



**Thermo Scientific**

# **Eluent Generator Cartridges**

## **Product Manual**

**P/N: 065018-04**

**November 2012**

# **Product Manual**

**for**

## **Eluent Generator Cartridges**

(EGC)

### **EGC III KOH**

(Potassium Hydroxide Cartridge, P/N 074532)

### **EGC 500 KOH**

(Potassium Hydroxide Cartridge, P/N 075778)

### **EGC-KOH (Capillary)**

(Capillary Potassium Hydroxide Cartridge, P/N 072076)

### **EGC III NaOH**

(Sodium Hydroxide Cartridge, P/N 074533)

### **EGC III LiOH**

(Lithium Hydroxide Cartridge, P/N 074534)

### **EGC III K<sub>2</sub>CO<sub>3</sub>**

(Potassium Carbonate Cartridge, P/N 074536)

### **EPM III**

(Electrolytic pH Modifier, P/N 080135)

### **EGC Carbonate Mixer**

(4 mm, P/N 079943; 2 mm, P/N 063443)

### **EGC III MSA**

(Methanesulfonic Acid Cartridge, P/N 074535)

### **EGC 500 MSA**

(Methanesulfonic Acid Cartridge, P/N 075779)

### **EGC-MSA (Capillary)**

(Capillary Methanesulfonic Acid Cartridge, P/N 072077)

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#### Revision History:

Revision 04, November, 2012, Rebranded for Thermo Scientific. Added EGC 500.

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## Safety and Special Notices

Make sure you follow the precautionary statements presented in this guide. The safety and other special notices appear in boxes.

Safety and special notices include the following:



**SAFETY**

*Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.*



**WARNING**

*Indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment.*



**CAUTION**

*Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. Also used to identify a situation or practice that may seriously damage the instrument, but will not cause injury.*



**NOTE**

*Indicates information of general interest.*

**IMPORTANT**

*Highlights information necessary to prevent damage to software, loss of data, or invalid test results; or might contain information that is critical for optimal performance of the system.*

**Tip**

*Highlights helpful information that can make a task easier.*

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# 1. Introduction

A Reagent-Free™ Ion Chromatography system with Eluent Generation (RFIC™-EG) is capable of generating high purity acid, base and salt eluents online at the point of use utilizing only deionized (DI) water as the carrier. The use of EG in Ion Chromatography (IC) offers several significant advantages. Mainly, separations can be performed using only DI water as the carrier and the need to prepare eluent is eliminated. RFIC-EG systems produce high purity, contaminant free eluents online. The use of these high purity eluents can significantly improve the performance of IC methods.

An important advantage of EG is that gradient separations can be performed using electrical current to generate gradients with minimal delay. In addition, the use of EG can reduce the maintenance costs of a pumping system since the pump only comes in contact with DI water instead of corrosive acids or bases.

Thermo Scientific offers 10 Eluent Generator Cartridges (EGC). Five are high purity hydroxide eluent cartridges used for anion separations with hydroxide selective columns:

1. EGC III KOH cartridge for the generation of potassium hydroxide (KOH).
2. EGC III NaOH cartridge for the generation of sodium hydroxide (NaOH).
3. EGC III LiOH cartridge for the generation of lithium hydroxide (LiOH).
4. EGC-KOH (Capillary) cartridge for the generation of potassium hydroxide (KOH) at capillary flow rates (0.001 – 0.030 mL/min).
5. EGC 500 KOH cartridge for the generation of potassium hydroxide (KOH) in high pressure IC systems at pressures up to 5,000 psi

In addition, Thermo Scientific offers a high purity carbonate eluent cartridge and an Electrolytic pH Modifier for use with anion separations with carbonate eluent based columns:

1. EGC III K<sub>2</sub>CO<sub>3</sub> cartridge for the generation of potassium carbonate (K<sub>2</sub>CO<sub>3</sub>).
2. EPM III eluent pH modifier for the in-line titration of potassium carbonate to potassium bicarbonate (KHCO<sub>3</sub>).

Finally, Thermo Scientific offers three high purity methanesulfonic acid cartridges for use with cation separations:

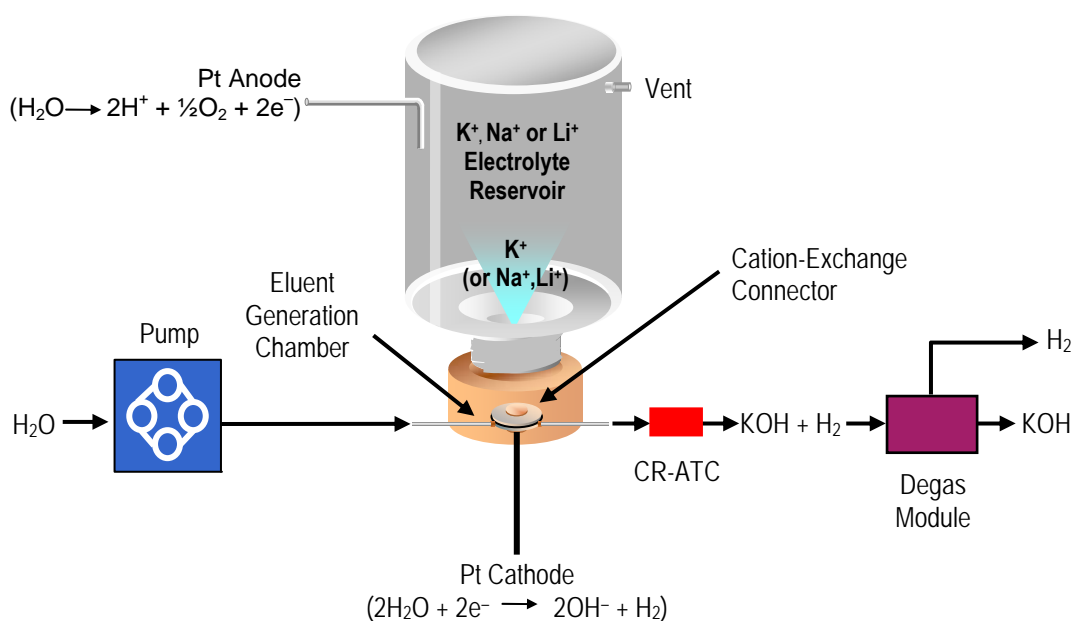
1. EGC III MSA cartridge for the generation of methanesulfonic acid (CH<sub>3</sub> SO<sub>3</sub>H).
2. EGC-MSA (Capillary) cartridge for the generation of methanesulfonic acid (CH<sub>3</sub> SO<sub>3</sub>H) at capillary flow rates (0.001 – 0.030 mL/min).
3. EGC 500 MSA cartridge for the generation of methanesulfonic acid (CH<sub>3</sub>SO<sub>3</sub>H) in high pressure IC systems at pressures up to 5,000 psi.

