separation for hydrocarbon distillation methods • Recommended for high boilers, contaminants, or carryovers	Enhanced PBDEs: ZB-SemiVolatiles Alternate polarity: ZB-5HT, ZB-35HT, ZB-XLB-HT
8	**ZB-5ms** General purpose 5 % phenyl-arylene phase with enhanced selectivity for aromatics 5 % Phenyl-Arylene / 95% Dimethylpolysiloxane	**-60 to 325/350 °C**	✓	G27, G36, G41	Acids, Alkaloids, Amines, Dioxins, Drugs, EPA Methods Essential Oils/Flavors, FAMEs, Halo-hydrocarbons, PCBs/Aroclors, Pesticides/Herbicides, Phenols, Residual Solvents, Semi-volatiles, Solvent Impurities	• Most popular starting column for method developers • Arylene Matrix Technology™ (AMT) provides a highly stable arylene phase for enhanced resolution of PAHs and multi-ring aromatic compounds • Suited to high sensitivity work using GC/MS	SVOCs, PAHs, or PBDEs: ZB-SemiVolatiles Alternate phenyl selectivity: ZB-5*PLUS*
8	**ZB-SemiVolatiles** 2015 Innovation Achievement Award 5 % phenyl-arylene phase specifically for improved inertness of acids and amines with Enviro-Inert™ Technology 5 % Phenyl-Arylene / 95% Dimethylpolysiloxane	**-60 to 325/350 °C**	✓	G27, G36, G41	Semi-volatiles (SVOCs), PAHs, PBDEs, EPA Methods (525, 610, 625, 8100, 8270D)	• Popular choice for semi-volatiles, PAHs, and PBDEs • Inert, rugged performance for 5% phenyl-arylene selectivity with Enviro-Inert Technology • Supreme inertness for acids, amines, and other notoriously active compounds • Detect down to ultra-low levels (0.2 ng on-column) and improve critical pair resolution	
9	**ZB-XLB** Low polarity si-arylene phase with extra Low Bleed for sensitive analyses Proprietary	**30 to 340/360 °C** * Thicker films (≥ 1.0 µm) are rated to 320/340 °C	✓		EPA Methods, PCBs, Pesticides/Herbicides	• Low polarity si-arylene column for MS detectors • Alternative selectivity to standard 5-type phases • Used for confirmation of pesticide, PCB, or other environmental samples • Suited for unknown sample screening and identification	Enhanced pesticide testing: ZB-MultiResidue-1 High temperatures: ZB-XLB-HT
9	**ZB-XLB-HT Inferno** High temperature stability up to 400 °C with extra Low Bleed Proprietary	**30 to 400 °C** * Thicker films (≥ 1.0 µm) are rated to 340/360 °C	✓		EPA Methods, PCBs, Pesticides/Herbicides, Unknown Samples	• Non-metal si-arylene low bleed phase stable to 400 °C • Provides alternate selectivity to 5% phenyl phases • Often used for confirmation of pesticides, PCB, or other environmental samples • Robust column performance for high temperature bakeouts	Enhanced pesticide testing: ZB-MultiResidue-1 Alternate polarity: ZB-5HT, ZB-35HT
11	**ZB-MultiResidue™-1** Novel phase designed for pesticides, herbicides, and insecticides Proprietary	**-60 to 320/340 °C**	✓		Aroclors/PCBs, Haloacetic Acids, Insecticides, Multi-Pesticide Screening, Nitrogen Containing Pesticides, Organochlorine Pesticides, Organophosphorous Pesticides	• Specifically designed for optimized pesticide screening and confirmation by GC/ECD • Resolve common isomers with optimized selectivity • Decreased breakdown of sensitive pesticides such as DDT • Exceed EPA Method 8081 specifications when used with ZB-MultiResidue-2 • Our most popular phase for pesticide testing by GC/MS	Dual-column confirmation: ZB-MultiResidue-2 Chlorinated herbicides / HAAs: ZB-XLB and ZB-35 pair or ZB-CLPesticides-1 and 2 pair
13	**ZB-624** Optimized for volatile organic compounds (VOCs) and organic volatile impurities (OVIs) 6 % Cyanopropylphenyl / 94 % Dimethylpolysiloxane	**-20 to 260 °C**		G43	Pharmaceuticals, Residual Solvents, Volatile Organic Compounds (VOCs), EPA Methods (501.3, 502.2, 503.1, 524.2, 601, 602, 624, 8010, 8015, 8020, 8021, 8240, 8260)	• Increased temperature limit speeds run times and re-equilibration • Popular for residual solvent testing (USP Monograph <467>) • Widely used to separate volatile organic flavor and fragrance additives and residual solvents in industrial or pharmaceutical products (OVIs)	G16 phase for residual solvents: ZB-WAX*PLUS* MS certified G43, ZB-624*PLUS* for residual solvents by GC/MS
