
HALO®
HYPER-FAST & SUPER-RUGGED
UHPLC & HPLC COLUMNS
2013 PRODUCT CATALOG


HALO®

Hyper-fast & Super-rugged UHPLC & HPLC columns

The introduction of HALO® columns, developed using innovative Fused-Core® particle technology, has had a dramatic positive effect on liquid chromatography. Stationary phase support particles made with this technology, also referred to as superficially porous particles and core-shell particles, has facilitated the production of a variety of UHPLC and HPLC columns that display the desirable characteristics of extraordinarily high efficiency, low band broadening at high mobile phase flow velocity, relatively low back pressure, and excellent ruggedness and reliability. For those laboratories that possess UHPLC equipment, HALO UHPLC columns provide chromatographers with numerous column choices to optimize their ultra-high speed separations. Plus, HALO UHPLC columns provide a level of ruggedness and reliability not generally found with UHPLC columns packed with totally porous sub-2 µm particles. For laboratories with only legacy HPLC instruments, HALO HPLC columns "super-charge" the performance of those HPLC instruments to near UHPLC levels. Both 2.7 µm HALO UHPLC columns and 5 µm HALO-5 HPLC columns bridge the gap between HPLC and UHPLC by providing exceptional speed and resolution, while operating at relatively modest back pressure.

Advantages of HALO® HPLC & UHPLC columns

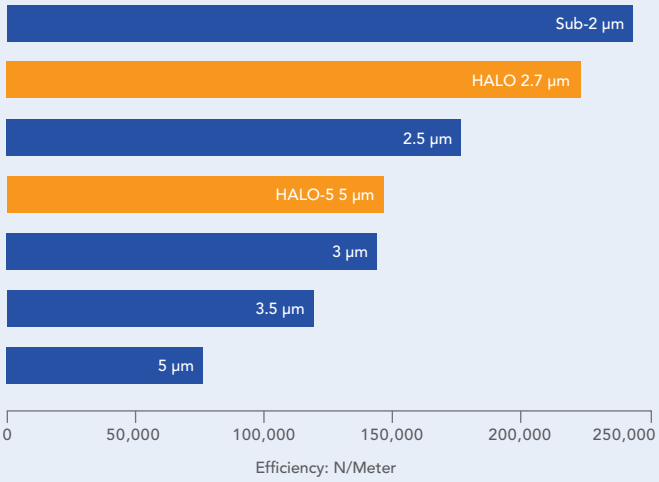
MORE SEPARATING POWER

HPLC and UHPLC columns packed with HALO particles deliver significantly more separating power compared to columns packed with traditional totally porous particles of the same size.

HYPER-FAST SEPARATIONS

The high efficiency of HALO Fused-Core particles permits the use of shorter columns to reduce analysis time without sacrificing resolution. In addition, HALO columns are engineered to excel when operating at high mobile phase velocity. Therefore, short HALO columns operating at high mobile phase velocity can be used to achieve hyper-fast, high-resolution separations.

FIGURE 1: UHPLC and HPLC columns packed with HALO Fused-Core particles deliver significantly more separating power (N/Meter) than columns packed with conventional totally porous particles of similar size.

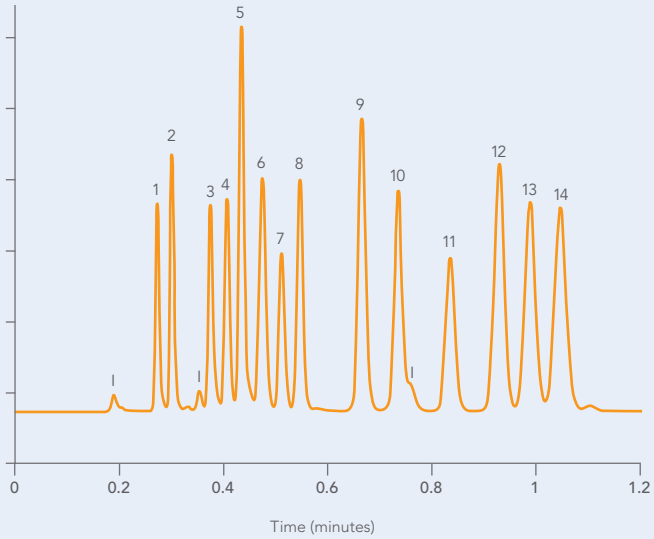


N/meter values were calculated at the optimum mobile phase linear velocity for each of these stationary phases. Extra column dispersion was not considered to be a factor in these calculations.