Thermo Scientific also offers a Continuously Regenerated Trap Column (CR-TC 500). A CR-TC 500 removes any extraneous contaminants from the DI water source. The CR-TC 500 is electrolytically regenerated, thus eliminating the need for online chemical regeneration. A CR-ATC 500 Trap Column is used for anion exchange applications while a CR-CTC 500 Trap Column is used for cation exchange applications. A CR-TC 500 can be used at pressures up to 5,000 psi, and is compatible with both standard and high pressure IC systems.



## 1.1 EGC 500 KOH, EGC III KOH, NaOH and LiOH, and EGC-KOH (Capillary) Principle of Operation

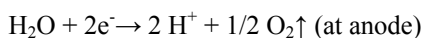
**Figure 1** EGC 500 KOH, EGC III KOH, NaOH, LiOH or EGC-KOH (Capillary) Cartridge for generation of KOH, NaOH or LiOH eluent.



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Figure 1 illustrates the operation principle of an EGC 500 KOH, EGC III KOH, NaOH, LiOH or EGC-KOH (Capillary). The cartridge consists of a high pressure eluent generation chamber and a low pressure  $K^+$ ,  $Na^+$  or  $Li^+$  ion electrolyte reservoir. The eluent generation chamber contains a perforated platinum (Pt) cathode where hydroxide ions are formed. The  $K^+$ ,  $Na^+$  or  $Li^+$  ion electrolyte reservoir contains a Pt anode and an electrolyte solution of  $K^+$ ,  $Na^+$  or  $Li^+$  ions. The eluent generation chamber is connected to the electrolyte reservoir by means of a cation exchange connector which permits the passage of ions from the electrolyte reservoir into the high pressure generation chamber, while preventing the passage of anions from the electrolyte reservoir into the generation chamber. The cation exchange connector also serves the critical role of a high pressure physical barrier between the low pressure electrolyte reservoir and the high pressure generation chamber.

To generate a KOH, NaOH or LiOH eluent, deionized water is pumped through the eluent generation chamber and a DC current is applied between the anode and cathode of the EGC. Under the applied field, the electrolysis of water occurs at both the anode and cathode of the device. As shown below, water is oxidized to form  $H^+$  ions and oxygen gas at the anode in the  $K^+$ ,  $Na^+$  or  $Li^+$  electrolyte reservoir.



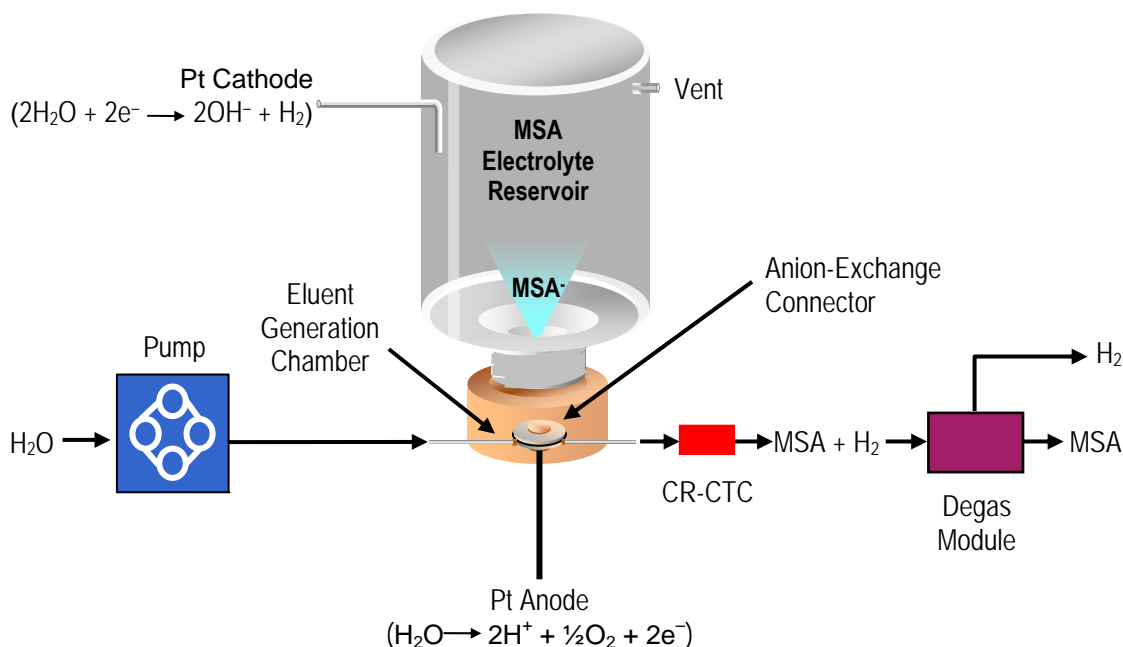
Water is reduced to form  $\text{OH}^-$  ions and hydrogen gas at the cathode in the KOH, NaOH or LiOH generation chamber.



