Organic Size Exclusion/Gel Permeation for Polymer Analysis

- **5 and 10 µm particle sizes**
- **Narrow bore (4.6 mm ID) solvent-saver to preparative columns available**
- **Alternative to Agilent® (Polymer Labs) PLgel™, Waters® Styragel® and Ultrastyragel™, and other columns (see p. 320)**
- **Highly cross-linked for mechanical and chemical stability**
- **Temperature stable to 140 °C**

Phenogel is available in seven different pore sizes, ranging from 50 Å to 10^6 Å†, and a linear bed configuration. Pore size distribution and pore volume are closely controlled parameters in the manufacturing process accounting for the high resolution, tight linear calibration curves, and excellent column-to-column reproducibility.

Sample Elution

Each standard dimension Phenogel column (300 x 7.8 mm) has an internal volume of 15 mL that is distributed as follows:

- 3 mL is occupied by the solid portions of the gel particles (20 % of total column volume)
- 6 mL is the pore volume of the packing material (40 % of total column volume)
- 6 mL is the interstitial volume or volume between the gel particles (40 % of total column volume)

Thus, about 6 mL of solvent must elute through each column before even the largest molecules can emerge, while the smallest molecules emerge with the total column volume of 12 mL. This constant distribution of volume makes it possible to predict the amount of solvent and time necessary to complete any analysis.

Technical Specifications

Material:	SDVB
Particle Size:	5, 10 µm
Porosities:	50 Å to 10^6 Å†, and mixed beds
Maximum Pressure:	1500 psi
Maximum Temperature:	140 °C
Minimum Efficiency*:	5 µm: 45,000 p/m** 10 µm: 35,000 p/m**
Typical Flow Rates:	4.6 mm ID: 0.35 mL/min 7.8 mm ID: 1.0 mL/min 21.2 mm ID: 7.0 mL/min

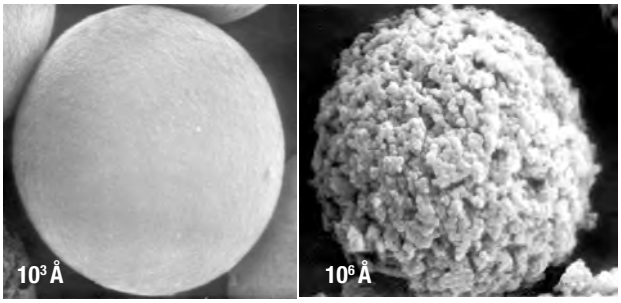
* Tested in THF ** For 300 x 7.8 mm ID columns

† See note on p. 444 regarding pore sizes and exclusion limits

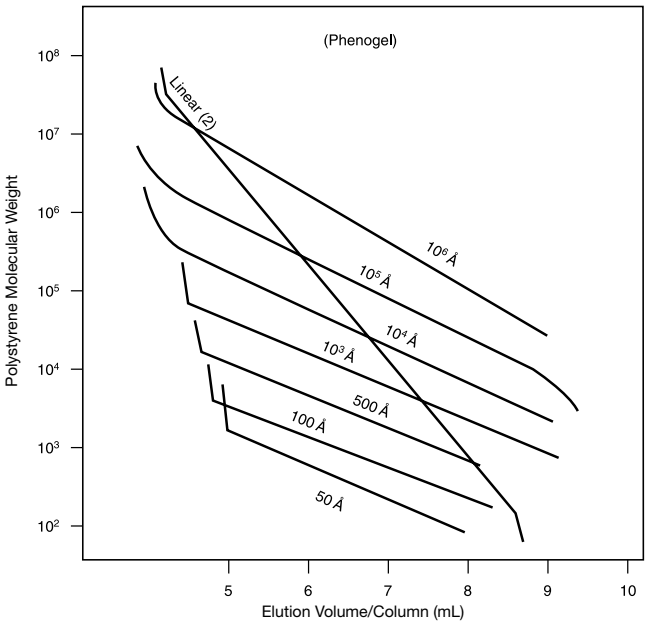
Column Selection by Molecular Weight

Sample Type	Molecular Weight	Phenogel Column
Small Organics	100 - 3 K 500 - 6 K 1 K - 15 K	50 Å 100 Å 500 Å
Resins	1 K - 75 K 5 K - 500 K 10 K - 1,000 K	10^3 Å 10^4 Å 10^5 Å
High MW Polymers	60 K - 10,000 K 100 - 10,000 K	10^6 Å Linear(2)

