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Ion chromatography

The role of guard columns in ion chromatography—best practices for Thermo Scientific Dionex columns

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Introduction

Ion chromatography (IC) is a powerful technique for separating inorganic anions, cations, and many polar organic compounds. In a typical IC system, an ion-exchange analytical column resolves ions in the sample while a suppressor and detector translate their elution into an electrical signal. Real-world samples, however, contain particulates, strongly retained species, and other matrix components that can foul the separator column and shorten its life. To prevent this, Thermo Scientific™ Dionex™ ion chromatography systems use guard columns, which can intercept contaminants, protecting the separator column from damage.

In this white paper, we describe the purpose of guard columns, differentiate them from other in-line fluidic devices, such as Thermo Scientific™ Dionex™ InGuard™ cartridges, trap columns, and concentrator columns, and provide guidance on when and how to replace them. We focus on Thermo Scientific™ Dionex™ products; however, the concepts apply broadly across liquid chromatography. It is important to always check the performance of a new column before running a method using a Quality Assurance Report (QAR). Refer to the product manual for detailed information regarding column use and maintenance. Product manuals are found on thermofisher.com or thermofisher.com/iccolumns.

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Purpose and benefits of guard columns

Protecting the analytical column

The primary role of a guard column is to shield the analytical column from sample contaminants. Thermo Scientific™ IC column product manuals emphasize that a guard is essential to protect the analytical column. The guard retains strongly adsorbed substances and particulates before they reach the main separation column, thus providing valuable protection. It is much easier and more economical to replace the short guard column than the long analytical column.

Effect on retention times and capacity

Because the guard column adds extra resin volume, using a guard will slightly increase analyte retention times. There are three categories of guards related to their capacity relative to their respective separators: high (15–25%), medium (6–14%), and low (1–5%), as shown in Tables 1A, 1B, and 1C. The total retention time typically increases approximately in proportion to the relative capacity. For low relative guard-to-separator capacity column sets—such as the Thermo Scientific™ Dionex™ IonPac™ AG11-HC and AS11-HC—the analyte retention time increases approximately 5% under isocratic conditions, as shown in Figure 1 (Thermo Fisher Scientific, 2013). For high relative guard-to-separator capacity column sets—such as the Thermo Scientific™ Dionex™ IonPac™ CG21 and CS21—the analyte retention time increase is roughly 21% (Thermo Fisher Scientific, 2018). While this extra retention must be accounted for, in addition to protection, the guard column effectively increases overall capacity, allowing larger sample loads without overloading the analytical column. While the overall analysis time will increase, guard columns do not affect resolution or quantitation; in fact, they maintain quantitative accuracy by preventing separator fouling and peak tailing that may result from it.

Table 1A. IC anion column families categorized by the guard-to-separator capacity ratio and relative retention time impact.

Capacity ratio		
High	**Medium**	**Low**
Retention time impact		
15–25%	6–14%	1–5%
AS4A-SC	AS12A	AS9-HC
AS5	AS28	AS11-HC
AS7		AS16
AS10		AS18
AS11		AS19
AS14		AS20
AS14A		AS21
AS15		AS22
AS17-C		AS23
AS32		AS24
		AS24A
		AS25
		AS26
		AS27
		AS29
		AS30
		AS31

Table 1B. IC cation column families categorized by the guard-to-separator capacity ratio and relative retention time impact.

Capacity ratio		
High	**Medium**	**Low**
Retention time impact		
15–25%	6–14%	1–5%
CS5A		CS19
CS10		
CS11		
CS12A		
CS14		
CS15		
CS16		
CS17		
CS18		
CS20		
CS21		

Table 1C. Thermo Scientific™ Dionex™ CarboPac™ column families categorized by the guard-to-separator capacity ratio and relative retention time impact.

Capacity ratio		
High	**Medium**	**Low**
Retention time impact		
15–25%	6–14%	1–5%
PA1		SA10
PA10		PA300
PA20		
PA100		
PA200		
PA210		
MA1		

To illustrate this concept, we compare chromatograms from each capacity ratio category for guard/separator pairs with and without a guard in place.