As  $\text{H}^+$  ions, generated at the anode, displace  $\text{K}^+$ ,  $\text{Na}^+$  or  $\text{Li}^+$  ions in the electrolyte reservoir, the displaced ions migrate across the cation exchange connector into the eluent generation chamber. These ions combine with  $\text{OH}^-$  ions generated at the cathode to produce the KOH, NaOH or LiOH solution, which is used as the eluent for anion exchange chromatography. The concentration of generated KOH, NaOH or LiOH is determined by the current applied to the generator and the carrier water flow rate through the generation chamber. Therefore, given the carrier flow rate, the EG module will precisely control the applied current to accurately and reproducibly generate KOH, NaOH or LiOH at the desired concentration.

## 1.2 EGC 500 MSA, EGC III MSA, and EGC-MSA (Capillary) Principle of Operation

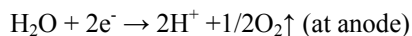
**Figure 2 EGC 500 MSA, EGC III MSA or EGC-MSA (Capillary) Cartridge for generation of MSA eluent.**



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The concept described for the generation of hydroxide can be applied to the generation of acid. Figure 2 illustrates the operation principle of an EGC 500 MSA, EGC III MSA or EGC-MSA (Capillary) cartridge. The cartridge consists of a high pressure eluent generation chamber and a low pressure methanesulfonate ( $\text{MSA}^-$ ) ion electrolyte reservoir. The eluent generation chamber contains a perforated platinum (Pt) anode. The electrolyte reservoir contains a Pt cathode and an electrolyte solution of  $\text{MSA}^-$  ions. The eluent generation chamber is connected to the  $\text{MSA}^-$  ion electrolyte reservoir using an anion exchange connector which permits the passage of  $\text{MSA}^-$  ions from the electrolyte reservoir into the high pressure generation chamber, while preventing the passage of cations. The anion exchange connector also serves the critical role of a high pressure physical barrier between the low pressure electrolyte reservoir and the high pressure eluent generation chamber.

To generate a MSA eluent, deionized water is pumped through the MSA generation chamber and a DC current is applied between the anode and cathode of the eluent generator cartridge. Under the applied field, the electrolysis of water occurs at the anode and cathode of the device. Water is oxidized to form  $\text{H}^+$  ions and oxygen gas at the anode in the MSA generation chamber as shown below.



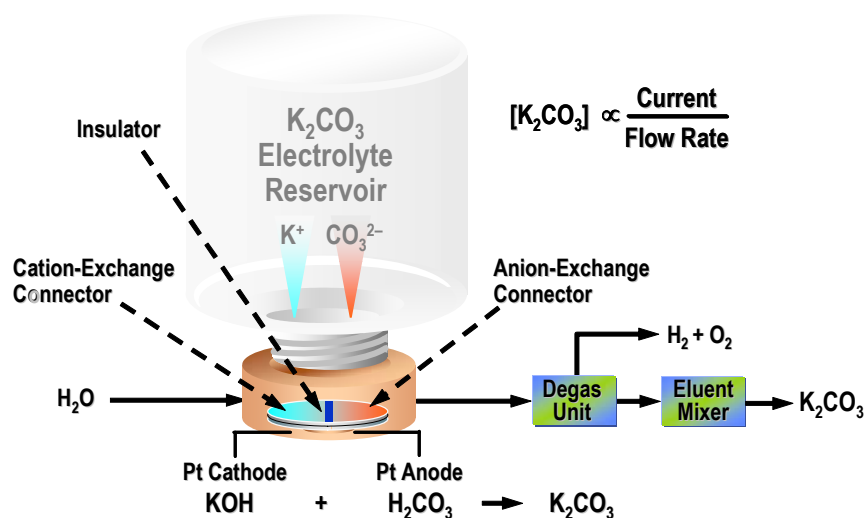
Water is reduced to form  $\text{OH}^-$  ions and hydrogen gas at the cathode in the  $\text{MSA}^-$  electrolyte reservoir.



As the  $\text{OH}^-$  ions, generated at the cathode, displace  $\text{MSA}^-$  ions in the electrolyte reservoir,  $\text{MSA}^-$  ions migrate across the anion exchange connector into the MSA electrolysis chamber. The  $\text{MSA}^-$  ions combine with  $\text{H}^+$  ions generated at the anode to produce a methanesulfonic acid (MSA) solution, which is used as the eluent for cation exchange chromatography. The concentration of MSA generated is determined by the current applied to the MSA generator and the carrier flow rate through the MSA generation chamber. Therefore, given the carrier flow rate, the EG module will control the applied current in order to accurately and reproducibly generate MSA at the desired concentration.

### 1.3 EGC III K<sub>2</sub>CO<sub>3</sub> Principle of Operation

Figure 3 EGC III K<sub>2</sub>CO<sub>3</sub> Cartridge for generation of Carbonate eluents.

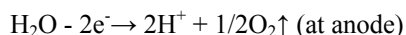


The Potassium Carbonate Eluent Generator Cartridge (EGC III K<sub>2</sub>CO<sub>3</sub>) is the heart of the electrolytic carbonate eluent generation process. Figure 3 shows the principle of electrolytic generation of carbonate eluents. Carbonate eluents are generated by using an EGC III K<sub>2</sub>CO<sub>3</sub> cartridge. The EGC III K<sub>2</sub>CO<sub>3</sub> cartridge consists of an electrolyte reservoir and a high-pressure eluent generation chamber, which are connected together through an ion exchange connector. The ion exchange connector contains two sections: a cation exchange section and an anion exchange section.

The cation exchange section is located directly above the cathode and the anion exchange section is located directly above the anode in the eluent generation chamber. To generate a potassium carbonate solution, deionized water is pumped into the eluent generation chambers and a DC electrical current is applied to the anode and cathode of the device. Water is reduced to form OH<sup>-</sup> ions and hydrogen gas at the cathode.