SEM Photos of Phenogel Polymer Beads



Column Molecular Weight Calibration Curves



Solvent and Temperature Compatibility

- **Phenogel columns are packed in tetrahydrofuran (THF)**
- **Columns can also be shipped in solvents such as DMF and chloroform to help minimize equilibration time**

Solvent Compatibility Table

	Phenogel Pore Size (Å)								
Mobile Phase Solvent	50	100	500	10^3	10^4	10^5	10^6	Linear & Mixed	Suggested Operating Temp.
Acetone	Y	Y	Y	Y				Y	
Benzene	Y	Y	Y	Y	Y	Y	Y	Y	
Carbon Tetrachloride	Y	Y	Y	Y	Y	Y	Y	Y	
Chloroform	Y	Y	Y	Y	Y	Y	Y	Y	
30 % HFIP/Chloroform	Y	Y	Y	Y	Y	Y	Y	Y	
Diethyl Ether	Y	Y	Y	Y	Y	Y	Y	Y	
Dimethylacetamide (DMAC)	Y*	Y	Y	Y	Y	Y	Y	Y	60 °C
Dimethylformamide (DMF)	Y*	Y	Y	Y	Y	Y	Y	Y	60 °C
Dioxane	Y	Y	Y	Y	Y	Y	Y	Y	
DMSO	Y*	Y	Y	Y	Y	Y	Y	Y	60 °C
Ethyl Acetate	Y	Y	Y	Y	Y	Y	Y	Y	
Hexafluoroisopropanol (HFIP)	Y	Y	Y	Y	Y	Y	Y	Y	
Hexane	Y	Y	Y	Y	Y	Y	Y	Y	
M-Cresol	Y*	Y	Y	Y	Y	Y	Y	Y	100 °C
Methyl Ethyl Ketone	Y	Y	Y	Y	Y	Y	Y	Y	
Methylene Chloride	Y	Y	Y	Y	Y	Y	Y	Y	
0-Chlorophenol	Y*	Y	Y	Y	Y	Y	Y	Y	100 °C
0-Dichlorobenzene	Y*	Y	Y	Y	Y	Y	Y	Y	135 °C
Quinolin	Y*	Y	Y	Y	Y	Y	Y	Y	60 °C
Tetrahydrofuran	Y	Y	Y	Y	Y	Y	Y	Y	
Toluene	Y	Y	Y	Y	Y	Y	Y	Y	
Trichlorobenzene	Y*	Y	Y	Y	Y	Y	Y	Y	135 °C
Water	N	N	N	N	N	N	N	N	
Xylene	Y	Y	Y	Y	Y	Y	Y	Y	

*Not recommended on 5 µm 50 Å columns.

N = Not Compatible
Y = Compatible

Solvent Switching Considerations

Although Phenogel columns are rugged and can withstand strong solvent changes, care should be exercised when switching from high-swell solvents (A) to low-swell solvents (B, C, and D). Improper solvent switches can result in a void. Best results are attained when an intermediate-swell solvent is used and column lifetime is improved. Contact Phenomenex regarding solvents not listed below.

Column life can be maximized by dedicating certain columns to certain solvents. This will also minimize solvent switches. If care is not taken, a void may occur.