Column: See chromatogram
Eluent: 4.5 mM Na_2CO_3/1.4 mM $NaHCO_3$
Flow rate: 0.3 mL/min
Temperature: 30 °C
Inj. volume: 2.5 µL
Detection: Suppressed conductivity, 2 mm

Analyte:	mg/L (ppm)
1. Fluoride	5.0
2. Acetate	20.0
3. Chloride	10.0
4. Nitrite	15.0
5. Bromide	25.0
6. Nitrate	25.0
7. Phosphate	40.0
8. Sulfate	30.0

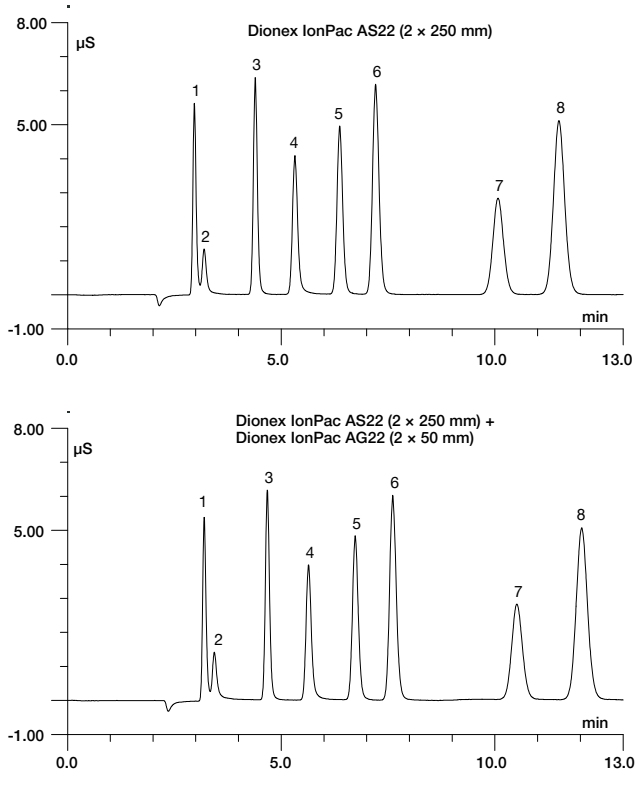

Figure 1. Chromatograms comparing IC separation using the Thermo Scientific™ Dionex™ IonPac™ AS22 Analytical Column with (top) and without (bottom) the low relative capacity Thermo Scientific™ Dionex™ IonPac™ AG22 Guard Column. The impact-to-retention time is approximately 4% (12/11.5 min).

Column: See chromatogram
Eluent: 55 mM KOH
Eluent source: Dionex EGC 500 KOH cartridge
Flow rate: 0.3 mL/min
Inj. volume: 2.5 µL
Temperature: 30 °C
Detection: Suppressed conductivity, Dionex AERS 500 suppressor, 2 mm, AutoSuppression, recycle mode

Peaks:	mg/L
1. Fluoride	2.0
2. Chloride	5.0
3. Carbonate	---
4. Nitrite	10.0
5. Sulfate	10.0
6. Bromide	20.0
7. Nitrate	20.0