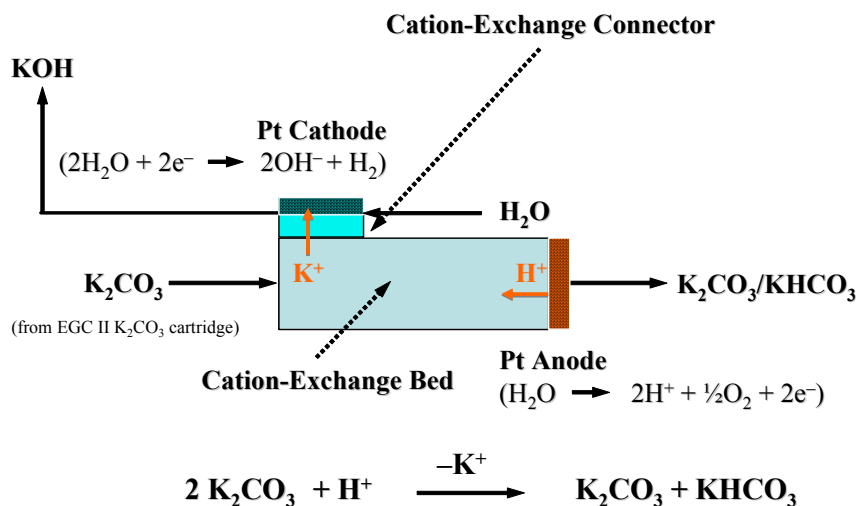
Water is oxidized to form H<sup>+</sup> ions and oxygen gas at the anode.



Under the applied electrical field, potassium ions in the electrolyte reservoir migrate across the cation exchange connector and combine with the hydroxide ions produced at the cathode through the reduction of water to form a KOH solution. In the meantime, carbonate ions migrate across the anion exchange connector and combine with H<sup>+</sup> ions produced at the anode through the oxidation of water to form a carbonic acid solution. The potassium hydroxide solution reacts with the carbonic acid solution to form a potassium carbonate (K<sub>2</sub>CO<sub>3</sub>) solution, which can be used as the eluent in ion chromatography. The concentration of K<sub>2</sub>CO<sub>3</sub> formed is directly proportional to the applied DC current and inversely proportional to the flow rate of DI water going through the eluent generation chamber.

## 1.4 EPM III Principle of Operation

**Figure 4** Electrolytic Generation of  $K_2CO_3/KHCO_3$  eluents using an EGC III  $K_2CO_3$  cartridge and EPM III.



When the EGC III  $K_2CO_3$  cartridge is combined with an Electrolytic pH Modifier (EPM III), eluents of carbonate and bicarbonate can be generated electrolytically. The EPM III consists of a cation exchange bed that is fitted with an anode at its outlet. The inlet end of the device is connected to a cathode through the cation exchange connector. A DC current is applied to the EPM III to remove a controlled amount of potassium ions which are forced to migrate across the cation exchange connector. The displaced potassium ions move toward the cathode and combine with hydroxide ions to form a solution of potassium hydroxide, which is directed to waste. In the meantime, hydronium ions generated at the anode converts carbonate into bicarbonate. The net reaction is shown in Figure 4. Therefore, by controlling the applied current, the pH of the incoming potassium carbonate eluent can be modified to form a potassium carbonate and bicarbonate solution for use as the eluent in IC separations.

## 1.5 Differences between EGC II, EPM and EGC III, EPM III

The EGC III and EPM III are direct replacements for the EGC II and EPM. The following table outlines the discontinued products and their direct replacements:

Discontinued EGC and EPM Products		Direct Replacement EGC and EPM Products	
Old P/N	Old Description	New P/N	New Description
058900	EGC II KOH	074532	EGC III KOH
058908	EGC II NaOH	074533	EGC III NaOH
058906	EGC II LiOH	074534	EGC III LiOH
058904	EGC II K <sub>2</sub> CO <sub>3</sub>	074536	EGC III K <sub>2</sub> CO <sub>3</sub>
063175	EPM	080135	EPM III
058902	EGC II MSA	074535	EGC III MSA

A chip has been added to the cable of the EGC III and EPM III devices. This chip will be ignored by instruments that do not include a chip reader, such as the EG40, EG50, ICS-2000, ICS-2100, ICS-3000 EG and RFC-30. Newer instruments such as the ICS-5000 EG module do include a chip reader to make use of this new feature.



### NOTE

***The ICS-5000 EG requires an EGC III, EPM III or EGC (Capillary) to function. The ICS-5000 EG will not function with an EGC II or EPM.***

The EGC III and EPM III reservoir, membranes, screens and electrodes use the same materials and undergo the same testing as the EGC II and EPM they replace. The EGC III can be used in place of the EGC II without any change in form, fit or function. The EPM III can be used in place of the EPM without any change in form, fit or function.

## 1.6 Differences between EGC III and EGC 500

The EGC 500 is not a direct replacement for the EGC III. The EGC 500 is designed to enable high pressure operation in High Pressure RFIC systems such as the Dionex ICS-5000<sup>+</sup>. In order to operate above 3,000 psi, a High Pressure RFIC system must be fitted with an EGC 500. The following table outlines the equivalent EGC III and EGC 500 products:

EGC III Products	Equivalent EGC 500 Products
074532 EGC III KOH	075778 EGC 500 KOH
074535 EGC III MSA	075779 EGC 500 MSA



### NOTE

***The EGC 500 is not compatible with non-High Pressure RFIC systems and modules such as the Dionex ICS-5000, Dionex ICS-2100 or Dionex RFC-30. If an EGC 500 is installed into a non-High Pressure RFIC system the cartridge will not be recognized.***

