

GEL PERMEATION CHROMATOGRAPHY (GPC) COLUMNS AND CONSUMABLES



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INTRODUCTION

Gel Permeation Chromatography (GPC) Columns and Consumables

GPC Columns, Standards, and Reagents

In 1964 John C. Moore, of the Dow Chemical Company, published his work on the preparation of gel permeation chromatography (GPC) and changed how scientists studied synthetic polymers and macromolecules. Shortly thereafter Waters Corporation licensed the technology from Dow to produce the first commercially-available gel permeation chromatograph, the GPC-100. With dedicated, purpose-built instrumentation combined with the innovations from the Dow Chemical Company it was possible for GPC to provide critical information to scientists that was difficult to obtain by other methods.

For over 40 years, Waters has continued to refine the instrumentation, packing materials, and technology to improve GPC and SEC analysis. These innovations allow size-exclusion techniques to expand outside of the original polymer analysis to include applications for separating small and large molecules from interfering matrices, such as those found in foods, pharmaceutical preparations, and natural products.

As a market leader in GPC analysis, Waters provides you with the highest quality GPC products and expert applications support. As a primary manufacturer of chromatographic instrumentation and consumables, all our facilities follow strict ISO, FDA and cGMP guidelines. This is your assurance that Waters will continue to provide you with solutions that will be at the forefront of separation science.

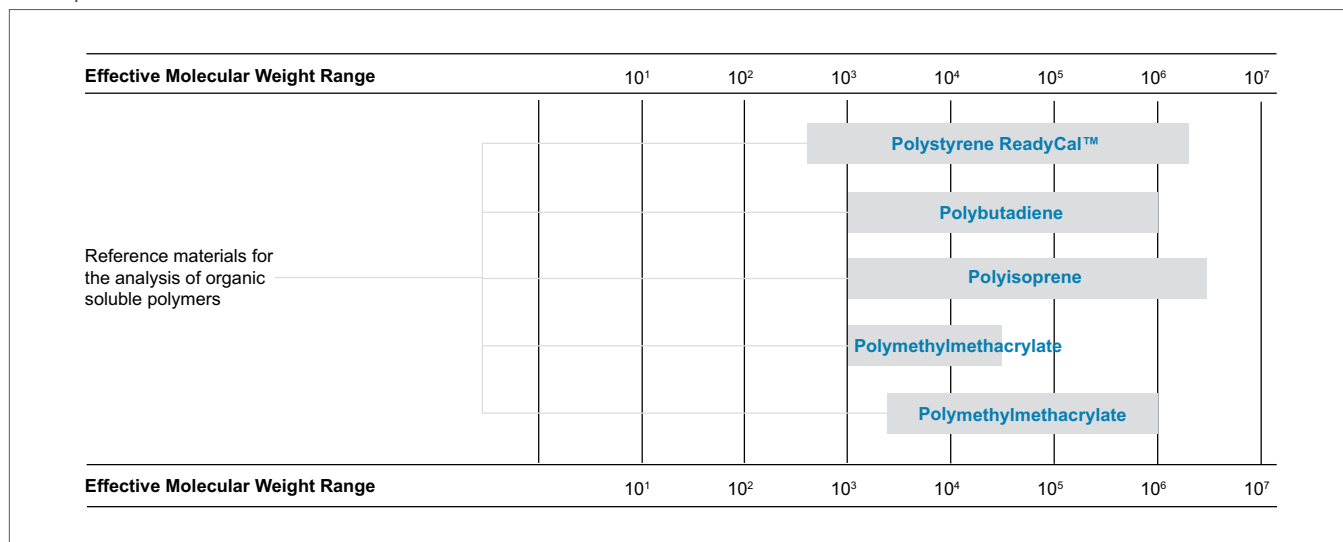
ORGANIC-SOLUBLE POLYMERS

Standards for Non-Aqueous Calibration

Reference Materials for Non-Aqueous Samples

We understand that accurate and reliable data is only achieved using a properly calibrated system. By providing you with well-characterized polymer standards and reference materials we help you to focus on results and maintain your productivity. The polymers used in our reference materials have been specifically manufactured to provide known molecular weight data for a wide range of analysis. Whether your choice is for an individual standard or a cocktail mix, you can count on the traceability of our performance-based reference materials.

Non-Aqueous GPC Standards Guide



ReadyCal Standards

A ReadyCal Kit allows you to quickly and accurately prepare a multi-point calibration curve without the need to weigh chemicals. Each vial contains a polymer mix that spans a molecular weight range to provide baseline resolution of each component. Simply add solvent directly to the vial and mix.

ReadyCal Standards	
Description*	Part No.
Polystyrene ReadyCal Standards 4 mL Kit A complete kit of ready-to-use polystyrene calibration standards. Kit contains thirty, 4 mL autosampler vials which contain four polystyrene standards per vial. There are three separate molecular weight ranges in each kit, ten units of each range. Range is from 400 to 2,000,000 Da.	WAT058930
Polystyrene ReadyCal Standards 2 mL Kit A complete kit of ready-to-use polystyrene calibration standards. Kit contains thirty, 2 mL autosampler vials which contain four polystyrene standards per vial. There are three separate molecular weight ranges in each kit, ten units of each range. Range is from 400 to 2,000,000 Da.	WAT058931

*Values listed are approximate molecular weights.

Polymer Specific Calibration Standards

Tailored specifically for different types of polymer analysis, these conveniently prepared calibration standards provide the analyst a quick and reliable reference to known molecular weight ranges. Polymer type and MW ranges are specified in the product guide on [pages 314-315](#).

Polymer Specific Calibration Standards	
Description*	Part No.
Polybutadiene Standards Kit 0.5 g/vial polybutadiene at each molecular weight: 1000, 3000, 7000, 10,000, 30,000, 70,000, 100,000, 300,000, 700,000, 1,000,000	WAT035709
Polyisoprene Standards Kit 0.5 g/vial polyisoprene at each molecular weight: 1000, 3000, 10,000, 30,000, 70,000, 100,000, 300,000, 500,000, 1,000,000, 3,000,000	WAT035708
Polymethylmethacrylate Low MW Standards Kit 0.5 g/vial polymethylmethacrylate at each molecular weight: 1000, 1700, 2500, 3500, 5000, 7000, 10,000, 13,000, 20,000, 30,000	WAT035707
Polymethylmethacrylate Mid MW Standards Kit 0.5 g/vial polymethylmethacrylate at each molecular weight: 2400, 9500, 31,000, 52,000, 100,000, 170,000, 270,000, 490,000, 730,000, 1,000,000	WAT035706
Polystyrene Low-Mid MW Standards Kit 10 g/vial polystyrene at each molecular weight: 400, 530, 950 5 g/vial polystyrene at each molecular weight: 2800, 6400, 10,000, 17,000, 43,000, 110,000, 180,000	WAT011588
Polystyrene Mid-High MW Standards Kit 5 g/vial polystyrene at each molecular weight: 430,000, 780,000 1 g/vial polystyrene at each molecular weight: 1,300,000, 2,800,000, 3,600,000, 4,300,000, 5,200,000, 6,200,000, 8,400,000, 20,000,000	WAT011610
Polystyrene Low MW Standards Kit 0.5 g/vial polystyrene at each molecular weight: 580, 950, 1,200, 1,800, 2,470, 3,770, 5,100, 7,600, 12,500, 17,000	WAT034208
Polystyrene Mid MW Standards Kit 0.5 g/vial polystyrene at each molecular weight: 1,200, 3,250, 10,200, 28,000, 68,000, 195,000, 490,000, 1,080,000, 1,750,000, 2,750,000	WAT034209
Polystyrene High MW Standards Kit 0.5 g/vial polystyrene at each molecular weight: 45,000, 1,270,000, 2,300,000, 3,260,000, 4,340,000, 8,000,000, 15,000,000	WAT034210

*Values listed are approximate molecular weights.

Individual MW Reference Materials

In many cases a single calibration standard is used to verify a molecular weight component in a sample mixture or extend the range of an existing calibration solution. These individual component standards make molecular weight identification simple and straightforward.