FIGURE 2: Fast UHPLC separation of a complex mixture

Peak Identities:
1. uracil **2.** benzamide
3. benzonitrile **4.** propyl paraben
5. benzyl benzoate **6.** diethylphthalate
7. toluene **8.** 1-chloro-4-nitrobenzene
9. di-n-propyl-phthalate
10. n-propylbenzene
11. n-butylbenzene
12. biphenyl
13. acenaphthene
14. phenanthrene
I=unknown impurities

Test Conditions:
Column: 4.6 x 50 mm HALO Phenyl-Hexyl
Mobile Phase: 77/23 MeOH/H_2O
Flowrate: 1.8 ml/min
Pressure: 200 bar
Detection: UV at 254 nm
Temperature: 40 °C

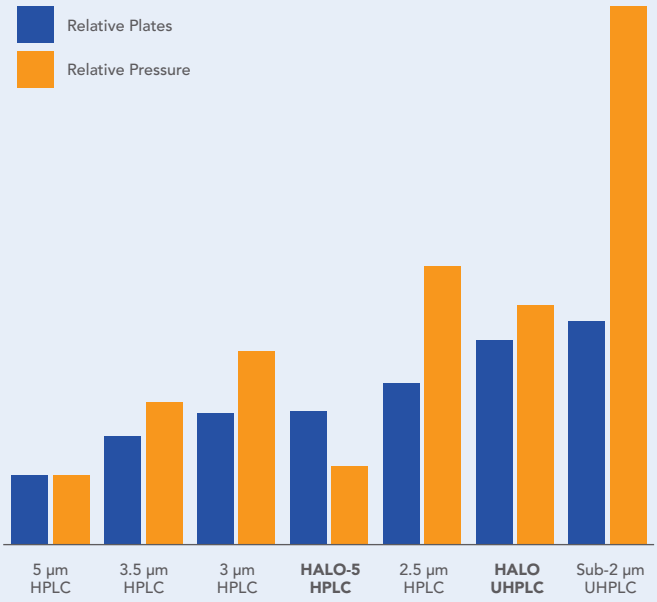


These 14 identified compounds, plus 3 unidentified compounds are separated in less than 72 seconds on a HALO UHPLC column.

HIGHER EFFICIENCY AT MUCH LOWER BACK PRESSURE

Columns packed with HALO particles deliver ~50% higher efficiency (theoretical plates) than what would typically be expected based on their particle size, but the back pressure from HALO columns is what is expected from their particle size. This means that when using HALO columns, you pay a significantly lower price in column back pressure for the same separating power compared to columns packed with traditional totally porous particles. The lower pressure also permits many HALO UHPLC columns to be used on HPLC instruments, significantly simplifying the transfer of methods developed on UHPLC instruments to HPLC instruments.

FIGURE 3: HALO UHPLC and HPLC columns deliver high efficiency at much lower back pressure



This chart shows how back pressure increases as column efficiency increases for columns of the same length packed with different particles. It also shows how back pressure increases at a much faster rate than efficiency. However, this chart also shows two notable exceptions to this common characteristic of columns packed with totally porous particles, the 5 µm HALO-5 HPLC column and the 2.7 µm HALO UHPLC column packed with Fused-Core particles. The HALO columns generate much less pressure than other columns with similar efficiency.

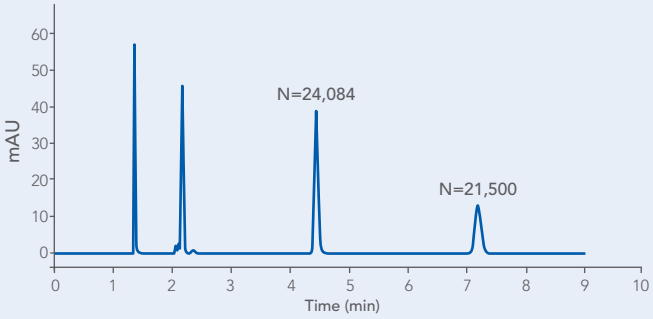
Note: Calculations of Relative Plates and Relative Pressure are made relative to the theoretical plates and back pressure of a column packed with 5 µm totally porous particles.