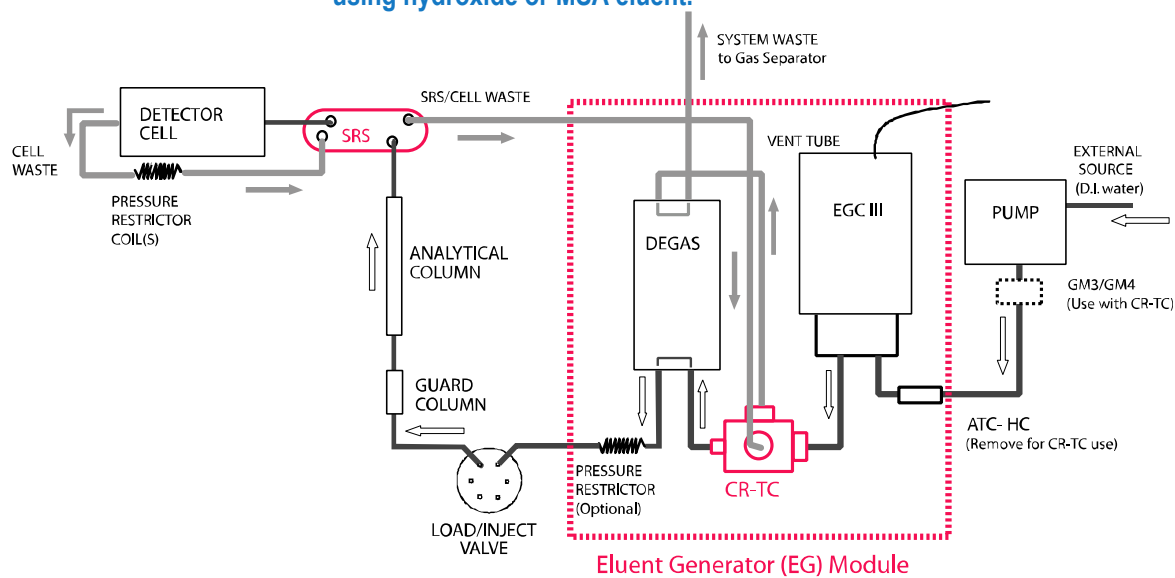
## 1.7 System Flow Diagram

### 1.7.1 Eluent Generator module with hydroxide or MSA eluent and CR-TC Trap Column

Figure 5 shows the configuration of a typical RFIC-EG system. The EG Module is placed between the outlet of the pump and the inlet of the sample injector. Deionized water is used as the carrier for the EG. For anion analysis, a Continuously Regenerated Trap Column (CR-TC 500) for Anions (CR-ATC 500, P/N 075550), should be placed at the Eluent Generator Cartridge (EGC) outlet to remove dissolved carbon dioxide and other anionic contaminants from the deionized water. For cation analysis, a Continuously Regenerated Cation Trap Column (CR-CTC 500, P/N 075551) should be placed at the EGC outlet to remove cationic contaminants such as ammonium from the acidic eluent.

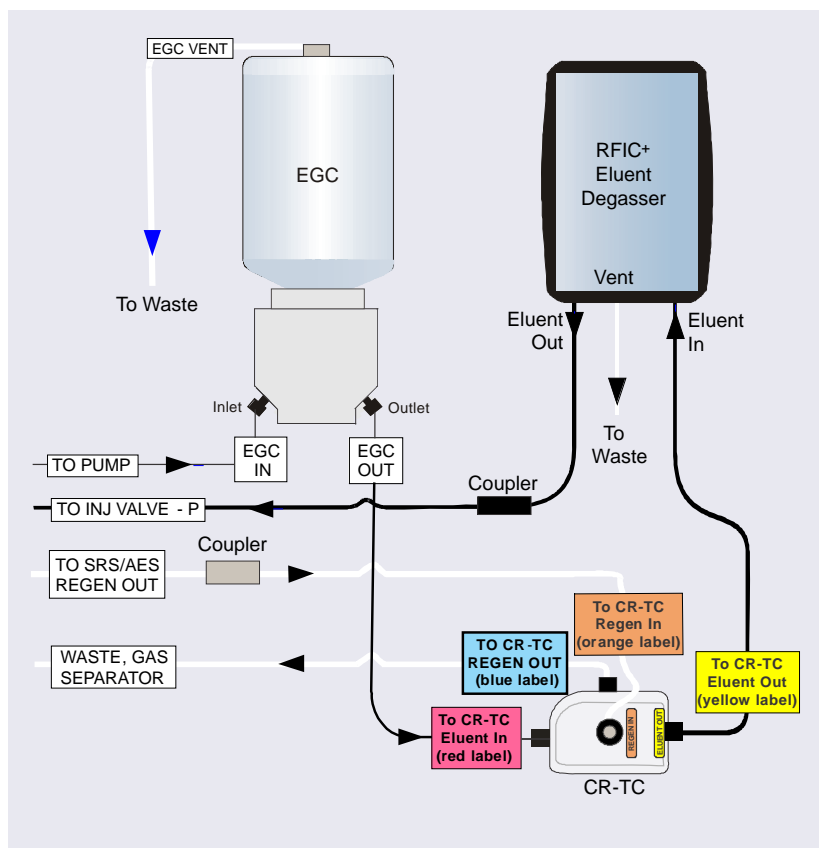
The high pressure degas tubing assembly is located between the outlet of the CR-TC 500 and the inlet of the sample injector to remove electrolysis gases generated during the eluent generation process. After exiting the degas tubing assembly, the high purity eluent passes through the injector, column, suppressor, and finally to the detector. Depending on the pressure drop across the guard and analytical column, an optional pressure restrictor can be installed between the outlet of the high pressure degas tubing assembly and the inlet of the sample injector for optimal system performance. A total backpressure of 2,300 psi is ideal. When using suppressed conductivity detection, the suppressor regenerant effluent is directed to flow through the degas tubing assembly to remove any released hydrogen or oxygen gas as shown in Figure 6.