Individual MW Reference Materials			
Description*	Part No.	Description*	Part No.
Polystyrene Standard 400 10 g/vial polystyrene, 400 MW	WAT011590	Polystyrene Standard 430,000 5 g/vial polystyrene, 430,000 MW	WAT011612
Polystyrene Standard 530 10 g/vial polystyrene, 530 MW	WAT011592	Polystyrene Standard 780,000 5 g/vial polystyrene, 780,000 MW	WAT011614
Polystyrene Standard 950 10 g/vial polystyrene, 950 MW	WAT011594	Polystyrene Standard 1,300,000 1 g/vial polystyrene, 1,300,000 MW	WAT011616
Polystyrene Standard 2,800 5 g/vial polystyrene, 2,800 MW	WAT011596	Polystyrene Standard 2,800,000 1 g/vial polystyrene, 2,800,000 MW	WAT011618
Polystyrene Standard 6,400 5 g/vial polystyrene, 6,400 MW	WAT011598	Polystyrene Standard 3,600,000 1 g/vial polystyrene, 3,600,000 MW	WAT011620
Polystyrene Standard 10,100 5 g/vial polystyrene, 10,100 MW	WAT011600	Polystyrene Standard 4,300,000 1 g/vial polystyrene, 4,300,000 MW	WAT011622
Polystyrene Standard 17,000 5 g/vial polystyrene, 17,000 MW	WAT011602	Polystyrene Standard 5,200,000 1 g/vial polystyrene, 5,200,000 MW	WAT011624
Polystyrene Standard 43,000 5 g/vial polystyrene, 43,000 MW	WAT011604	Polystyrene Standard 6,200,000 1 g/vial polystyrene, 6,200,000 MW	WAT011626
Polystyrene Standard 110,000 5 g/vial polystyrene, 110,000 MW	WAT011606	Polystyrene Standard 8,400,000 1 g/vial polystyrene, 8,400,000 MW	WAT011628
Polystyrene Standard 180,000 5 g/vial polystyrene, 180,000 MW	WAT011608	Polystyrene Standard 20,000,000 1 g/vial polystyrene, 20,000,000 MW	WAT011630

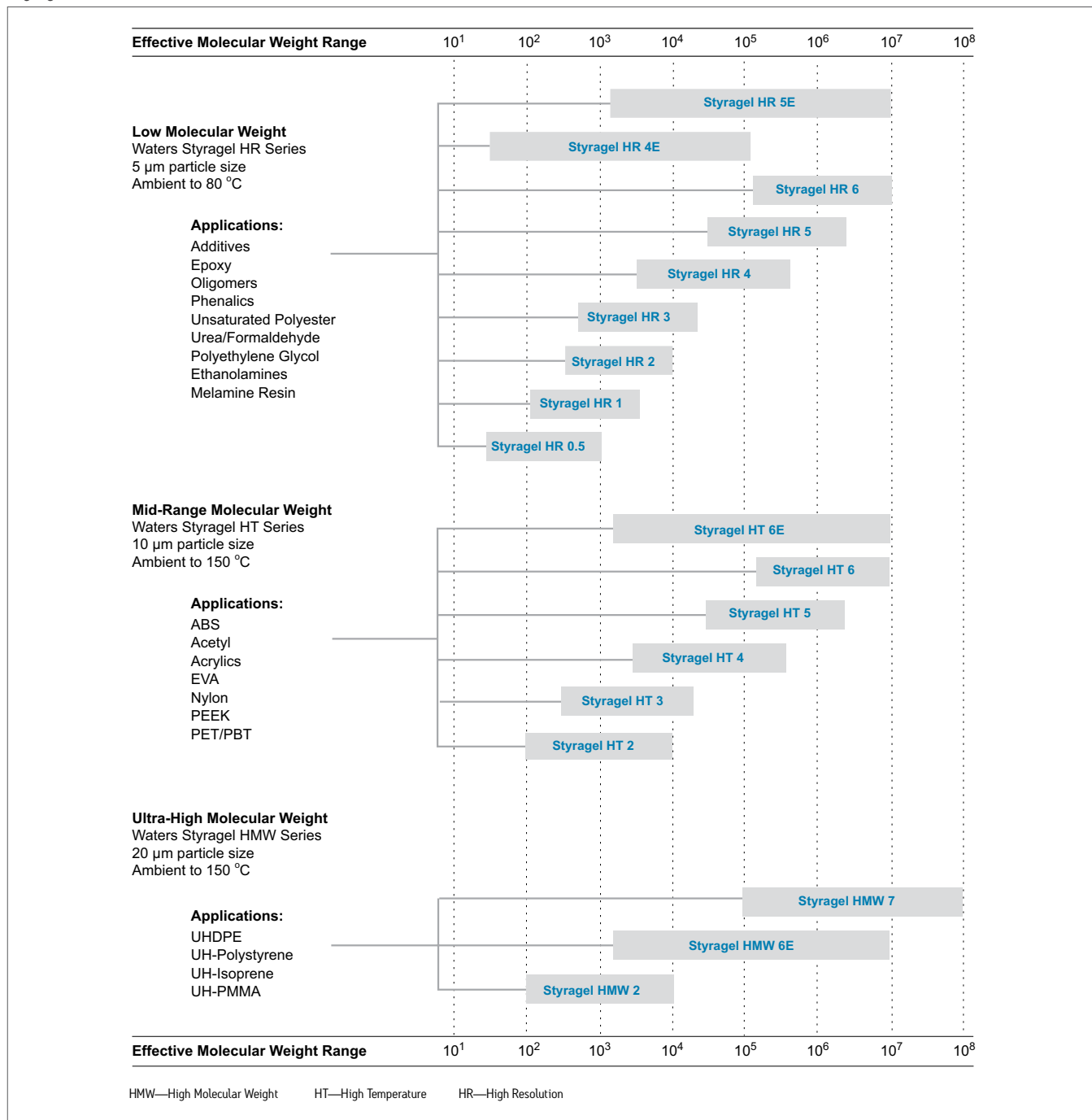
*Values listed are approximate molecular weights.