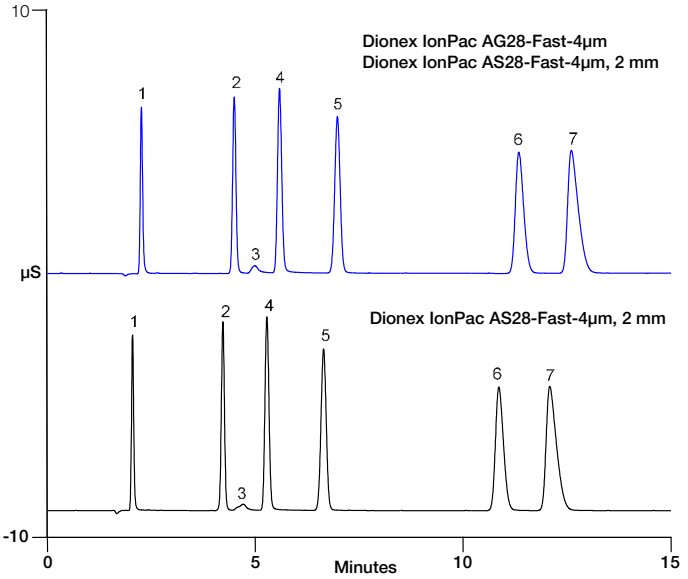

Figure 2. Chromatograms comparing an IC separation using the Thermo Scientific™ Dionex™ AS28 Analytical Column with (top) and without (bottom) the medium relative capacity Thermo Scientific™ Dionex™ AG28 Guard Column. The impact-to-retention time is approximately 12% (13.2/11.8 min).

Column: See chromatogram
Eluent: 4 mM MSA
Eluent source: Thermo Scientific™ Dionex™ EGC 500 MSA cartridge
Flow rate: 0.3 mL/min
Inj. volume: 10 µL
Temperature: 40 °C
Detection: Suppressed conductivity, Thermo Scientific™ Dionex™ CDRS 600 suppressor, 4 mm, AutoSuppression, recycle mode

Peaks:	mg/L
1. Potassium	2.0
2. Mepiquat	10.0
3. Magnesium	1.0

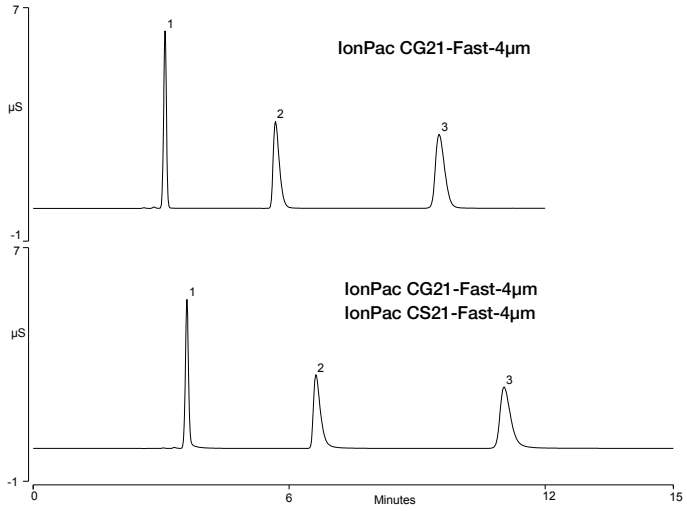

Figure 3. Chromatograms comparing an IC separation using the Dionex IonPac CS21 analytical column with (top) and without (bottom) the high relative capacity Dionex IonPac CG21 guard column. The impact-to-retention time is approximately 21% (11.5/9.5 min).

Protection from pressure fluctuations

Guard columns do more than deplete contaminants. The manual for the Thermo Scientific™ Dionex™ CarboPac™ PA20 column notes that the guard protects the main column not only from contamination but also from excessive pressure fluctuations caused by instrumentation or operator errors (Thermo Fisher Scientific, 2018). Pressure spikes can damage the resin bed or compress it unevenly, degrading performance. Having a guard column installed acts as a buffer against these shocks, improving robustness. Always account for the maximum pressure of the guard and separator columns as stated in the QAR when calculating the total pressure of the workflow.

Maintenance is easier and cheaper

Replacing a guard column is inexpensive compared with replacing an analytical column. Thermo Scientific™ manuals consistently recommend replacing the guard at the first sign of peak-efficiency loss or decreased retention time. In the troubleshooting section of the Dionex CarboPac PA20 column manual, the authors even advise having a spare guard on hand; if separation improves when the guard is removed, install a new guard and continue. Because fouling rates depend on the sample matrix, there is no universal lifetime specification; operators might replace multiple guards over the life of a single analytical column.