**Figure 5** Standard Pressure System Flow Diagram for a typical RFIC-EG application using hydroxide or MSA eluent.





**Figure 6** High Pressure System Flow Diagram for a typical RFIC-EG application using hydroxide or MSA eluent.



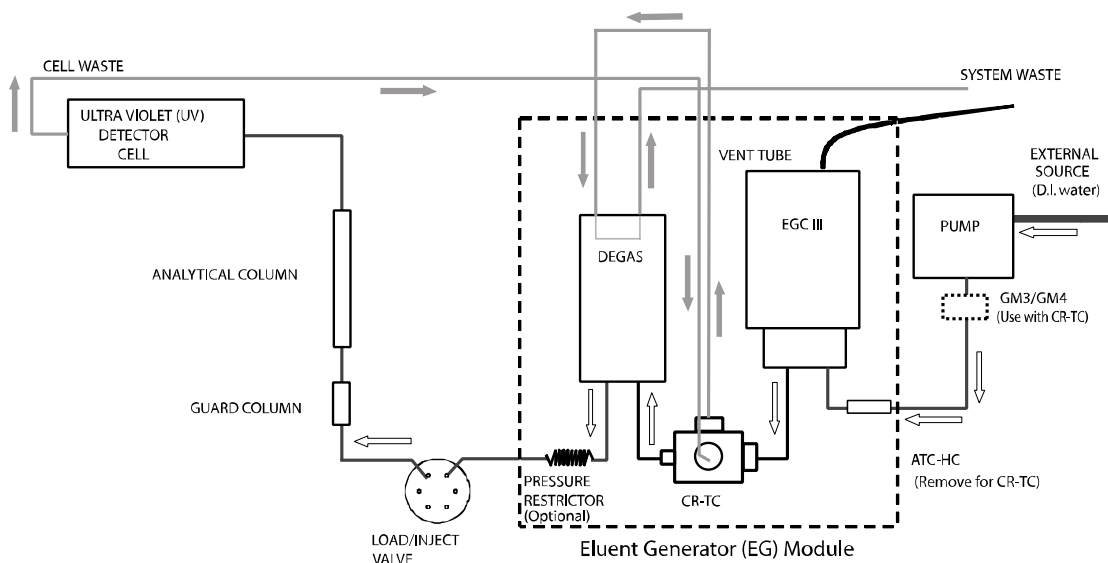
### 1.7.2 Eluent Generator module with hydroxide or MSA eluent and ATC-HC or CTC-1.

As an alternative to the CR-ATC 500, the ATC-HC Trap Column (P/N 059604) or ATC-HC 500 (P/N 075978) can be used for anion exchange applications. The IonPac CTC-1 Trap Column (P/N 040192) or CTC 500 (P/N 075977) can be used as an alternate to the CR-CTC 500 Trap Column for cation applications. See Appendix A.

### 1.7.3 Eluent Generator module with hydroxide or MSA eluent and UltraViolet (UV) Detection.

When using UV detection, the detector effluent is directed to flow through the degas tubing assembly to remove any released hydrogen gas, as shown in Figure 7.

**Figure 7** System Flow Diagram for a typical RFIC-EG application using hydroxide or MSA eluent and UV Detection.



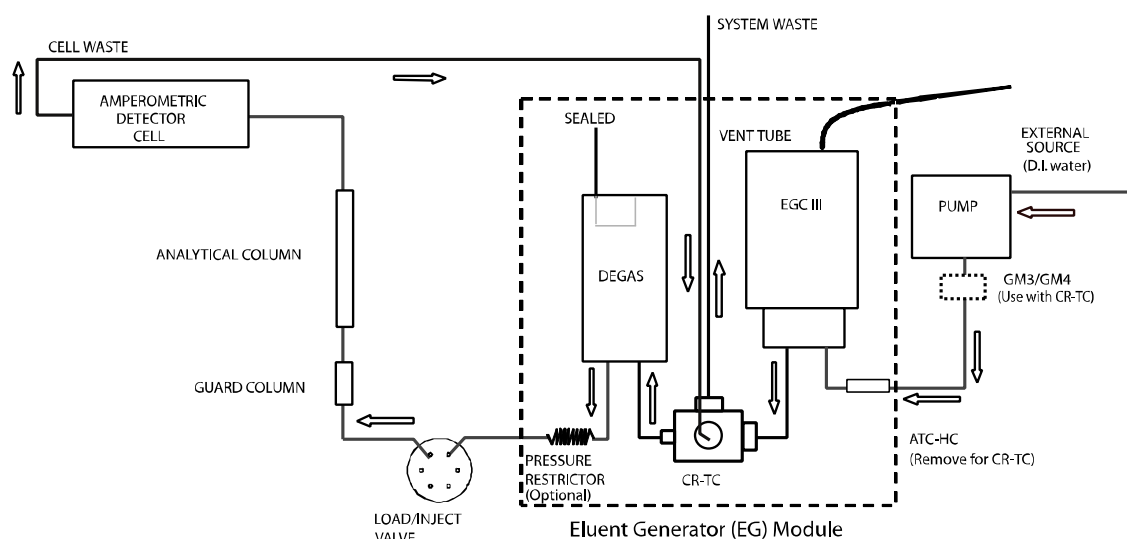
### 1.7.4 Eluent Generator module with hydroxide or MSA eluent and Amperometric Detection.

For carbohydrate analysis, the cell effluent is directed to the CR-ATC REGEN IN and then diverted to waste. A Dionex VP Vacuum Pump Kit (P/N 066463) or the EG/DP/SP Vacuum Degas Conversion Kit (P/N 063353) is installed to vacuum degas the EG eluent prior to operation.

The Dionex VP Vacuum Pump Kit contains a stand-alone vacuum pump with all the components required to connect the pump and to remove  $H_2$  gas from the EG Degas module.

The EG/DP/SP Vacuum Degas Conversion Kit contains all components required to convert the ICS-3000 DP or SP vacuum degas pump to remove  $H_2$  gas from EG Degas module. An ICS-3000 DP or SP with vacuum degas option is required.

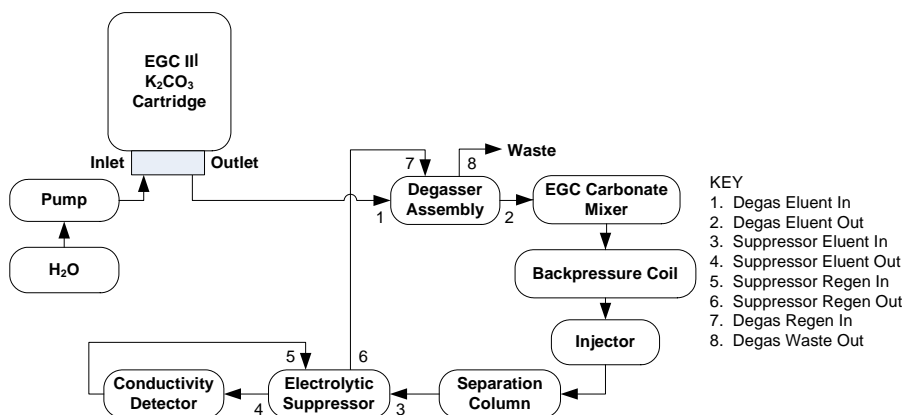
**Figure 8** System Flow Diagram for Carbohydrate Applications using an Eluent Generator module.