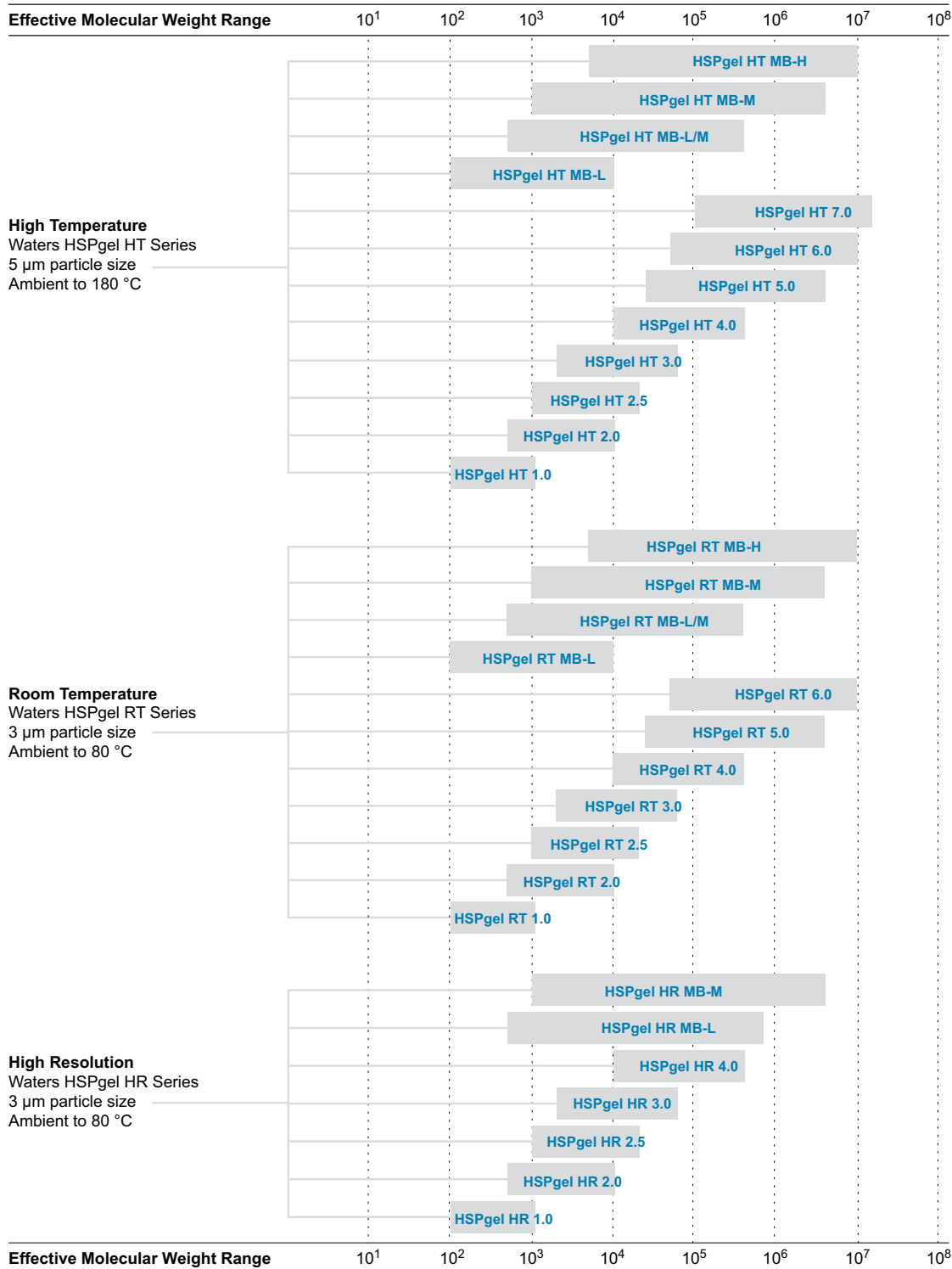
GPC Columns for Non-Aqueous Samples

A GPC Column is selected based on the goals of the separation, which often ranges from one of maximum speed for screening to that of maximum resolution for determining product quality control. Each analysis provides unique challenges for separation. By providing you with a comprehensive selection of GPC Columns, you can be certain that the column or column bank that you choose will be compatible with temperature, solvent, and polymer type.

The following charts may be used to quickly compare the molecular weight ranges for the specified columns. By connecting two or more columns in series, the effective molecular weight range can be extended to provide coverage for more complex sample analysis.

Styragel Columns Selection Guide





*MW ranges for HR and RT are based on polystyrene chain lengths.

HR—High Resolution
RT—Room Temperature

HT—High Temperature
MB—Mixed Bed

L—Low MW Range
M—Medium MW Range

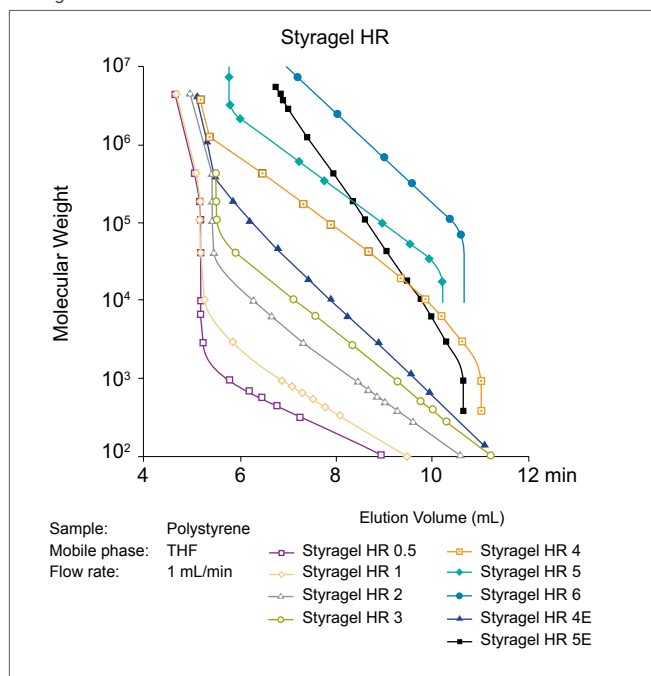
L/M—Low/Medium MW Range
H—High MW Range

Styragel Columns for Polymer Characterization

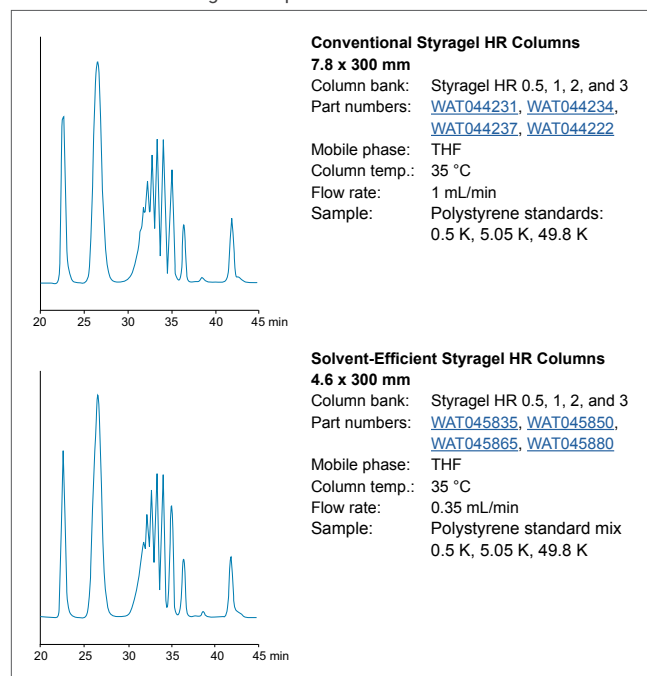
Styragel HR (High-Resolution) Columns

Designed particularly for low molecular weight samples, the Waters Styragel HR Columns are ideal for the analysis of oligomers, epoxies, and polymer additives where high resolution is critical. Packed with rigid 5 μm particles, these columns deliver unrivaled resolution and efficiency in the low-to-mid molecular weight region.

Calibration Curves for the Waters Styragel HR Series of High-Resolution Columns



Styragel HR Columns for Unrivaled Resolution of Low Molecular Weight Samples



Styragel HR Columns (7.8 x 300 mm)

Column	Effective MW Range	Part No. THF	Part No. DMF	Part No. Toluene
Styragel HR 0.5	0–1,000	WAT044231	WAT044232	WAT044230
Styragel HR 1	100–5,000	WAT044234	WAT044235	WAT044233
Styragel HR 2	500–20,000	WAT044237	WAT044238	WAT044236
Styragel HR 3	500–30,000	WAT044222	WAT044223	WAT044221
Styragel HR 4	5,000–600,000	WAT044225	WAT044226	WAT044224
Styragel HR 4E	50–100,000	WAT044240	WAT044241	WAT044239
Styragel HR 5	50,000–4,000,000	WAT054460	WAT054466	WAT054464
Styragel HR 5E	2,000–4,000,000	WAT044228	WAT044229	WAT044227
Styragel HR 6	200,000–10,000,000	WAT054468	WAT054474	WAT054470
Styragel Guard Column 4.6 x 30 mm	—	WAT054405	WAT054415	WAT054410

The 4.6 x 300 mm solvent-efficient Styragel Columns offer the same high resolution performance as our conventional 7.8 x 300 mm Styragel Columns, with the added advantage of reducing solvent consumption by two-thirds.