Distinguishing guard columns from other fluidic cleanup devices

Guard columns are sometimes confused with other IC fluidic cleanup devices, but each serves a different purpose and location in the flow path (Figure 4). In a traditional setup, the autosampler feeds directly into the injection valve, followed by a guard column and analytical column. Where a Dionex InGuard sample preparation cartridge and optional concentrator are used, these are placed between the autosampler and injection valve. Both systems employ a guard column in front of the analytical column.

Dionex InGuard cartridges—automated sample pretreatment

Dionex InGuard cartridges are in-line devices installed between the autosampler and the injection valve to remove matrix interferences from samples. The Thermo Fisher Scientific website describes Dionex InGuard cartridges as automatic sample preparation tools that remove cations (including transition metals), anions, or hydrophobic substances, improving separations and extending column life (Thermo Fisher Scientific, 2025). Dionex InGuard cartridges come in different chemistries (Ag, H, Na, hydrophobic resin [HRP], and a dual Na/HRP formulation) to target specific matrix components. Each cartridge contains an ion exchange or adsorption resin; for example, Thermo Scientific™ Dionex™ InGuard Ag cartridges remove halides by precipitation, while Thermo Scientific™ Dionex™ InGuard H cartridges remove alkaline earth and transition metals. The cartridges can be used individually or in series, and some can be regenerated.

Difference from guard columns: Dionex InGuard cartridges treat the sample rather than the eluent or column. They remove matrix species before injection to reduce interference and improve sensitivity, whereas guard columns protect the analytical column from fouling after the injection has occurred. Therefore, an IC system using Dionex InGuard cartridges still requires a guard column to protect the analytical column downstream. They address different parts of the flow path and are complementary rather than interchangeable.

Trap columns—protecting the eluent

Trap columns are used to purify the eluent, not the sample. The **Thermo Scientific concentrator and trap columns specification sheet** explains that Thermo Scientific™ Dionex™ IonPac™ trap columns contain high-capacity, low-efficiency ion exchange resin that strips trace contaminants from the eluent, preventing those contaminants from concentrating on the guard and analytical columns (Thermo Fisher Scientific, 2024). These trap columns are installed in the eluent line prior to the injection valve to eliminate baseline drift and spurious peaks during gradient chromatography.

The Thermo Scientific™ Dionex™ CR-ATC Continuously Regenerated Anion Trap Columns and CR-CTC Continuously Regenerated Cation Trap Columns are unique in the continuous electrolytic regeneration and removal of anionic or cationic impurities without manual regeneration.

Difference from guard columns: Trap columns clean the eluent flow; they never contact the sample matrix. Their purpose is to ensure a stable baseline during gradient runs, whereas guard columns protect against sample-borne contaminants. Both may exist simultaneously in the same system.

Concentrator columns— preconcentrating analytes

Concentrator columns are designed for trace analysis. They are used primarily for high purity water analysis and 2 D IC systems. The same specification sheet notes that Dionex IonPac concentrator columns retain ions from a measured sample volume, thereby concentrating analyte species and lowering detection limits to the µg L^{-1} or even ng L^{-1} level (Thermo Fisher Scientific, 2024). After loading the sample, the valve switches, and the eluent sweeps the concentrated analytes onto the analytical column.

Difference from guard columns: Concentrator columns enrich analytes; they are not primarily designed to protect the analytical column. When used, they are placed before the injection valve. They may be used in tandem with Dionex InGuard cartridges for matrix removal and still require a guard column downstream.

Table 2. Summary of column types and purposes.

Column types	Main purpose
Analytical	Separates analytes
Guard	Shields analytical column
InGuard	Depletes sample matrix contaminants
Trap	Depletes eluent contaminants
Concentrator	Enriches trace analytes