### 1.7.5 Eluent Generator module with Carbonate Eluent

Figure 9 shows the plumbing schematic for electrolytic generation of carbonate eluent only using an EGC III  $K_2CO_3$  cartridge in an ion chromatography system. The EGC III  $K_2CO_3$  Cartridge and EGC Carbonate Mixer are shipped in separate boxes. The EGC Carbonate Mixer is used to provide sufficient mixing of the KOH and  $H_2CO_3$  formed from the cathode chamber and anode chamber of the EGC III  $K_2CO_3$  cartridge, respectively. The EGC degas assembly is installed inside the EG module at the factory.

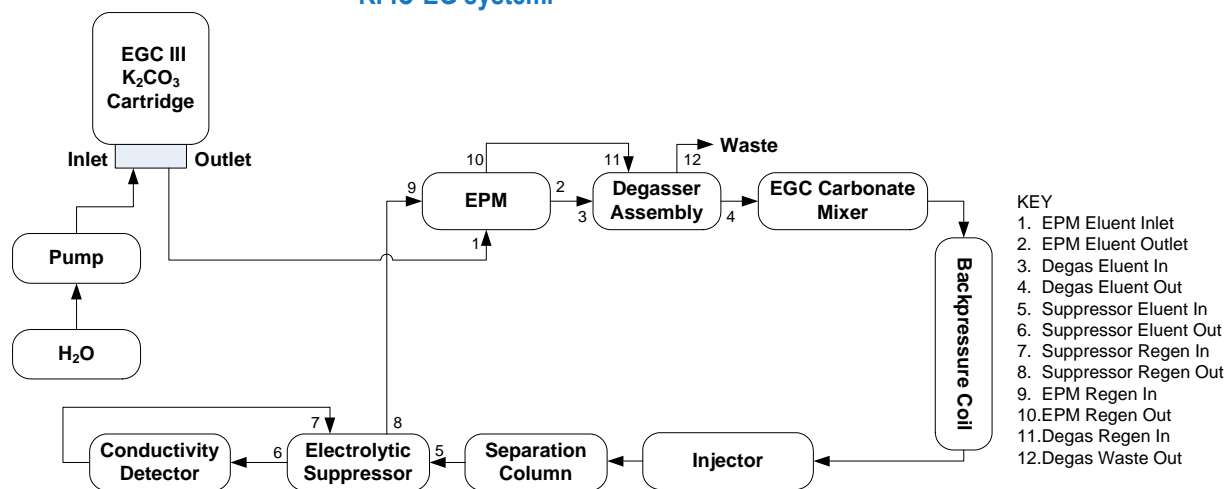
**Figure 9** Plumbing Schematic for Electrolytic Generation of Carbonate Only Eluent using an EGC III  $K_2CO_3$  Cartridge in an RFIC-EG system.



### 1.7.6 Eluent Generator module with Carbonate/Bicarbonate Eluent

To generate eluents of carbonate and bicarbonate, an EPM III is installed in the system. The system flow diagram is shown in Figure 10.

**Figure 10** Plumbing Schematic for Electrolytic Generation of Carbonate and Bicarbonate Mixed Eluents using an EGC III  $K_2CO_3$  Cartridge and EPM III in an RFIC-EG system.



## 2. Installation

The Eluent Generator Cartridges (EGC) are designed to be used with Dionex EG modules including EG40, EG50, RFC-30, ICS-2000, ICS-2100, ICS-3000 EG, ICS-5000 EG and ICS-5000<sup>+</sup> EG modules. For details regarding the operation of these modules please refer to their respective operating manuals.

The Potassium Carbonate Eluent Generator Cartridges (EGC III K<sub>2</sub>CO<sub>3</sub>) and Electrolytic pH Modifier (EPM III) are not compatible with the EG40, EG50 or RFC-30 modules and require Chromeleon Chromatography Management System, version 6.7 or higher. For details regarding the operation, please refer to the EG module operation manual.

The EGC-KOH (Capillary) and EGC-MSA (Capillary) Cartridges are designed to be used with a Dionex Capillary Ion Chromatography system such as the ICS-4000, ICS-5000 or ICS-5000<sup>+</sup> with IC Cube and Capillary pump heads. These cartridges are not compatible with analytical scale instruments.



NOTE

*The EGC-1 port of an ICS-5000<sup>+</sup>, ICS-5000 EG, ICS-3000 EG, ICS-2100 or ICS-2000 is assigned to control the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge, and the EGC-2 port is designed to control the EPM III.*

### 2.1 Procedure for EGC installation

#### 2.1.1 Preparation for Installation

- A. Remove the EGC from the box. Save the box and foam for future storage.
- B. Configure the EG module to operate the cartridge by entering the cartridge serial number. Please refer to the EG Module and Chromeleon user manuals for detailed procedures for entering the cartridge serial number.



NOTE

- *The ICS-5000<sup>+</sup> EG, ICS-5000 EG and ICS-4000 modules will automatically detect the cartridge type and do not require the serial number to be entered manually.*
- *The ICS-5000<sup>+</sup> and ICS-5000 EG modules require an EGC 500 (ICS-5000+ only), EGC III, EPM III or EGC (Capillary) cartridge. EGC II and EPM cartridges will not be recognized by these systems and will not function.*

- C. Place the EGC on a flat surface in front of the EG module with the Eluent Generation Chamber and INLET and OUTLET fittings facing up.
- D. Remove the plugs from the EGC INLET and OUTLET fittings.
- E. Turn over the EGC cartridge (fittings facing down). Shake the EGC cartridge vigorously, and tap it with the palm of your hand 10 to 15 times to dislodge the air bubbles that may be trapped in the electrolysis chamber.