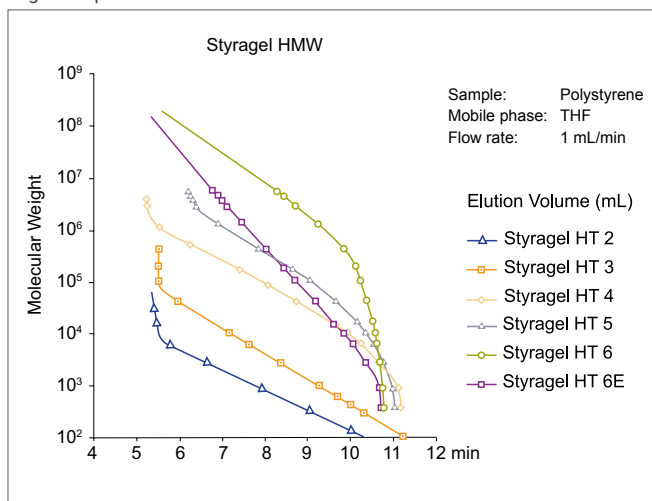
Styragel HR Columns (4.6 x 300 mm)

Column	Effective MW Range	Part No. THF	Part No. DMF	Part No. Toluene
Styragel HR 0.5	0–1,000	WAT045835	WAT045840	WAT045830
Styragel HR 1	100–5,000	WAT045850	WAT045855	WAT045845
Styragel HR 2	500–20,000	WAT045865	WAT045870	WAT045860
Styragel HR 3	500–30,000	WAT045880	WAT045885	WAT045875
Styragel HR 4	5,000–600,000	WAT045895	WAT045900	WAT045890
Styragel HR 4E	50–100,000	WAT045805	WAT045810	WAT045800
Styragel HR 5E	2,000–4,000,000	WAT045820	WAT045825	WAT045815

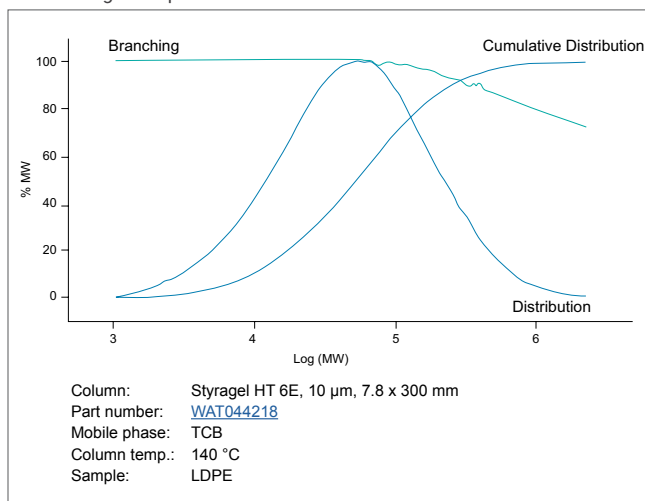
Styragel HT (High-Temperature) Columns

The Styragel HT Columns can be used with aggressive solvents at high temperatures without sacrificing resolution or column lifetime. Packed with rigid 10 µm particles, they have a typical plate count greater than 10,000 plates per column. These columns are extremely durable due to a narrow particle size distribution that results in a very stable column bed. Suitable for both ambient and high-temperature analysis, the Styragel HT Columns offer excellent resolution of polymers in the mid-to-high molecular weight range.

Calibration Curves for the Waters Styragel HT Series of High-Temperature Columns



Styragel HT Columns Deliver Superior Performance—Even at High Temperatures



Styragel HT Columns (7.8 x 300 mm)

Column	Effective MW Range	Part No. THF	Part No. DMF	Part No. Toluene
Styragel HT 2	100–10,000	WAT054475	WAT054480	WAT054476
Styragel HT 3	500–30,000	WAT044207	WAT044208	WAT044206
Styragel HT 4	5,000–600,000	WAT044210	WAT044211	WAT044209
Styragel HT 5	50,000–4,000,000	WAT044213	WAT044214	WAT044212
Styragel HT 6	200,000–10,000,000	WAT044216	WAT044217	WAT044215
Styragel HT 6E	5,000–10,000,000	WAT044219	WAT044220	WAT044218
Styragel Guard Column 4.6 x 30 mm	—	WAT054405	WAT054415	WAT054410

Styragel HT Columns (4.6 x 300 mm)*

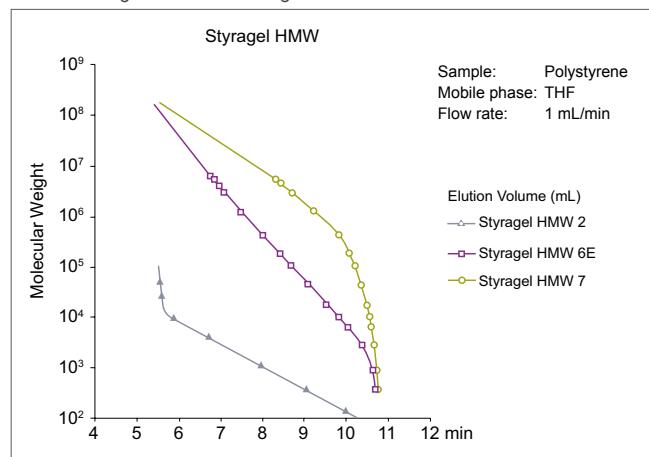
Column	Effective MW Range	Part No. THF	Part No. DMF	Part No. Toluene
Styragel HT 3	500–30,000	WAT045920	WAT045925	WAT045915
Styragel HT 4	5,000–600,000	WAT045935	WAT045940	WAT045930
Styragel HT 5	50,000–4,000,000	WAT045950	WAT045955	WAT045945
Styragel HT 6	200,000–10,000,000	WAT045965	WAT045970	WAT045960
Styragel HT 6E	5,000–10,000,000	WAT045980	WAT045985	WAT045975

*The same high performance as our conventional Styragel HT Columns with the added advantage of reducing your solvent consumption by two-thirds.

Styragel HMW (High-Molecular Weight) Columns

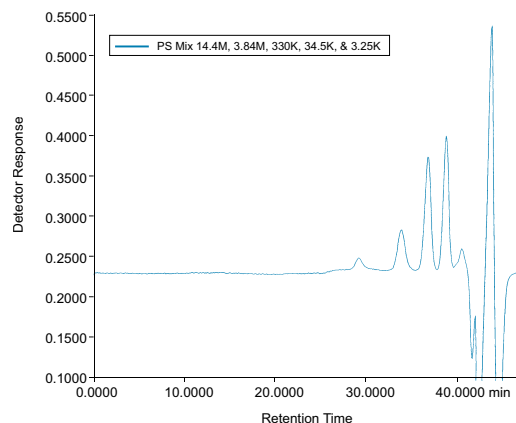
The Styragel HMW Columns were specifically designed for the analysis of ultra-high molecular weight polymers susceptible to shearing. Combining high-porosity 10 µm frits and 20 µm particles, the Styragel HMW Columns minimize polymer shear effects. These state-of-the-art columns can be used at ambient or elevated temperatures, and exhibit excellent column lifetime.

Calibration Curves for Waters Styragel HMW Series of High-Molecular Weight Columns

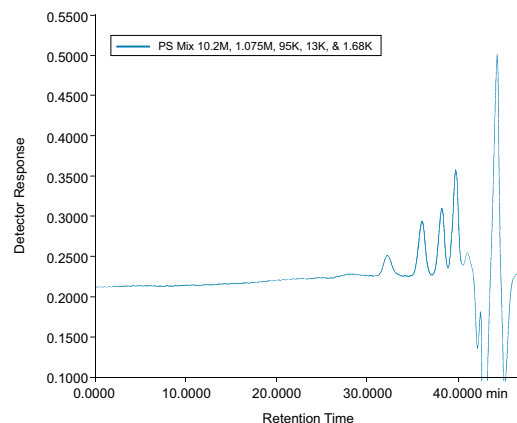


Styragel HMW Columns are Optimized for Analysis of Shear-Sensitive, Ultra-High Molecular Weight Polymers

Column bank: 2 Styragel HMW 7 and 2 Styragel HMW 6E, 15–20 µm
 Part numbers: [WAT044200](#) & [WAT044203](#)
 Column dimensions: 7.8 x 300 mm
 Polystyrene stds.: 14.4 M, 3.84 M, 330 K, 34.5 K, 3.25 K
 Flow rate: 1 mL/min
 Column temp.: 145 °C
 Solvent: TCB



Column bank: 2 Styragel HMW 7 and 2 Styragel HMW 6E, 15–20 µm
 Part numbers: [WAT044200](#) & [WAT044203](#)
 Column dimensions: 7.8 x 300 mm
 Polystyrene stds.: 10.2 M, 1.075 M, 95 K, 13 K, 1.68 K
 Flow rate: 1 mL/min
 Column temp.: 145 °C
 Solvent: TCB



Styragel HMW Columns (7.8 x 300 mm)

Column	Effective MW Range	Part No. THF	Part No. DMF	Part No. Toluene
Styragel HMW 2	100–10,000	WAT054488	WAT054494	WAT054490
Styragel HMW 7	500,000–1 x 10 ⁸	WAT044201	WAT044202	WAT044200
Styragel HMW 6E	5,000–1 x 10 ⁷	WAT044204	WAT044205	WAT044203
Styragel Guard Column 4.6 x 30 mm	—	WAT054405	WAT054415	WAT054410

Styragel HMW Columns (4.6 x 300 mm)*

Column	Effective MW Range	Part No. THF	Part No. DMF	Part No. Toluene
Styragel HMW 7	500,000–1 x 10 ⁸	WAT046805	WAT046810	WAT046800
Styragel HMW 6E	5,000–1 x 10 ⁷	WAT046820	WAT046825	WAT046815

System dead volume must be minimized for maximum column performance.