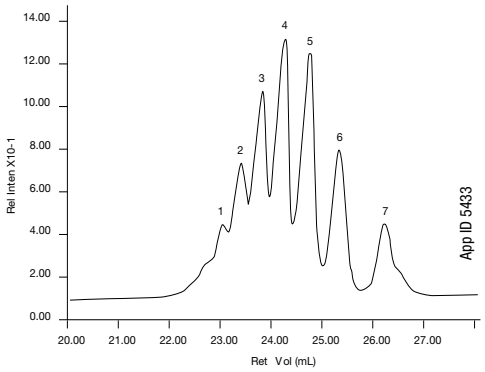
- **Reduce flow rate to 0.2 mL/min**
- **Backpressure must NEVER exceed 1500 psi**
- **Always check solvent miscibility in a beaker or follow the solvent miscibility table on page 442 before proceeding with ANY solvent switch.**
- **Compare the swell characteristics of solvent 1 (old solvent) to solvent 2 (new solvent) and use the following guidelines:**
  - If solvent 1 and solvent 2 belong to the same swell category (see table below), check the solvent miscibility and proceed with the switch.
  - If solvent 1 and solvent 2 belong to successive swell categories as indicated by the arrows in the table below, check the miscibility and proceed with the switch.
  - If solvent 1 and solvent 2 DO NOT belong to the same OR successive swell categories, switch to an intermediate solvent FIRST, as indicated by the arrows in the table.

Pharmaceutical Excipients Analysis

Gel permeation chromatography using Phenogel columns is an excellent method for measuring the molecular weight distribution and lot-to-lot consistency of fillers and dispersants.

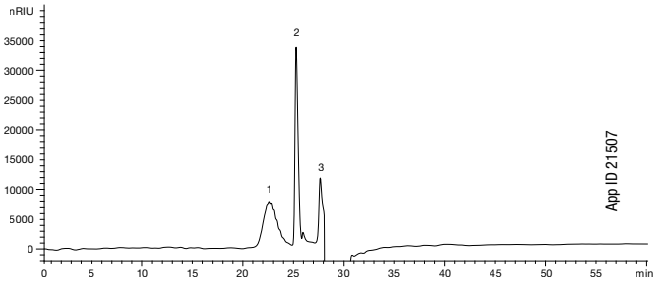
Polyethylene Glycol 330

Column: Phenogel 5 µm 50 Å, 100 Å, 500 Å
Dimensions: 300 x 7.8 mm
Guard Cartridge: AJ0-9292
Guard Holder: KJ0-4282
Solvent: THF
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.25 % w/v
Temperature: Ambient
Vial: AR0-9925-13
Filter: AF0-1102-52
Sample:
1. dp7 546 MW
2. dp6 458 MW
3. dp5 370 MW
4. dp4 282 MW
5. dp3 194 MW
6. dp2 106 MW
7. dp1 62 MW



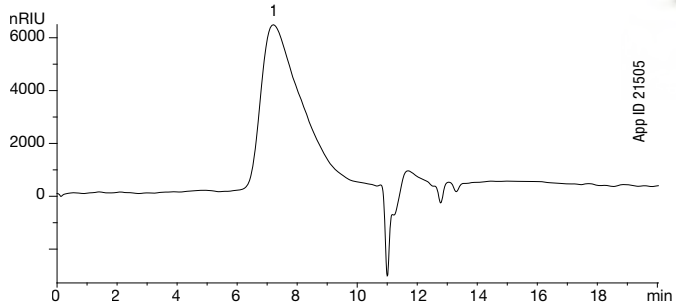
Polyethylene Glycol 106

Column: Phenogel 5 µm 50 Å, 100 Å, 500 Å
Dimensions: 300 x 7.8 mm
Guard Cartridge: AJ0-9292
Guard Holder: KJ0-4282
Mobile Phase: THF
Flow Rate: 1 mL/min
Detection: Refractive Index (RI)
Temperature: 40 °C
Vial: AR0-9925-13
Filter: AF0-1102-52
Sample:
1. PEG 106
2. API peak A (unknown)
3. API peak B (unknown)