13	**ZB-624*PLUS*™** The Optimal choice for the analysis of volatile compounds for Environmental, Pharmaceutical, Food, Cannabis and specialty chemicals Proprietary	**-20 to 300/320 °C**	✓	G43	Cannabis, Terpenes, Residual Solvents, Volatile Amines, EPA Method 8260, EPA Method 524, Food, Flavors and Fragrances, Solvent Purity, Alcohols	• Enhanced peak shape with superior deactivation • Increased sensitivity for high boiling solvent • Extremely Low Bleed fro GC-MS • High temperature Stability (300/320 C)	Optimized for volatile organic compounds (VOCs) and organic volatile impurities (OVIs)
15	**ZB-MultiResidue-2** Novel phase designed for pesticides, herbicides, and insecticides Proprietary	**-60 to 320/340 °C**	✓		Aroclors/PCBs, Haloacetic Acids, Insecticides, Multi-Pesticide Screening, Nitrogen Containing Pesticides, Organochlorine Pesticides, Organophosphorous Pesticides	• Specifically designed for optimized pesticide screening and confirmation by GC/ECD,GC/NPD, and GC/MS • Resolve common isomers with optimized selectivity • Decreased breakdown of sensitive pesticides such as DDT • Exceed EPA Method 8081 specifications when used with ZB-MultiResidue-1	Dual-column confirmation: ZB-MultiResidue-1 Chlorinated herbicides / HAAs: ZB-XLB-HT and ZB-35 pair or ZB-CLPesticides-1 and 2 pair
18	**ZB-35** Intermediate polarity for high molecular weight samples and method development screening 35 % Phenyl / 65% Dimethylpolysiloxane	**40 to 340/360 °C**	✓	G28, G32, G42	Amines, Aroclors, Drugs, EPA Methods (508, 608, 8081, 8141, 8151), Pesticides, Pharmaceuticals	• Intermediate polarity for high molecular weight analysis • Minimized analyte adsorption, improved reproducibility • More rugged (longer column life) than other polar phases • Excellent for trace analysis with bleed-sensitive detectors (MS, FID, ECD, NPD)	High temperatures: ZB-35HT
18	**ZB-35HT Inferno** Intermediate polarity with high temperature stability up to 400 °C 35 % Phenyl / 65% Dimethylpolysiloxane	**40 to 400 °C**	✓	G28, G32, G42	Amines, Aroclors, Chemicals, Drugs, EPA Methods (508, 608, 8081, 8141, 8151), Pesticides, Pharmaceuticals, Steroids	• Rugged, high temperature stable (400 °C) • Robust performance for high temperature bakeouts • True boiling point separation for hydrocarbon distillation methods • Recommended for high boilers, contaminants, or carry-overs	Enhanced pesticide testing: ZB-MultiResidue-1 Alternate polarity: ZB-5HT, ZB-XLB-HT
19	**ZB-1701** Alternate selectivity to phenyl phases, with similar polarity 14 % Cyanopropylphenyl/ 86% Dimethylpolysiloxane	**-20 to 280/300 °C** * Thicker films (≥ 1.0 µm) are rated to 260/280 °C		G46	Alcohols, Amines, Aromatic Hydrocarbons, Drugs, Esters, PAHs, PCBs, Pharmaceutical Intermediates, Phenols, Solvents, Steroids, TMS Sugars, Tranquilizers	• Fast run and re-equilibration times for enhanced sample throughput and productivity • Provides alternate selectivity to phenyl phases with similar polarity	Enhanced pesticide testing: ZB-MultiResidue-1 Enhanced Endrin and DDT: ZB-1701P 7 EPA Methods on one pair: ZB-CLPesticides-1 & 2
19	**ZB-1701P** Specifically designed for improved DDT and Endrin response 14 % Cyanopropylphenyl/ 86% Dimethylpolysiloxane	**-20 to 280/300 °C** * Thicker films (≥ 1.0 µm) are rated to 260/280 °C		G46	Aroclors, Nitrogen Containing Pesticides, Organochlorine Pesticides, Organophosphorous Pesticides	• Specially tested to ensure response of DDT, Endrin, Endrin Aldehyde, and Endrin Ketone • Guaranteed column for pesticide analysis • EPA Method 8081 Certified	Enhanced pesticide testing: ZB-MultiResidue-1
24	**ZB-50** High polarity phase with stability for high temperature bakeouts 50 % Phenyl / 50% Dimethylpolysiloxane	**40 to 320/340 °C**	✓	G3, G17	Antidepressants, Aroclors, Cholesterols, Drugs of Abuse, EPA Methods (508, 608, 8081, 8141, 8151), Glycols, Pesticides/ Herbicides, Steroids, Triglycerides	• High polarity column capable of high temperature bakeout to remove contaminants • Inert to minimize analyte adsorption, improve efficiency, and reproducibility • More rugged (longer column life) than other polar phases • Great for toxicology and environmental compounds	Enhanced pesticide testing: ZB-MultiResidue-1 Drug screening: ZB-Drug-1