*The same high performance as our conventional Styragel HMW Columns with the added advantage of reducing your solvent consumption by two-thirds.

Ultrastyrigel Columns

Ultrastyrigel Preparative Columns provide high-efficiency GPC separations for compound isolation and sample cleanup. Closely related to Styragel GPC Columns, the family of Ultrastyrigel Columns provide a two- to three-fold increase in efficiency (plates/meter) that improves separation speed and reduces solvent consumption for preparative isolation. Separations that once required several smaller Styragel Columns can be performed on a single, more efficient Ultrastyrigel Preparative Column.

Ultrastyrigel Columns (19 x 300 mm)				
Pore Size	Effective MW Range	Flow Rate (mL/min)	Part No. Toluene	Part No. THF
100Å	50–1,500	4–10	WAT025866	WAT025859
500Å	100–10,000	4–10	WAT025867	WAT025860
1000Å	200–30,000	4–10	WAT025868	WAT025861
10,000Å	5,000–600,000	4–10	WAT025869	WAT025862
100,000Å	50,000–4,000,000	4–10	WAT025870	WAT025863
1,000,000Å	200,000–10,000,000	4–10	WAT025871	WAT025864
Linear	2,000–4,000,000	4–10	WAT025872	WAT025865

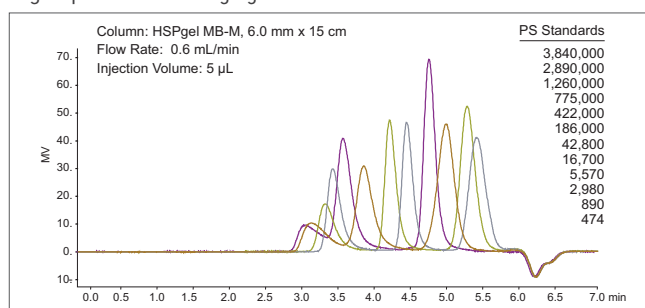
Ultrastyrigel Columns (7.8 mm I.D. x 300 mm)				
Column	Effective MW Range	Pore Size	Part No. THF	Part No. Toluene
Ultrastyrigel	50–1,500	100Å	WAT010570	WAT085500
Ultrastyrigel	100–10,000	500Å	WAT010571	WAT085501

HSPgel Columns for High-Speed GPC Analysis

Waters HSPgel column offering for high-speed GPC analysis, provides accurate and precise molecular weight determination, increased sample throughput, and greatly reduced solvent consumption and disposal. Waters offers a series of 6.0 x 150 mm high-speed GPC Columns.

- HSPgel HR series for high resolution, room temperature GPC
- HSPgel RT series for routine room temperature GPC
- HSPgel HT series for high temperature GPC

High-Speed GPC of Polystyrene Standards



HSPgel HR Series

The HSPgel HR series are designed for high resolution, room temperature, organic polymer GPC. These columns are packed in THF and can be converted once to toluene, methylene chloride, or chloroform.

HSPgel HR Columns				
Column	Solvent	Particle Size	MW Range	Part No.
Ultra-High Resolution GPC*				
HSPgel HR 1.0	THF	3 µm	100–1,000	186001741
HSPgel HR 2.0	THF	3 µm	500–10,000	186001742
HSPgel HR 2.5	THF	3 µm	1,000–20,000	186001743
HSPgel HR 3.0	THF	3 µm	2,000–60,000	186001744
HSPgel HR 4.0	THF	3 µm	10,000–400,000	186001745
HSPgel HR MB-L	THF	3 µm	500–700,000	186001746
HSPgel HR MB-M	THF	3, 5 µm	1,000–4,000,000	186001747

*MW ranges for HR and RT are based on polystyrene chain length

HR—High Resolution MB—Mixed Bed L/M—Low/Medium MW Range
RT—Room Temperature L—Low MW Range H—High MW Range
HT—High Temperature M—Medium MW Range

HSPgel RT Series

The HSPgel RT series are designed for room temperature, routine work of organic polymer GPC. These come packed in THF and can be converted multiple times from THF to toluene, chloroform, methylene chloride, DMF, DMSO, etc.

HSPgel RT Columns				
Column	Solvent	Particle Size	MW Range	Part No.
Room-Temperature GPC*				
HSPgel RT 1.0	THF	3 µm	100–1,000	186001749
HSPgel RT 2.0	THF	3 µm	500–10,000	186001750
HSPgel RT 2.5	THF	3 µm	1,000–20,000	186001751
HSPgel RT 3.0	THF	3 µm	2,000–60,000	186001752
HSPgel RT 4.0	THF	3 µm	10,000–400,000	186001753
HSPgel RT 5.0	THF	3 µm	25,000–4,000,000	186001754
HSPgel RT 6.0	THF	5 µm	50,000–10,000,000	186001755
HSPgel RT MB-L	THF	3 µm	100–10,000	186001757
HSPgel RT MB-L/M	THF	3 µm	500–400,000	186001758
HSPgel RT MB-M	THF	3 µm	1,000–4,000,000	186001759
HSPgel RT MB-H	THF	3, 5 µm	5,000–10,000,000	186001760

*MW ranges for HR and RT are based on polystyrene chain length

HR—High Resolution MB—Mixed Bed L/M—Low/Medium MW Range
 RT—Room Temperature L—Low MW Range H—High MW Range
 HT—High Temperature M—Medium MW Range

HSPgel HT Series

The HSPgel HT series are designed for room temperature to high temperature (180 °C) organic GPC. The columns come shipped in either THF or ODCB. The ODCB packed column should be used for direct conversion to TCB. These columns can withstand multiple solvent switches.

HSPgel HT Columns				
Column	Solvent	Particle Size	MW Range	Part No.
High-Temperature GPC				
HSPgel HT 1.0	THF	5 µm	100–1,000	186001761
HSPgel HT 2.0	THF	5 µm	500–10,000	186001762
HSPgel HT 2.5	THF	5 µm	1,000–20,000	186001763
HSPgel HT 3.0	THF	5 µm	2,000–60,000	186001764
HSPgel HT 4.0	THF	5 µm	10,000–400,000	186001765
HSPgel HT 5.0	THF	5 µm	25,000–4,000,000	186001766
HSPgel HT 6.0	THF	5 µm	50,000–10,000,000	186001767
HSPgel HT 7.0	THF	5 µm	100,000–15,000,000	186001768
HSPgel HT MB-L	THF	5 µm	100–1,000	186001769
HSPgel HT MB-L/M	THF	5 µm	500–400,000	186001770
HSPgel HT MB-M	THF	5 µm	1,000–4,000,000	186001771
HSPgel HT MB-H	THF	5 µm	5,000–10,000,000	186001772
HSPgel HT 1.0	ODCB	5 µm	100–1,000	186001773
HSPgel HT 2.0	ODCB	5 µm	500–10,000	186001774
HSPgel HT 2.5	ODCB	5 µm	1,000–20,000	186001775
HSPgel HT 3.0	ODCB	5 µm	2,000–60,000	186001776
HSPgel HT 4.0	ODCB	5 µm	10,000–400,000	186001777
HSPgel HT 5.0	ODCB	5 µm	25,000–4,000,000	186001778
HSPgel HT 6.0	ODCB	5 µm	50,000–10,000,000	186001779
HSPgel HT 7.0	ODCB	5 µm	100,000–15,000,000	186001780
HSPgel HT MB-L	ODCB	5 µm	100–1,000	186001781
HSPgel HT MB-L/M	ODCB	5 µm	500–400,000	186001782
HSPgel HT MB-M	ODCB	5 µm	1,000–4,000,000	186001783
HSPgel HT MB-H	ODCB	5 µm	5,000–10,000,000	186001784

Shodex GPC Columns

Waters is proud to distribute Shodex GPC Columns and accessories. For over 25 years, Shodex GPC Columns have been used successfully by scientists worldwide. The following selection of highly-reproducible GPC Columns contains styrene divinylbenzene resins.