Polyvinylpyrrolidone

Column: Phenogel 5 µm Linear(2) x2
Dimensions: 300 x 7.8 mm
Part No: 00H-3259-K0
Guard Cartridge: AJ0-9292
Guard Holder: KJ0-4282
Mobile Phase: 10 mM Lithium bromide in DMF
Flow Rate: 2 mL/min
Detection: Refractive Index (RI)
Column Temp: 40 °C
Vial: AR0-9925-13
Filter: AF0-1102-52
Sample: 1. Polyvinylpyrrolidone (PVP)

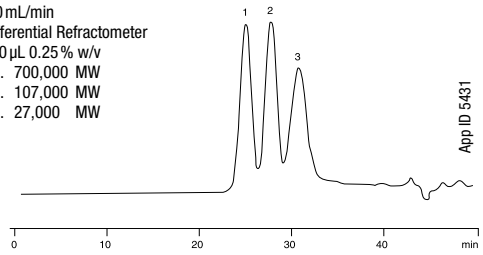


50 Å - 10^6 Å Columns

- **High resolution at low cost**
- **Customize your analysis by coupling different pore-size columns**
- **Wide range of solvent compatibility**

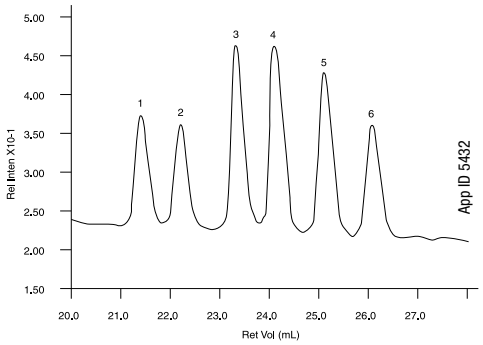
Polymethyl Methacrylates (Wide MW Range)

Column: Phenogel 5 µm 10^5 Å, 10^4 Å, 10^3 Å, 500 Å
Dimensions: 300 x 7.8 mm
Solvent: THF
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.25 % w/v
Sample:
1. 700,000 MW
2. 107,000 MW
3. 27,000 MW



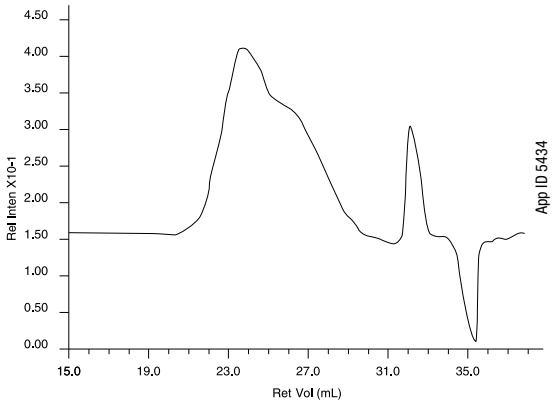
Closely Related Hydrocarbons

Column: Phenogel 5 µm 50 Å, 100 Å, 500 Å
Dimensions: 300 x 7.8 mm
Solvent: THF
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.25 % w/v
Temperature: Ambient
Sample:
1. C40 562 MW
2. C32 450 MW
3. C24 338 MW
4. C20 282 MW
5. C16 226 MW
6. C13 184 MW



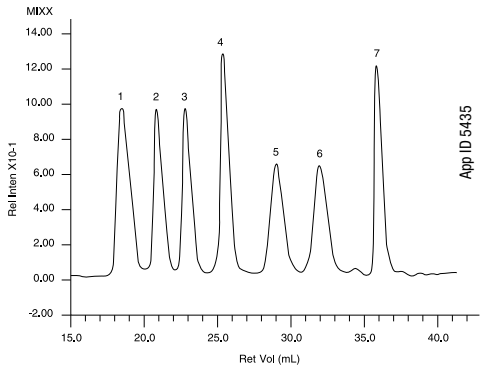
Polyethylene Oxide (PEO)