FIGURE 4: HALO columns provide higher efficiency at lower back pressure

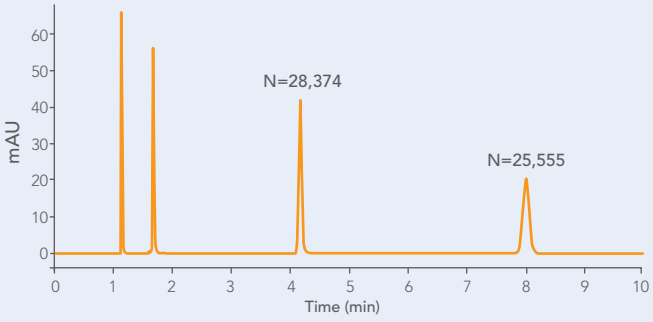
Conditions:
Column: 4.6 x 150 mm, C18
Mobile phase: HALO-5 column = 50% Acetonitrile, 50% Water
3 µm column = 60% Acetonitrile, 40% Water
Flow rate: 1.0 mL/min
Temperature: 30 °C

Peak Identities:
1. Uracil
2. Phenol
3. 1-Cl-4-nitrobenzene
4. Naphthalene

3 µm Totally Porous Column P=140 bar



HALO-5 Column P=78 bar



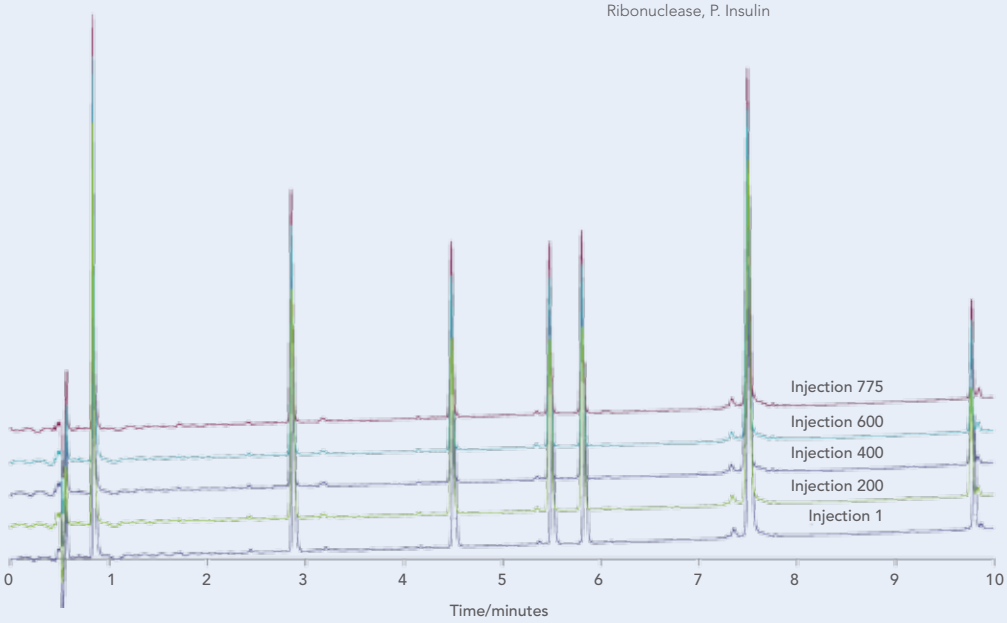
In this comparison, the HALO-5 HPLC column provided over 17% more theoretical plates than a column of the same dimensions packed with 3 µm totally porous particles, but generated less than 60% of the back pressure.

SUPER-RUGGED AND RELIABLE HPLC AND UHPLC SEPARATIONS

The exceptionally small size distribution of HALO Fused-Core particles permits the packing of extremely stable columns and the use of larger porosity inlet frits than what is required with other HPLC and UHPLC columns. HALO columns, therefore, are stable under extremes of flow rate and pressure and are much less prone to column plugging from particulates. This makes HALO columns particularly well suited for applications where consistent, reliable separations are required. In addition, the lower back pressure of HALO columns puts less strain on HPLC and UHPLC systems, leading to less maintenance and more trouble free operation.