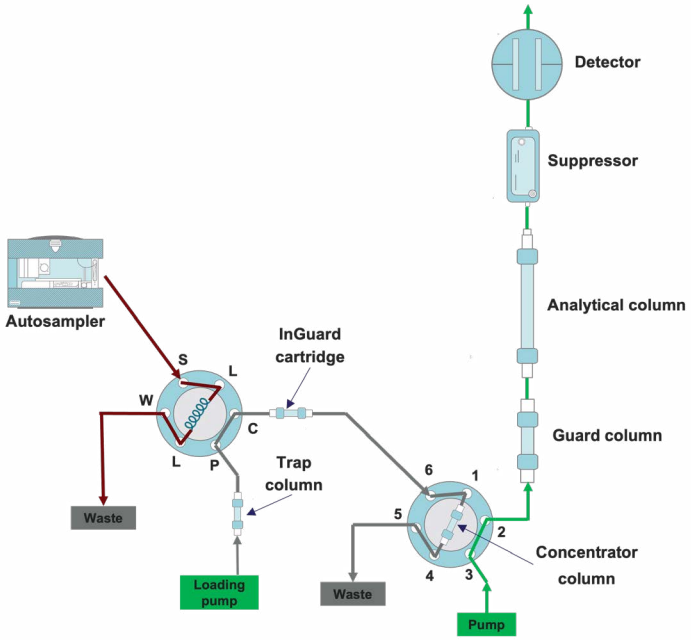

Figure 4. System configuration showing the location of each fluidic cleanup device in the flow path relative to sample and eluent.

Expected lifespan of guard columns

Thermo Scientific manuals emphasize that there is no fixed injection count for guard column lifetime. Instead, you should monitor chromatographic performance and replace the guard column at the first sign of peak-efficiency loss or decreased retention time. Because sample matrices vary widely, some guard columns may last hundreds of injections, while others may foul quickly (for example, when analyzing dairy products or samples with heavy particulate loads).

In troubleshooting guidelines, Thermo Scientific IC column product manuals advise always having a spare guard. If peak efficiency decreases, run a standard separation with the guard removed; if the separation improves, install a new guard. It is reasonable to replace guard columns several times during the lifetime of an analytical column. This approach avoids prematurely discarding an expensive analytical column and ensures consistent performance.

Guard columns are designed to be disposable. Although some mild cleaning protocols exist (e.g., flushing with a strong base or acid), repeated regeneration can distort the resin bed. It is usually more efficient to replace the guard when performance declines.

Signs that a guard column needs replacing:

1. Loss of efficiency or resolution: Peaks broaden or tail more than expected.
2. Decreased retention or selectivity: Anions elute earlier or in a different order compared with new column chromatograms.
3. Increased back pressure: Fouling may cause a noticeable rise in system pressure.
4. Irregular baseline or extra peaks: An unexpectedly high baseline or spurious peaks can indicate contamination.

Numbers 1, 2, and 3 can be monitored using interactive charts in Thermo Scientific™ Chromeleon™ Chromatography Data System (CDS).

Replacing a guard column—general guidance

Replacing a guard column is straightforward and can usually be done in minutes. Below are the high-level steps to take when replacing a guard column. Keep a spare guard column on hand to minimize downtime.

1. Record baseline performance.
2. Select the correct guard column.
3. Equilibrate the new guard column.
4. Verify performance.
5. Document the replacement.

Conclusion

Guard columns are the unsung heroes of ion chromatography. By sacrificing themselves to protect analytical columns from contaminants and pressure fluctuations, they extend column life and ensure consistent separations. Manuals for Thermo Scientific™ products emphasize that guards should be used at all times and replaced whenever peak efficiency or retention time declines. Their modest effect on retention times is a small price to pay for the protection they provide.

As discussed, there are guard columns, and there are sample prep tools. Dionex InGuard cartridges remove matrix interferences before the sample reaches the injection valve. Trap columns purify the eluent to reduce baseline drift during gradient IC. Concentrator columns preconcentrate analytes for trace analysis. Each plays a distinct role, and all may be used together. Regardless of configuration, guard columns remain essential for protecting the analytical column.

References

Product manual: Thermo Scientific Dionex IonPac AS11-HC-4µm Column

Product Manual: Dionex IonPac AS28-Fast-4µm Columns

Product Manual: Dionex IonPac CS21-Fast-4µm Columns

Product Manual: Thermo Scientific Dionex InGuard Cartridges

Learn more at **thermofisher.com/iccolumns**