Column: Phenogel 10 µm 10^5, 10^4, 10^3 Å
Dimensions: 300 x 7.8 mm
Mobile Phase: DMF (0.1 M LiBr)
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.125 % w/v
Temperature: 50 °C
Sample: 400,000 MW



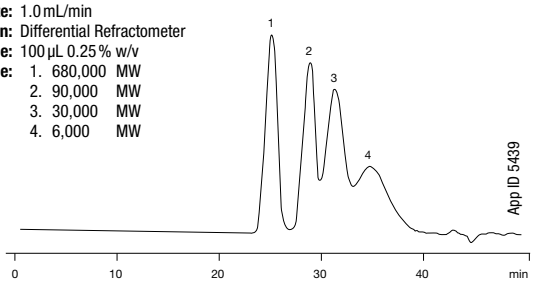
Polystyrenes (Wide MW Range)

Column: Phenogel 10 µm 10^5, 10^4, 10^3 Å
Dimensions: 300 x 7.8 mm
Mobile Phase: THF
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.125 % w/v
Temperature: Ambient
Sample:
1. 1,560,000 MW
2. 260,000 MW
3. 94,000 MW
4. 30,000 MW
5. 6,100 MW
6. 845 MW
7. 146 MW



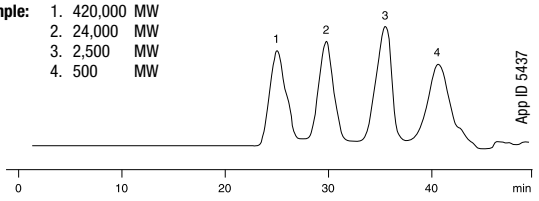
Poly-(α-Methyl Styrene) (Wide MW Range)

Column: Phenogel 5 µm 10^5, 10^4 , 10^3 , 500 Å
Dimensions: 300 x 7.8 mm
Solvent: THF
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.25 % w/v
Sample:
1. 680,000 MW
2. 90,000 MW
3. 30,000 MW
4. 6,000 MW



Polybutadienes (Wide MW Range)

Column: Phenogel 5 µm 10^5, 10^4, 10^3, 500 Å
Dimensions: 300 x 7.8 mm
Solvent: THF
Flow Rate: 1.0 mL/min
Detection: Differential Refractometer
Injection Volume: 100 µL 0.25 % w/v
Sample:
1. 420,000 MW
2. 24,000 MW
3. 2,500 MW
4. 500 MW

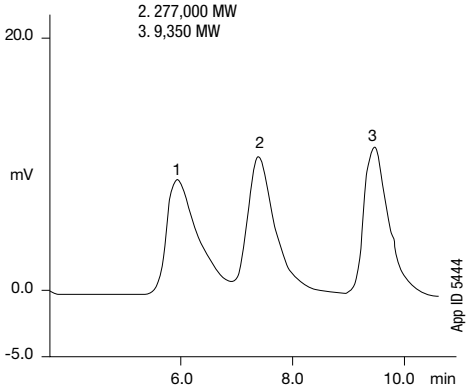


Linear Columns

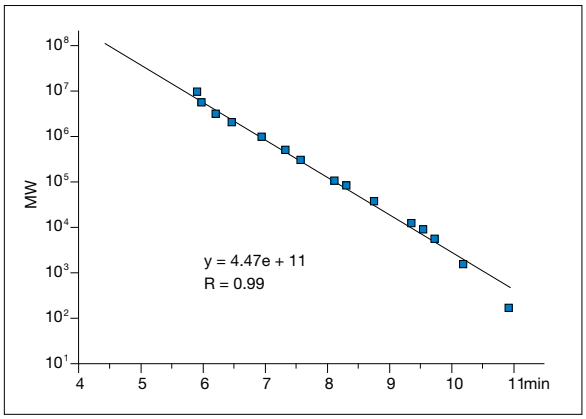
- **Linear calibration to 10 million daltons**
- **Long column lifetime**
- **Excellent mechanical stability**
- **Excellent for analyzing a wide range of molecular weights**