FIGURE 5: Stability testing of a HALO column

Column: HALO Peptide ES-C18, 2.1 x 100 mm
Mobile Phase: A: 0.1% TFA; B: 0.1% TFA/70% ACN; Gradient: 9-55% B in 10 min
Flow Rate: 0.5 mL/min
Temperature: 60 °C
Sample: Gly-Tyr, Val-Tyr-Val, Met-enk, Angio II, Leu-enk, Ribonuclease, P. Insulin

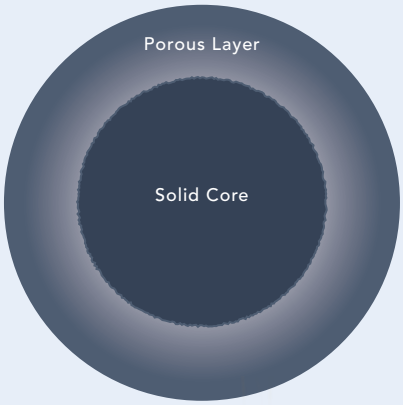


After 775 chromatographic separations, this HALO column continued to maintain its high efficiency and retention times remained unchanged.

HALO® Fused-Core particle technology

Fused-Core particle technology was developed by Jack Kirkland, renowned research scientist and widely recognized as one of the founders of modern liquid chromatography. His goal was to produce UHPLC columns that would provide fast separations and high sample throughput without sacrificing column ruggedness and reliability that generally plague UHPLC columns. As the name implies, Fused-Core particles are manufactured by "fusing" a porous silica layer onto a solid silica sphere.

FIGURE 6: HALO Fused-Core particles



As the name implies, Fused-Core particles are manufactured by "fusing" a porous silica layer onto solid spherical silica particles.

Fused-Core particle technology was first used to generate 2.7 µm silica stationary phases supports. These particles were then bonded with a variety of stationary phases and packed into columns that were commercialized as HALO brand UHPLC columns. The HALO columns packed with 2.7 µm particles deliver the best performance when used with UHPLC instruments, although their relatively low back pressure does permit them to be used with many HPLC instruments.

The success of HALO UHPLC columns led to the development of HALO-5 HPLC columns packed with 5 µm Fused-Core particles. The HALO-5 columns are particularly well suited for use with legacy HPLC instruments, providing high-speed separations at low back pressure.

HALO UHPLC columns and HALO-5 HPLC columns help laboratories bridge the gap between HPLC and UHPLC.

HALO® Stationary Phases

C18

C18 bonded phases are the most widely used stationary phases in HPLC and UHPLC. Their mechanism of separation is primarily hydrophobic binding interaction, which can be successfully utilized to separate a wide variety of sample types. Plus, C18 phases are generally well understood by chromatographers and considered to be stable and reliable. In general, C18 is used to separate analytes differing in hydrophobicity.

BONDED PHASE	Densely bonded octadecyldimethylsilane
ENDCAPPED	Yes
BONDED PHASE COVERAGE	3.5 µmoles/m²
CARBON LOAD	7.7%
PH RANGE	2 to 9
MAXIMUM TEMPERATURE	60 °C

C8

The primary mechanism of separation of C8 bonded phases is hydrophobic binding interaction, as with C18 phases. However, the interactions on C8 phases are weaker than on C18 phases. They are recommended for the same types of analytes as C18 phases, but are generally found to be more useful for mixtures containing both moderately polar and very hydrophobic analytes, since the difference in retention between analytes of widely differing polarity will be much less, often leading to more optimized separations.

BONDED PHASE	Densely bonded octyldimethylsilane
ENDCAPPED	Yes
BONDED PHASE COVERAGE	3.7 µmoles/m²
CARBON LOAD	5.4%
PH RANGE	2 to 9
MAXIMUM TEMPERATURE	60 °C

PHENYL-HEXYL

The Phenyl-Hexyl bonded phase provides multiple mechanisms of separation, including strong π-π and dipole-dipole interaction and moderate hydrophobic binding interaction. It is recommended for the separation of mixtures containing analytes with π bonds and/or different dipole moments. Applications would include substituted aromatic compounds, stereoisomers and steroids, just to name a few. Because of the polarity of the Phenyl-Hexyl phase, it can be used with highly aqueous mobile phases.