K-800 Series (8 x 300 mm)

Ultra-high-efficiency columns designed for high-resolution performance. They are available in THF, DMF, or chloroform.

Shodex GPC K-800 Columns (8 x 300 mm)			
Column	Particle Size	Polystyrene Exclusion Limit	Part No.
Shodex KF-800 (THF)			
Shodex KF-801	5 µm	1500	WAT030697
Shodex KF-802	5 µm	5000	WAT030698
Shodex KF-802.5	5 µm	20,000	WAT030699
Shodex KF-803	5 µm	70,000	WAT034100
Shodex KF-804	5 µm	400,000	WAT034101
Shodex KF-805	5 µm	4,000,000	WAT034102
Shodex KF-807	5 µm	200,000,000	WAT034104
Shodex KF-806M (linear)	5 µm	40,000,000	WAT034105
Shodex KF-G Guard (5 µm, 4.6 x 10 mm)	—	—	WAT034106
Shodex K-800 (Chloroform)			
Shodex K-802.5	5 µm	20,000	WAT034109
Shodex K-803	5 µm	70,000	WAT034110
Shodex K-804	5 µm	400,000	WAT034111
Shodex K-805	5 µm	4,000,000	WAT034112
Shodex K-G Guard (5 µm, 4.6 x 10 mm)	—	—	WAT035524
Shodex KD-800 (DMF)			
Shodex KD-801	5 µm	2500	WAT034116
Shodex KD-802	5 µm	5000	WAT034117
Shodex KD-802.5	5 µm	20,000	WAT034118
Shodex KD-803	5 µm	70,000	WAT034119
Shodex KD-804	5 µm	400,000	WAT034120
Shodex KD-806	5 µm	40,000,000	WAT034122
Shodex KD-807	5 µm	200,000,000	WAT034123
Shodex KD-806M (linear)	5 µm	40,000,000	WAT034124
Shodex KD-G Guard (5 µm, 4.6 x 10 mm)	—	—	WAT034125
Shodex KS-800			
Shodex KS-801	7 µm	1000	WAT034276
Shodex KS-802	7 µm	10,000	WAT034277
Shodex KS-804	7 µm	400,000	WAT034279
Shodex KS-800 Guard (7 µm, 4.6 x 10 mm)	—	—	WAT034282

HFIP-800 Series (8 x 300 mm)

These columns have the same high efficiency as the K-series columns but are available in HFIP.

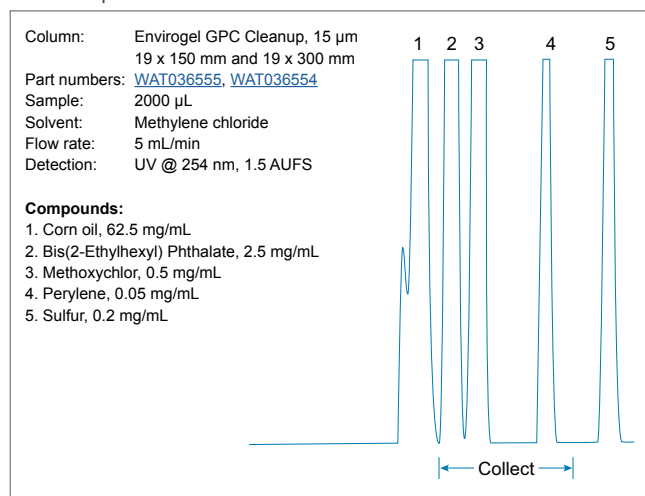
Shodex GPC HFIP-800 Columns (8 x 300 mm)			
Column	Particle Size	Polystyrene Exclusion Limit	Part No.
Shodex HFIP-803	5 µm	70,000	WAT035605
Shodex HFIP-806M (linear)	5 µm	40,000,000	WAT035611
Shodex HFP-LG Guard (8 x 50 mm)	5 µm	—	WAT035612

Envirogel High-Resolution GPC Cleanup Columns

The Envirogel™ High-Efficiency GPC Cleanup Columns are specifically designed to remove low volatility, high-molecular-weight interferences, such as lipids and natural resins, from environmental samples as specified in EPA Method 3640A. In the past, the cleanup procedure for environmental samples was performed on low-efficiency GPC Columns based on packing particle diameters of 37–75 µm (200–400 mesh) Bio-Beads® S-X resins. The high-efficiency Envirogel GPC Cleanup Columns increase the speed of this process while simultaneously reducing solvent consumption.

For optimum capacity and resolution, a 150 mm column is used in series with the 300 mm column. The use of both the 150 mm column and the 300 mm column provides maximum loading capacity while the 300 mm column provides maximum throughput and reduction in solvent consumption when used alone.

Column Optimization



Envirogel High-Resolution GPC Cleanup Columns

Column	Solvent	Dimension	Part No.
Envirogel GPC Cleanup	Methylene Chloride	19 x 150 mm	WAT036555
Envirogel GPC Cleanup	Cyclohexane/Ethyl Acetate	19 x 150 mm	186001915
Envirogel GPC Cleanup	Methylene Chloride	19 x 300 mm	WAT036554
Envirogel GPC Cleanup	Cyclohexane/Ethyl Acetate	19 x 300 mm	186001916
Envirogel GPC Guard	Methylene Chloride	4.6 x 30 mm	186001913
Envirogel GPC Guard	Cyclohexane/Ethyl Acetate	4.6 x 30 mm	186001914

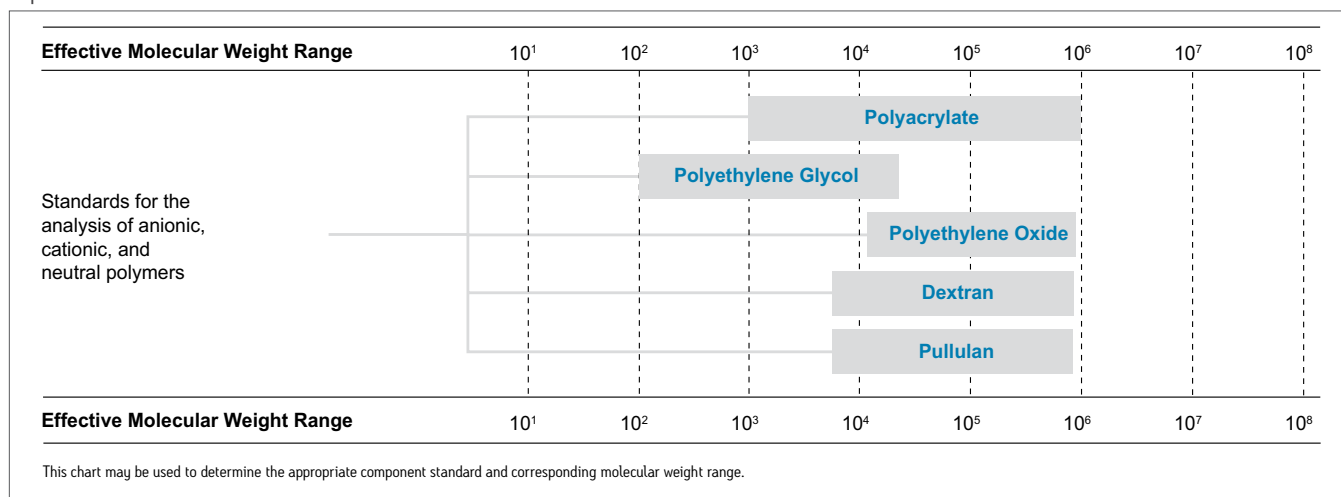
WATER-SOLUBLE POLYMERS AND SMALL MOLECULES

Standards for Aqueous Calibration

Reference Materials for Aqueous Samples

Reliable SEC results depend on the quality of the reference materials used for the molecular weight calibration. Waters SEC Calibration Standards are precisely formulated to provide you with accurate molecular weight reference materials that are conveniently packaged to minimize errors in SEC calibration methods. Our fully traceable aqueous-based polymer reference kits simplify routine calibration procedures that improve your workflow and increase your productivity.

Aqueous SEC Standards Guide



Full-Range Calibration Standards for SEC

These conveniently prepared and prepackaged standards provide you with an accurate calibration range for molecular weight determination of common water soluble polymers. The kits contain a series of well-characterized standards of the specified polymer type and include certificates that list component ranges, and concentrations.