Mixed Polystyrene Standard

Column: Phenogel 5 µm Linear(2)
Dimensions: 300 x 7.8 mm
Part No.: 00H-3259-K0
Guard Cartridge: AJ0-9292
Guard Holder: KJ0-4282
Mobile Phase: THF
Flow Rate: 1.0 mL/min
Detection: RI
Injection Volume: 50 µL
Temperature: 35 °C
Vial: AR0-9925-13
Filter: AF0-1102-52
Sample: Polystyrene standards injected
1. 2,860,000 MW
2. 277,000 MW
3. 9,350 MW



Calibration Curve: Linear (2) - Phenogel 5 µm 300 x 7.8 mm



Narrow Bore Columns

An Improved Dimension in GPC Analysis

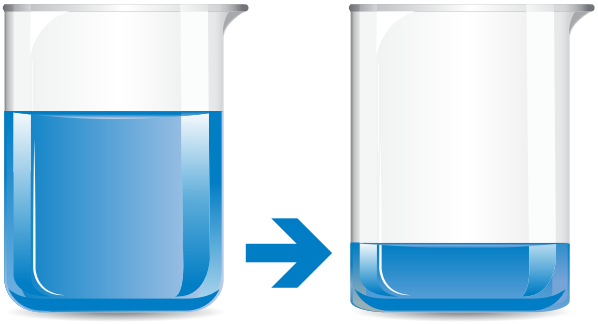
- **Decrease solvent consumption**
- **Retain same elution profile**
- **Reduce solvent disposal costs**

Phenogel-NB (Narrow Bore) columns are optimized to reduce solvent consumption. The Phenogel-NB columns have a 4.6 mm column ID and run at 0.35 mL/min, reducing solvent consumption and disposal costs up to 65 %!

Loading

With narrow bore GPC/SEC columns, the volume in which the sample elutes is significantly decreased, thus increasing the effective concentration of the sample. In GPC, this leads to overloading effects and proportionally lower sample loadings must be used.

Cut Down on Waste!



DISCOVER HOW MUCH YOU WILL SAVE
when switching to Phenogel Narrow Bore columns!
Try our NEW solvent savings calculator web tool at
www.phenomenex.com/GPCSavings

Ordering Information

5 µm Analytical Columns (mm)		Shipping Solvent THF	Chloroform	DMF	Guards	SecurityGuard™ Cartridges (mm)
		300 x 7.8	300 x 7.8	300 x 7.8	50 x 7.8	4 x 3.0*
Pore Size	**MW Range**				ea	/3pk
50 Å	100-3 K	00H-0441-K0	—	00H-0441-K0-DF	03B-2088-K0	AJ0-9292
100 Å	500-6 K	00H-0442-K0	—	—	03B-2088-K0	AJ0-9292
500 Å	1 K-15 K	00H-0443-K0	—	—	03B-2088-K0	AJ0-9292
10^3 Å	1 K-75 K	00H-0444-K0	—	00H-0444-K0-DF	03B-2088-K0	AJ0-9292
10^4 Å	5 K-500 K	00H-0445-K0	00H-0445-K0-CL	—	03B-2088-K0	AJ0-9292
10^5 Å	10 K-1,000 K	00H-0446-K0	—	00H-0446-K0-DF	03B-2088-K0	AJ0-9292
10^6 Å	60 K-10,000 K	00H-0447-K0	—	—	03B-2088-K0	AJ0-9292
		300 x 7.8	300 x 7.8	300 x 7.8	50 x 7.8	4 x 3.0*
Mixed Beds					ea	/3pk
Linear(2)	100-10,000 K	00H-3259-K0	00H-3259-K0-CL	00H-3259-K0-DF	03B-2088-K0	AJ0-9292