BONDED PHASE	Densely bonded phenylhexyldimethylsilane
ENDCAPPED	Yes
BONDED PHASE COVERAGE	3.6 µmoles/m²
CARBON LOAD	7.1%
PH RANGE	2 to 9
MAXIMUM TEMPERATURE	60 °C

RP-AMIDE

Separations on the RP-Amide bonded phase are influenced by both moderately strong hydrophobic binding interaction and hydrogen bonding with the embedded amide group. Analytes with hydrogen bond donor characteristics will likely be more retained on the RP-Amide phase than on the C18 phase. In general, acids will be retained more, bases will be retained slightly less, and neutral analytes will be retained about the same as on a C18 phase.

BONDED PHASE	Densely bonded alkylamidesilane
ENDCAPPED	Yes
BONDED PHASE COVERAGE	3.0 µmoles/m²
CARBON LOAD	8.2%
PH RANGE	2 to 9
MAXIMUM TEMPERATURE	60 °C

PFP

Separations on the PFP phase are primarily influenced by hydrogen bonding and dipole-dipole interactions, although π-π and weak hydrophobic binding interactions often contribute to retention and selectivity. PFP is particularly well suited for the separation of halogenated compounds, nitro-aromatic compounds and polar bases. It is also recommended for separating highly water soluble compounds that require high aqueous mobile phases. When a C18 or C8 phase fails to provide a satisfactory separation due to poor retention or inadequate selectivity, the PFP phase should be considered.

BONDED PHASE	Densely bonded pentafluorophenylpropylsilane
ENDCAPPED	Yes
BONDED PHASE COVERAGE	3.6 µmoles/m²
CARBON LOAD	5.5%
PH RANGE	2 to 9
MAXIMUM TEMPERATURE	60 °C

ES-CN

The ES-CN bonded phase provides strong dipole-dipole interaction and weak hydrophobic binding interaction with analytes. This versatile phase is typically used for reversed phase separations, but can also be used as a stationary phase for HILIC and normal-phase modes of separation. The CN group is sterically-protected to improve stability compared to conventional CN phases. Its rapid equilibration with changes in mobile phase combined with its low-bleed makes the ES-CN phase suitable for high throughput LC-MS applications.

BONDED PHASE	Sterically-protected Extra Stable (ES) CN, cyanopropyldiisopropylsilane
ENDCAPPED	Yes
BONDED PHASE COVERAGE	2.5 µmoles/m²
CARBON LOAD	3.5%
PH RANGE	1 to 9
MAXIMUM TEMPERATURE	90 °C

PEPTIDE ES-C18

Peptide ES-C18 is a C18 phase bonded to a Fused-Core particle with a pore size (160Å) specifically selected for ultra-fast, high-resolution separation of peptides up to 20 kDa. The mechanism of separation offered by the bonded phase is hydrophobic binding interaction, well suited for peptide separations. The pore size is selected to balance the importance of allowing peptides full access to the stationary phase pore volume while maintaining sufficient surface area for analyte-stationary phase-mobile phase interaction. Furthermore, the bonded phase is sterically-protected to facilitate reliable operations under the low pH and high temperature conditions that are often used for separating peptides by reversed phase.

BONDED PHASE	Sterically-protected Extra Stable (ES) C18, octadecyldiisobutylsilane
ENDCAPPED	No
BONDED PHASE COVERAGE	2.0 µmoles/m²
CARBON LOAD	4.6%
PH RANGE	1 to 8
MAXIMUM TEMPERATURE	90 °C

PENTA-HILIC

The Penta-HILIC is specifically designed and intended for hydrophilic interaction liquid chromatography, HILIC. The HALO Penta-HILIC stationary phase is a highly polar ligand that possesses 5 hydroxyl groups tethered to the silica via novel proprietary linkage chemistry. The retention mechanism offered by the Penta-HILIC phase is a combination of hydrophilic interaction, ion-exchange and weak hydrophobic binding interaction. Retention in HILIC mode as a function of mobile phase is opposite that of reversed phase. For example, increasing the mobile phase strength involves increasing the polarity of the mobile phase by increasing the aqueous component. Penta-HILIC is particularly recommended for the separation of highly polar analytes that are poorly retained in reversed phase mode. The Penta-HILIC phase is also recommended for LC-MS applications because of the MS friendly mobile phase conditions typically used with Penta-HILIC.