Full-Range Calibration Standards for SEC

Description*	Part No.
Polyacrylic Acid Standards Kit 250 mg/vial polyacrylic acid at each molecular weight: 1000, 3000, 7000, 15,000, 30,000, 70,000, 100,000, 300,000, 700,000, and 1,000,000	WAT035714
Polyethylene Glycol Standards Kit 1.0 g/vial polyethylene glycol at each molecular weight: 100, 200, 400, 600, 1000, 1500, 4300, 7000, 13,000, and 22,000	WAT035711
Polyethylene Oxide Kit 500 mg/vial polyethylene oxide at each molecular weight: 24,000, 40,000, 79,000, 160,000, 340,000, 570,000, and 850,000	WAT011572
Dextrans Standard 500 mg/vial dextrans at each molecular weight: 5000, 12,000, 24,000, 48,000, 148,000, 273,000, 410,000, and 750,000	WAT054392
Pullulan Kit 200 mg/vial pullulan at each molecular weight: 5000, 10,000, 20,000, 50,000, 100,000, 200,000, 400,000, and 800,000	WAT034207

*Values listed are approximate molecular weights.

For a complete line of Biosuite SEC Columns for characterizing large biomolecules, see page 273.

Individual Calibration Standards for SEC

In many cases a single calibration standard is used to verify a molecular weight component in a sample mixture. These individual component standards make molecular weight identification simple and straightforward.

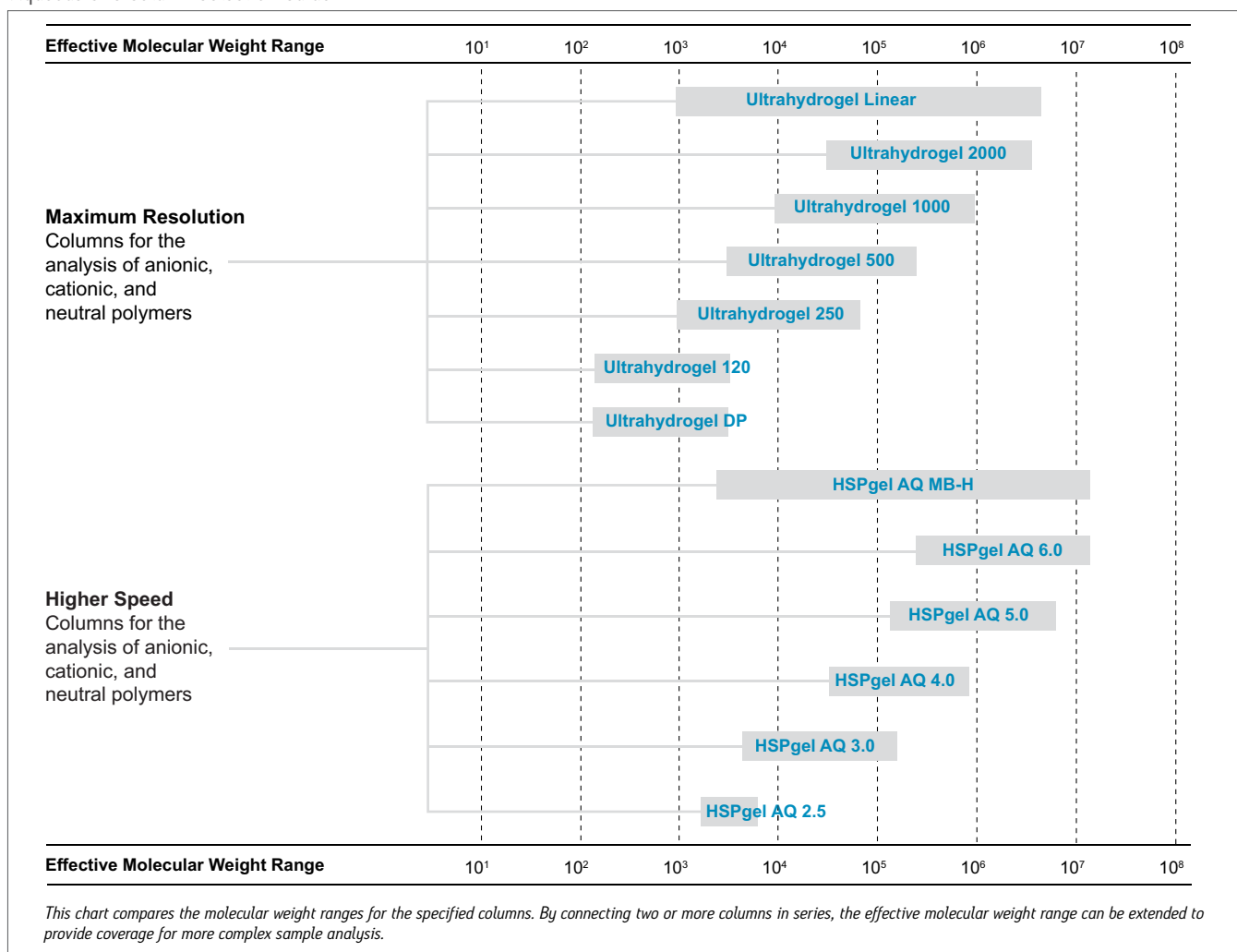
Individual Calibration Standards for SEC			
Description*	Part No.	Description*	Part No.
Polyethylene Oxide Standard 24,000 Polyethylene Oxide, 24,000 MW	WAT011574	Polyethylene Oxide Standard 340,000 Polyethylene Oxide, 340,000 MW	WAT011582
Polyethylene Oxide Standard 40,000 Polyethylene Oxide, 40,000 MW	WAT011576	Polyethylene Oxide Standard 570,000 Polyethylene Oxide, 570,000 MW	WAT011584
Polyethylene Oxide Standard 79,000 Polyethylene Oxide, 79,000 MW	WAT011578	Polyethylene Oxide Standard 850,000 Polyethylene Oxide, 850,000 MW	WAT011586
Polyethylene Oxide Standard 160,000 Polyethylene Oxide, 160,000 MW	WAT011580		

*Values listed are approximate molecular weights.

SEC Columns for Aqueous Samples

Size exclusion chromatography (SEC) and gel filtration chromatography (GFC) are synonymous techniques that are used to separate macromolecules in aqueous environments based on their hydrodynamic volume. Waters SEC Columns allow scientists to efficiently separate cationic, anionic and non-ionic macromolecules under a wide range of physical, chemical, and biological environments. Whether you are choosing a column bank for maximum molecular weight resolution or selecting a column for quick screening, you can count on the stability, lifetime, and performance of a Waters Ultrahydrogel SEC Column or HSPgel SEC Column.