for 3.2–8.0 mm ID

5 µm Narrow Bore (NB) Columns (mm)			Guards	SecurityGuard Cartridges (mm)
		300 x 4.6	30 x 4.6	4 x 3.0*
Pore Size	**MW Range**		ea	/3pk
50 Å	100-3 K	00H-0441-E0	03A-2088-E0	AJ0-9292
100 Å	500-6 K	00H-0442-E0	03A-2088-E0	AJ0-9292
500 Å	1 K-15 K	00H-0443-E0	03A-2088-E0	AJ0-9292
10^3 Å	1 K-75 K	00H-0444-E0	03A-2088-E0	AJ0-9292
10^4 Å	5 K-500 K	00H-0445-E0	03A-2088-E0	AJ0-9292
10^5 Å	10 K-1,000 K	00H-0446-E0	03A-2088-E0	AJ0-9292
10^6 Å	60 K-10,000 K	00H-0447-E0	03A-2088-E0	AJ0-9292
		300 x 4.6	30 x 4.6	4 x 3.0*
Mixed Beds			ea	/3pk
Linear(2)	100-10,000 K	00H-3259-E0	03A-2088-E0	AJ0-9292

for 3.2–8.0 mm ID

10 µm Analytical Columns (mm)			Guards	SecurityGuard Cartridges (mm)
		300 x 7.8	50 x 7.8	4 x 3.0*
Pore Size	**MW Range**		ea	/3pk
50 Å	100-3 K	00H-0641-K0	03B-2090-K0	AJ0-9292
100 Å	500-6 K	00H-0642-K0	03B-2090-K0	AJ0-9292
500 Å	1 K-15 K	00H-0643-K0	03B-2090-K0	AJ0-9292
10^3 Å	1 K-75 K	00H-0644-K0	03B-2090-K0	AJ0-9292
10^4 Å	5 K-500 K	00H-0645-K0	03B-2090-K0	AJ0-9292
10^5 Å	10 K-1,000 K	00H-0646-K0	03B-2090-K0	AJ0-9292
10^6 Å	60 K-10,000 K	00H-0647-K0	03B-2090-K0	AJ0-9292
		300 x 7.8	50 x 7.8	4 x 3.0*
Mixed Beds			ea	/3pk
Linear(2)	100-10,000 K	00H-3260-K0	03B-2090-K0	AJ0-9292

for 3.2–8.0 mm ID

5 µm Preparative Columns (mm)			Guards
		300 x 21.2	50 x 21.2
Pore Size	**MW Range**		ea
100 Å	500-6 K	00H-0442-P0	03B-0642-P0

10 µm Preparative Columns (mm)			Guards
		300 x 21.2	50 x 21.2
Pore Size	**MW Range**		ea
100 Å	500-6 K	00H-0642-P0	03B-0642-P0

Guard Cartridge Holder

Part No.	Description
KJ0-4282	Reusable Holder (SecurityGuard Kit)

Column Union

Part No.	Description	Unit
AQ0-8507	Zero Dead Union, SS, with 10-32 fittings	ea

Note: Additional union (AQ0-8507) may be necessary for SecurityGuard to fit in column oven with less than 30 cm length capacity.

Phenogel Columns are a Recommended Alternative to:

Manufacturer	Columns
Agilent® (Polymer Labs)	PLgel™
Jordi Labs	Jordi Resolve™ RP DVB Column Jordi Resolve DVB 13µ GPC Columns Jordi Resolve DVB GPC Column
Polymer Standards Service (PSS)	SDV® GRAM PolarSil PFG POLEFIN®
Shodex®	GPC K-800 Series GPC KF-800 Series GPC KD-800 Series GPC KF-200 Series
Tosoh Bioscience®	TSKgel® Hxl TSKgel Hhr
Waters®	Styragel® Ultrastyragel™ HSPgel™

*SecurityGuard Analytical Cartridges require holder, Part No.: KJ0-4282

For Column Heater, see p. 416

SecurityGuard cartridges for Non-Aqueous Polymer GPC columns are not compatible with HFIP solvent.