BONDED PHASE	Densely bonded proprietary penta-hydroxyl phase
ENDCAPPED	Yes
BONDED PHASE COVERAGE	2.6 µmoles/m²
CARBON LOAD	3.6%
PH RANGE	2 to 9
MAXIMUM TEMPERATURE	60 °C

HILIC

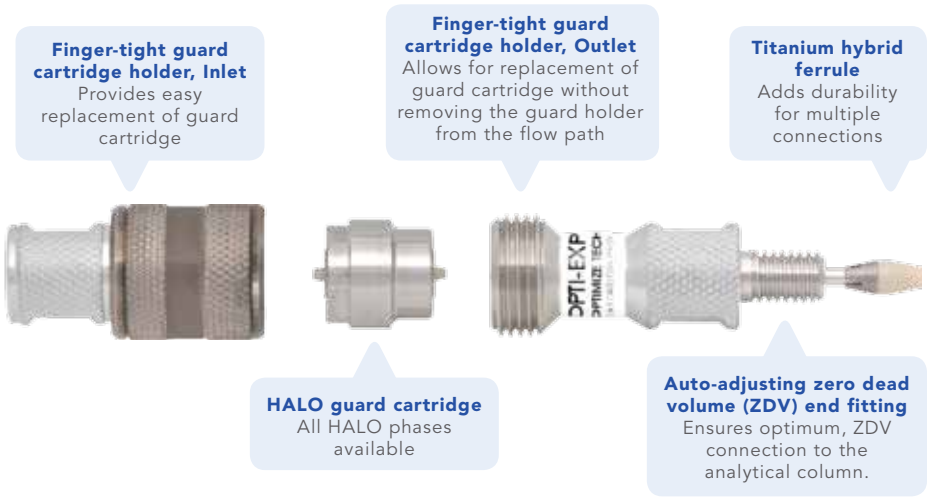
The HILIC phase is an unbonded pure silica. It can be used for either normal-phase or HILIC mode of separation. When used in HILIC mode, it is recommended for similar applications as the Penta-HILIC phase described previously. Separations on HILIC are expected to be similar to Penta-HILIC, although subtle differences in selectivity will often occur, favoring one phase over the other when developing an optimized HILIC separation.

BONDED PHASE	High purity Type B unbonded silica
ENDCAPPED	No
BONDED PHASE COVERAGE	150 m²/gram
CARBON LOAD	– – –
PH RANGE	1 to 8
MAXIMUM TEMPERATURE	60 °C

HALO® UHPLC and HPLC Guard Columns

- Ultra-low dispersity for UHPLC as well as HPLC columns
- Effectively filters-out particulate material and prevents column inlet frit plugging
- Collects non-eluting compounds and prevents column fouling
- Finger-tight guard cartridge replacement design
- Auto-adjusting ZDV fitting ensures optimum connection to all HPLC or UHPLC columns

See parts list to identify the correct guard cartridges for use with a particular HALO UHPLC or HPLC column.



HALO® Stationary Phase Support Specifications

All HALO stationary phase supports are made using Fused-Core particle technology.

HALO UHPLC particles

- 2.7 µm particle size
- A 0.5 µm porous silica layer fused to a solid silica core
- Ultra-pure, "Type B" silica
- Spherical shape
- 90 Å pore size
- 150 m^2/gram surface area

HALO-5 HPLC particles

- 4.6 µm particle size
- A 0.6 µm porous silica layer fused to a solid silica core
- Ultra-pure, "Type B" silica
- Spherical shape
- 90 Å pore size
- 90 m^2/gram surface area

HALO Peptide particles

- 2.7 µm particle size
- A 0.5 µm porous silica layer fused to a solid silica core
- Ultra-pure, "Type B" silica
- Spherical shape
- 160 Å pore size
- 80 m^2/gram surface area

Advanced Materials Technology uses a Beckman Coulter Microsizer III to conduct particle size measurements. The Coulter Counter relies on the fact that particles moving through an electric field cause measurable disturbances in that field.The magnitudes of these disturbances are proportional to the size of the particles in the field. This measurement tool provides reliable measurements of the size of silica particles, which are counted to 30,000 particles and the number mode is reported in our specifications.