52	**ZB-WAX*PLUS*™** 100 % aqueous stability with high retention of alcohols and chlorinated solvents 100% Polyethylene Glycol (PEG)	**20 to 250/260 °C** * Thicker films (≥ 1.0 µm) are rated to 230/240 °C		G14, G15, G16, G20, G39, G47	Alcohols, Aldehydes, Aromatics, Essential Oils, Flavors & Fragrances, Free Fatty Acids, Glycols, OVIs, Pharmaceuticals, Solvents / Residual Solvents, Styrene, Xylene Isomers	• Exceptional stability to repeated injections • Extremely inert for acidic compounds • Enhanced selectivity for low boiling solvents; high retention of alcohols and chlorinated solvents • Increased efficiency at 20 °C	G43 phase for residual solvents: ZB-624 Free fatty acids testing: ZB-FFAP
57	**ZB-WAX** Bonded, solvent rinseable phase excellent for complex polar samples 100% Polyethylene Glycol (PEG)	**40 to 250/260 °C**	✓	G14, G15, G16, G20, G39, G47	Alcohols, Aldehydes, Aromatics, Basic Compounds, Essential Oils, Flavors & Fragrances, Glycols, Pharmaceuticals, Solvents, Styrene, Xylene Isomers	• Low activity for amines • Excellent separations of polar complex mixtures; widely used for profiling and "fingerprinting"	Enhanced aqueous stability: ZB-WAX*PLUS* Free fatty acids testing: ZB-FFAP
58	**ZB-FFAP** Excellent peak shape for underivatized acids, organic acids, free fatty acids, and alcohols 100 % Nitroterephthalic Modified Polyethylene Glycol	**40 to 250/260 °C**	✓	G25, G35	Acrylates, Alcohols, Aldehydes, Free Fatty Acids, Ketones, Organic Acids, Phenols, Volatile Free Acids	• Popular choice for food industry method development • High polarity with excellent thermal and chemical stability • Improve peak shape for underivatized acids, organic acids, free fatty acids, and alcohols • Bonded, solvent rinseable nitroterephthalic acid phase	Enhanced aqueous stability: ZB-WAX*PLUS*
PROPRIETARY	**ZB-FAME** The FAST FAME GC column Proprietary High Cyano	**-20 to 280 °C**	✓	G48	Fatty Acid Methyl Ester (FAMEs), cis/trans FAME isomers, Omega 3, Omega 6 FAME	• Fatty acid methyl esters (FAMEs), Cis/trans FAME isomers	
	ZB-BAC-1 & 2 RD 100 More accurate results for blood alcohols and post-mortem samples Proprietary	**-20 to 260/280 °C**	✓		Abused Inhalant Anesthetics, Blood Alcohol Analysis	• Enhance resolution of ethanol and acetone peaks • Resolve t-butanol and n-propanol for greater selection of internal standards • 2 min run time with baseline resolution of key components • Dual-column confirmation with two elution order changes	Drugs of abuse: ZB-Drug-1
	ZB-Bioethanol Fast and accurate bioethanol separations Proprietary	**-60 to 340/360 °C**	✓		Alcohols, Ethanol Testing, Fusel Alcohols	• Meet ASTM D5501 requirements – resolve methanol and ethanol from all other denaturant peaks • Great resolution of fusel alcohols • Allows for quick bakeout between runs to eliminate contaminants	Biodiesel testing: ZB-1HT or ZB-5HT
	ZB-CLPesticides-1 & 2 RD 100 Optimized chlorinated pesticide phases for dual-column methods on one column set Proprietary	**40 to 320/340 °C**			Dual-column chlorinated pesticide EPA Methods (8081 and 8081 extended, 8082, 8151, 504, 505, 508, 552)	• Guaranteed alternative to Restek® Rtx®-CLPesticides • Optimized, versatile selectivity for chlorinated pesticides and herbicides • Well-suited for dual-column configurations using GC/ECD • Run EPA Methods 8081 and 8081 extended, 8082, 8151, 504, 505, 508, and 552 on without changing columns – save time	Pesticide screens and enhanced pesticide testing: ZB-MultiResidue-1 & 2 pair
	ZB-Drug-1 Optimized for drugs of abuse separations with resolution of target analytes and interferences Proprietary	**40 to 320/340 °C**	✓		Drug Screening (6-MAM, Amphetamines, Barbiturates, Benzodiazepines, Opiates, PCP, THC)	• Specially deactivated to improve inertness, peak shape, and quantitation for drug compounds • Improve resolution of analytes from matrix interferences • Run amphetamines in under 6 minutes and opiates in under 5 minutes	GC/MS pesticide screen: ZB-MultiResidue-1 & 2