Aqueous SEC Column Selection Guide

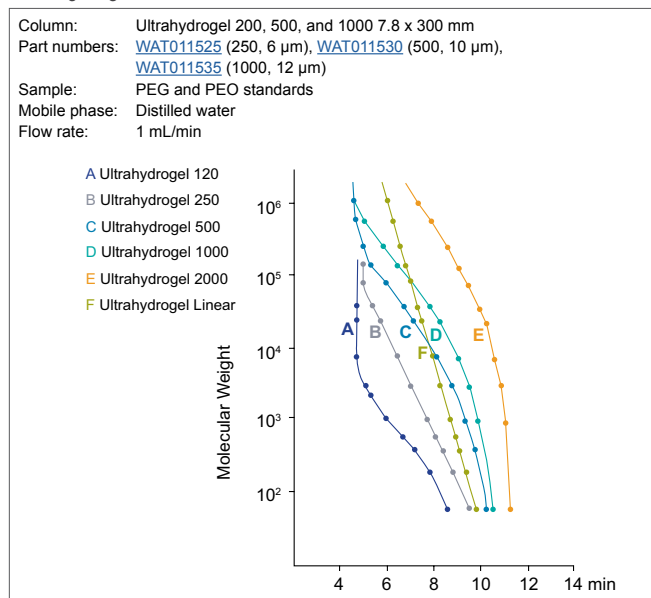


Ultrahydrogel Columns

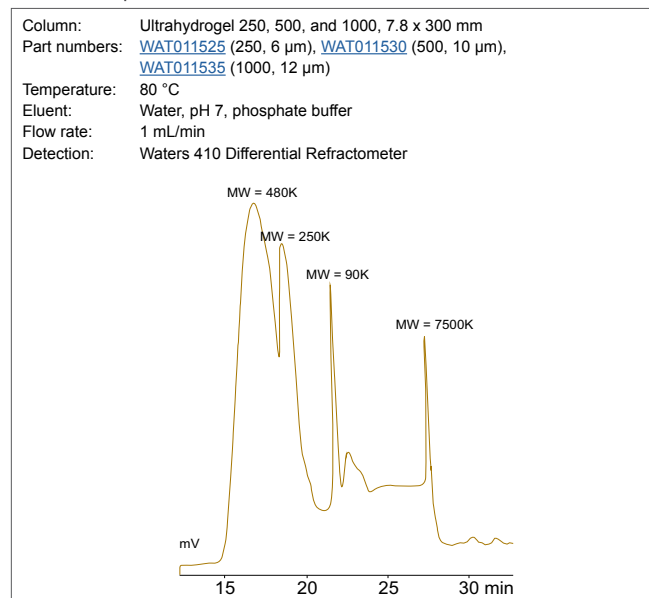
Packed with hydroxylated polymethacrylate-based gel, Waters Ultrahydrogel SEC Columns are ideal for the analysis of aqueous-soluble samples, such as oligomers; oligosaccharides; polysaccharides; and cationic, anionic, and amphoteric polymers. Measuring 7.8 x 300 mm, these high-resolution columns offer many advantages over conventional aqueous SEC Columns, such as:

- Wide-pH range (2–12)
- Compatibility with high concentrations of organic solvents (up to 20% organic, 50% organic if the mobile phase is introduced by gradient)
- Greater flexibility for the mobile phase
- Minimal non-size-exclusion effects

Ultrahydrogel Columns Calibration Curves



Gelatin Sample



Ultrahydrogel Columns (7.8 x 300 mm)*

Column	Particle Size	Pore Size	Exclusion Limit	Part No.
Ultrahydrogel 120	6 µm	120Å	5000	WAT011520
Ultrahydrogel 250	6 µm	250Å	80,000	WAT011525
Ultrahydrogel 500	10 µm	500Å	400,000	WAT011530
Ultrahydrogel 1000	12 µm	1000Å	1,000,000	WAT011535
Ultrahydrogel 2000	12 µm	2000Å	7,000,000	WAT011540
Ultrahydrogel Linear	10 µm	Blend	7,000,000	WAT011545
Ultrahydrogel DP*	6 µm	120Å	5000	WAT011550
Ultrahydrogel Guard Column	6 µm	N/A	N/A	WAT011565
Ultrahydrogel Guard Column DP*	6 µm	N/A	N/A	WAT011570

*DP = Degree of Polymerization, choice of column when working with glucose oligomers.

HSPgel Columns

Waters HSPgel SEC Columns are optimized for high-speed polymer analysis in aqueous solution. HSPgel Columns will reduce solvent consumption, increase throughput, and provide accurate molecular weight data for any room-temperature analysis. The column dimensions are 6.0 x 150 mm.

HSPgel Columns for High-Speed SEC Analysis**

	Solvent	Particle Size	MW Range	Part No.
HSPgel AQ 2.5	Water	4 µm	500–2,000	186001785
HSPgel AQ 3.0	Water	4 µm	1,000–60,000	186001786
HSPgel AQ 4.0	Water	6 µm	10,000–400,000	186001787
HSPgel AQ 5.0	Water	7 µm	50,000–4,000,000	186001788
HSPgel AQ 6.0	Water	9 µm	100,000–10,000,000	186001789
HSPgel AQ MB-H	Water	9 µm	500–10,000,000	186001790

**Exclusion limits for AQ series extrapolated from highest MW PEO standard (~900,000).

SOLVENT CONSIDERATIONS

One of the most important decisions for an analyst is finding a suitable solvent to dissolve the polymer for analysis. This may sound trivial, but remember that GPC is a separation technique based on the size of the polymer in solution. Polymer chains will open up to a certain relaxed conformation in solution, and the solvent chosen will determine what this size will be. Many polymers are soluble at room temperature in various solvents, but in some cases (especially for highly crystalline polymers) high temperature is required for dissolution. The following is a guide for both aqueous and non-aqueous soluble polymers.

Aqueous SEC Solvent Selection Guide

Polymer	Class	Eluent
Polyethylene oxide Polyethylene glycol Polysaccharides, pullulans Dextrans Celluloses (water-soluble) Polyvinyl alcohol Polyacrylamide	Neutral	0.10 M Sodium nitrate
Polyvinyl pyrrolidone	Neutral, hydrophobic	80:20 0.10 M Sodium nitrate/Acetonitrile
Polystyrene sulfonate Lignin sulfonate	Anionic, hydrophobic	
Collagen/gelatin	Amphoteric	
Polyacrylic acid Polyalginic acid/alginate Hyaluronic acid Carrageenan	Anionic	0.10 M Sodium nitrate
DEAE dextran Polyvinylamine	Cationic	0.80 M Sodium nitrate
Polyepiamine	Cationic	0.10% TEA
n-Acetylglucosamine	Cationic	0.10 M TEA/1% Acetic acid
Polyethyleneimine Poly(n-methyl-2-vinyl pyridinium) I salt	Cationic, hydrophobic	0.50 M Sodium acetate/0.50 M Acetic acid
Lysozyme Chitosan	Cationic, hydrophobic	0.50 M Acetic acid/0.30 M Sodium sulfate
Polylysine	Cationic, hydrophobic	5% Ammonium biphosphate/3% Acetonitrile (pH = 4.0)
Peptides	Cationic, hydrophobic	0.10% TFA/40% Acetonitrile

Non-Aqueous GPC Solvent Selection Guide

Polymer	GPC Solvent
Polyisobutylene	Toluene
Polybutylene Chlorinated rubber Polybutadiene Polyisoprene Polydimethylsiloxane	Toluene/75 °C
Chlorinated polyethylene Polyethylene–Ethylacrylate Polyethylene–Vinylacetone Polyethylene–Methacrylic acid Polyphenyleneoxide Poly-4-methylpentene(1) Polyethylene	TCB/135–160 °C
Ultra-high Molecular Weight Polyethylene Polypropylene	TCB/135–160 °C
Polyetheretherketone Polyetherketone	Phenol/TCB 1:1/145 °C
Polycarbonate	Methyl chloride
Polyglycolic acid	gamma-Butyl lactone
Acrylonitrile–Methylmethacrylate Cellulose acetate Cellulose acetate–Butyrate Cellulose acetate–Propionate Cellulose nitrate Cellulose propionate Cellulose triacetate Diallyl phthalate Ethyl cellulose Epoxy Polyester alkyd Polybutene(1) Polybutadiene–Styrene Phenol–Formaldehyde Phenol–Furfural Polymethylmethacrylate Polypropyleneglycol Polystyrene Polysulfone Polyvinylacetate Polyvinylbutyral Polyvinylchloride Polyvinylchloride–Acetate Polyvinylidenechloride Polyvinylformal Polystyrene acrylonitrile Polystyrene–Alphamethylstyrene Polyester thermoset Phenolics Rosin acids Polyglycolic acid	THF/40 °C
Melamine–Formaldehyde Nylon (all types) Polybutylene–Terphthalate Polyethylene–Terphthalate	Hexafluoroisopropanol + 0.075 M Sodium trifluoroacetate/55 °C or m-Cresol + 0.05 m LiBr/100 °C
Poly acrylonitrile ABS (Acrylonitrile–Butadiene–Styrene) ASA (Acrylic–Styrene–Acrylonitrile) ABA (Acrylonitrile–Butadiene–Acrylate) Carboxymethyl cellulose ABS/Polycarbonate Polybutadiene–Acrylonitrile Polyurethane	DMF + 0.05 m LiBr/85 °C
Polyacetal Polyoxymethylene	DMF + 0.05 m LiBr/145 °C
Polyimide Polyamide–imide Polyetherimide Polyethersulfone Polyvinylidene fluoride	N-Methyl pyrrolidone + 0.05 m LiBr/100 °C
Polyfuran–Formaldehyde	Dimethylacetamide/60 °C