HALO® UHPLC and HALO-5 HPLC Columns Part Numbers

ID (mm)	Length (mm)	dp (µm)	C18	C8	Phenyl-Hexyl	RP-Amide	PFP	ES-CN	Peptide ES-C18	Penta-HILIC	HILIC
0.075	50	2.7	98219-402	98219-408					91229-402		
0.075	150	2.7	98219-702	98219-708					91229-702		
0.1	50	2.7	98218-402	98218-408					91228-402		
0.1	150	2.7	98218-702	98218-708					91228-702		
0.2	50	2.7	98217-402	98217-408					91227-402		
0.2	150	2.7	98217-702	98217-708					91227-702		
0.3	50	2.7	98216-402	98216-408					91226-402		
0.3	150	2.7	98216-702	98216-708					91226-702		
1.0	30	2.7	92811-302	92811-308	92811-306	92811-307	92811-309	92811-304	92121-302	92811-305	92811-301
1.0	30	5	95811-302	95811-308	95811-306		95811-309	95811-304		95811-305	95811-301
1.0	50	2.7	92811-402	92811-408	92811-406	92811-407	92811-409	92811-404	92121-402	92811-405	92811-401
1.0	50	5	95811-402	95811-408	95811-406		95811-409	95811-404		95811-405	95811-401
1.0	100	2.7	92811-602	92811-608	92811-606	92811-607	92811-609	92811-604	92121-602	92811-605	92811-601
1.0	100	5	95811-602	95811-608	95811-606		95811-609	95811-604		95811-605	95811-601
1.0	150	2.7	92811-702	92811-708	92811-706	92811-707	92811-709	92811-704	92121-702	92811-705	92811-701
1.0	150	5	95811-702	95811-708	95811-706		95811-709	95811-704		95811-705	95811-701
1.0	250	5	95811-902	95811-908	95811-906		95811-909	95811-904		95811-905	95811-901
2.1	20	2.7	92812-202	92812-208	92812-206	92812-207	92812-209	92812-204	92122-202	92812-205	92812-201
2.1	20	5	95812-202	95812-208	95812-206		95812-209	95812-204		95812-205	95812-201
2.1	30	2.7	92812-302	92812-308	92812-306	92812-307	92812-309	92812-304	92122-302	92812-305	92812-301
2.1	30	5	95812-302	95812-308	95812-306		95812-309	95812-304		95812-305	95812-301
2.1	50	2.7	92812-402	92812-408	92812-406	92812-407	92812-409	92812-404	92122-402	92812-405	92812-401
2.1	50	5	95812-402	95812-408	95812-406		95812-409	95812-404		95812-405	95812-401
2.1	75	2.7	92812-502	92812-508	92812-506	92812-507	92812-509	92812-504	92122-502	92812-505	92812-501
2.1	75	5	95812-502	95812-508	95812-506		95812-509	95812-504		95812-505	95812-501
2.1	100	2.7	92812-602	92812-608	92812-606	92812-607	92812-609	92812-604	92122-602	92812-605	92812-601
2.1	100	5	95812-602	95812-608	95812-606		95812-609	95812-604		95812-605	95812-601
2.1	150	2.7	92812-702	92812-708	92812-706	92812-707	92812-709	92812-704	92122-702	92812-705	92812-701
2.1	150	5	95812-702	95812-708	95812-706		95812-709	95812-704		95812-705	95812-701
2.1	250	5	95812-902	95812-908	95812-906		95812-909	95812-904		95812-905	95812-901
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3.0	20	5	95813-202	95813-208	95813-206		95813-209	95813-204		95813-205	95813-201
3.0	30	2.7	92813-302	92813-308	92813-306	92813-307	92813-309	92813-304	92123-302	92813-305	92813-301
3.0	30	5	95813-302	95813-308	95813-306		95813-309	95813-304		95813-305	95813-301
3.0	50	2.7	92813-402	92813-408	92813-406	92813-407	92813-409	92813-404	92123-402	92813-405	92813-401
3.0	50	5	95813-402	95813-408	95813-406		95813-409	95813-404		95813-405	95813-401
3.0	75	2.7	92813-502	92813-508	92813-506	92813-507	92813-509	92813-504	92123-502	92813-505	92813-501
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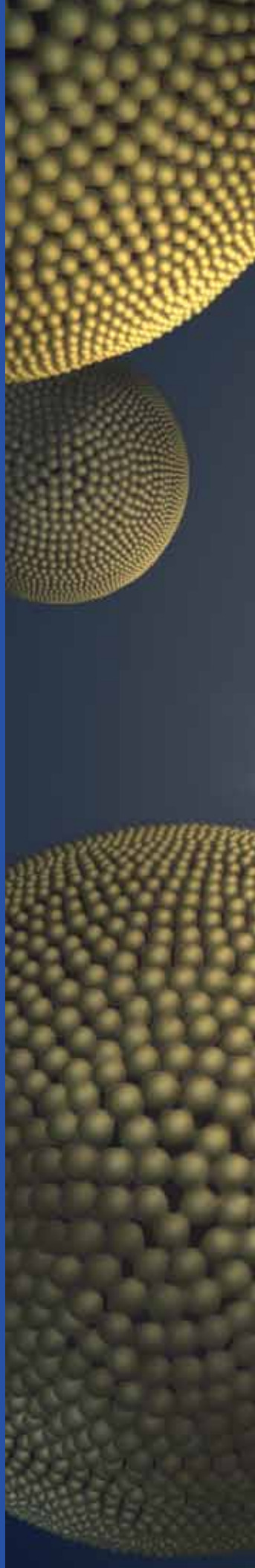
3.0	100	2.7	92813-602	92813-608	92813-606	92813-607	92813-609	92813-604	92123-602	92813-605	92813-601
3.0	100	5	95813-602	95813-608	95813-606		95813-609	95813-604		95813-605	95813-601
3.0	150	2.7	92813-702	92813-708	92813-706	92813-707	92813-709	92813-704	92123-702	92813-705	92813-701
3.0	150	5	95813-702	95813-708	95813-706		95813-709	95813-704		95813-705	95813-701
3.0	250	5	95813-902	95813-908	95813-906		95813-909	95813-904		95813-905	95813-901
4.6	20	2.7	92814-202	92814-208	92814-206	92814-207	92814-209	92814-204	92124-202	92814-205	92814-201
4.6	20	5	95814-202	95814-208	95814-206		95814-209	95814-204		95814-205	95814-201
4.6	30	2.7	92814-302	92814-308	92814-306	92814-307	92814-309	92814-304	92124-302	92814-305	92814-301
4.6	30	5	95814-302	95814-308	95814-306		95814-309	95814-304		95814-305	95814-301
4.6	50	2.7	92814-402	92814-408	92814-406	92814-407	92814-409	92814-404	92124-402	92814-405	92814-401
4.6	50	5	95814-402	95814-408	95814-406		95814-409	95814-404		95814-405	95814-401
4.6	75	2.7	92814-502	92814-508	92814-506	92814-507	92814-509	92814-504	92124-502	92814-505	92814-501
4.6	75	5	95814-502	95814-508	95814-506		95814-509	95814-504		95814-505	95814-501
4.6	100	2.7	92814-602	92814-608	92814-606	92814-607	92814-609	92814-604	92124-602	92814-605	92814-601
4.6	100	5	95814-602	95814-608	95814-606		95814-609	95814-604		95814-605	95814-601
4.6	150	2.7	92814-702	92814-708	92814-706	92814-707	92814-709	92814-704	92124-702	92814-705	92814-701
4.6	150	5	95814-702	95814-708	95814-706		95814-709	95814-704		95814-705	95814-701
4.6	250	5	95814-902	95814-908	95814-906		95814-909	95814-904		95814-905	95814-901
10	150	2.7	92810-702								
10	150	5	95810-702								

Guard Cartridges, 3-pack

2.1	5	2.7	92812-102	92812-108	92812-106	92812-107	92812-109	92812-104	92112-102	92812-105	92812-101
2.1	5	5	95812-102	95812-108	95812-106	95812-107	95812-109	95812-104		95812-105	95812-101
3.0	5	2.7	92813-102	92813-108	92813-106	92813-107	92813-109	92813-104	92113-102	92813-105	92813-101
3.0	5	5	95813-102	95813-108	95813-106	95813-107	95813-109	95813-104		95813-105	95813-101
4.6	5	2.7	92814-102	92814-108	92814-106	92814-107	92814-109	92814-104	92114-102	92814-105	92814-101
4.6	5	5	95814-102	95814-108	95814-106	95814-107	95814-109	95814-104		95814-105	95814-101

Guard Cartridge Holder	94900-001



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