NOTE

*Be sure to repeat Step 5 each time the eluent generation chamber is turned upward.*

- F. Connect the pump outlet to the EGC INLET port of the cartridge and the OUTLET port of the cartridge to the ELUENT IN port of the RFIC Eluent Degasser Assembly.
- G. Orient the cartridge with the cable aligned with the slot in the holder of the EG enclosure and then slide the cartridge down into the holder until secured.
- H. Connect the cartridge electrical cable to the EGC-1 port of the EG module.
- I. Connect the ELUENT OUT port of the RFIC Eluent Degasser Assembly to a yellow PEEK backpressure restrictor tubing (P/N 053765) with 2,000 psi backpressure at 1.0 mL/min.

### 2.1.2 Conditioning the EGC

- A. Fill a 2-L eluent reservoir bottle with ASTM filtered, Type I (18-megohm) deionized water. Connect the reservoir to the eluent inlet line of the pump.
- B. Prime the pump as instructed by the system operation manual.
- C. Set the pump flow rate to 1.0 mL/min.
- D. Unscrew and remove the plug from the vent opening on the side of the cartridge (EGC III) or loosen the plug on the top of the cartridge (EGC 500).
- E. Direct the outlet of the yellow PEEK backpressure tubing to a waste container.
- F. Turn on the pump and pump DI water through the cartridge for 10 minutes.
- G. Set the concentration to the value listed in Table 1 from the front control panel of the Chromeleon Chromatography Data System and turn on the EGC.
- H. Run the EGC for the duration listed in Table 1.
- I. Turn off the pump.

**Table 1 EGC Conditioning Conditions.**

EGC Type	Eluent Flow Rate	Eluent Concentration	Duration
EGC III K <sub>2</sub> CO <sub>3</sub>	1.0 mL/min	9 mM	30 minutes
EGC 500 KOH, EGC III KOH, NaOH, LiOH, EGC 500 MSA, EGC III MSA	1.0 mL/min	50 mM	30 minutes

- A. Disconnect the backpressure restrictor tubing from the EGC outlet tubing.

If installing an EGC III K<sub>2</sub>CO<sub>3</sub>, proceed to Section 2.2. If installing a new Continuously Regenerated Trap Column (CR-TC 500) proceed to Section 2.1.4. If the CR-TC is already installed, proceed to Section 2.1.5.

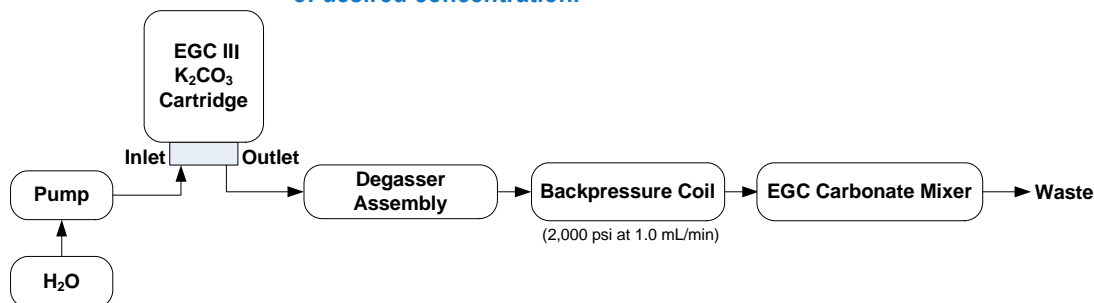
## 2.2 Conditioning the capillary EGC cartridges

- A. Fill a 2 L eluent reservoir bottle with ASTM filtered, Type I (18 megohm) deionized water. Connect the reservoir to the eluent inlet line of the pump.
- B. Prime the pump as instructed by the system operation manual.
- C. Pump DI water through the capillary EGC at 1.0 mL/min for 30 minutes (use the capillary pump in the prime mode to perform this step).
- D. Connect the outlet port of the capillary EGC to a PEEK backpressure tubing that generate 2000 psi at 30 uL/min
- E. Set the pump flow rate to 30 uL/min and the EGC concentration to 50 mM and condition the cartridge for 60 minutes.
- F. Direct the EGC effluent to a waste container.
- G. Turn off the pump.
- H. Disconnect the backpressure restrictor tubing from the EGC outlet tubing.

### 2.2.1 Filling the EGC Carbonate Mixer with $K_2CO_3$ Eluent of Desired Concentration

- A. Connect the outlet of the yellow pressure restrictor tubing (P/N 053765) to the union attached to the INLET port of the EGC Carbonate Mixer (P/N 074907 for 4-mm columns or P/N 074908 for 2-mm columns) as shown in Figure 11.
- B. Install the EGC Carbonate Mixer in the ICS-5000 EG or ICS-2100 system enclosure by pushing the mixer onto the mixer holder clip. The OUTLET of the EGC Carbonate Mixer must point upward to ensure sufficient mixing of the eluents generated.
- C. Set the pump flow rate at 1.0 mL/min and turn on the pump.
- D. Set the desirable  $K_2CO_3$  concentration on EGC-1 (e.g., 9 mM for AS9-HC columns) and turn on EGC-1 current control.
- E. Operate EGC III  $K_2CO_3$  cartridge to generate carbonate eluents. The main purpose of this step is to fill the EGC Carbonate Mixer with the electrolytic eluents having the desired carbonate concentration (e.g. 9 mM  $K_2CO_3$  for AS9-HC columns) for your application.
- F. The 4-mm EGC Carbonate Mixer has a void volume of about 16 mL. At 1.0 mL/min, it will take about 16 minutes to fill the Mixer with the  $K_2CO_3$  eluent of the set concentration upon initial installation. The 2-mm EGC Carbonate Mixer has a void volume of about 5.0 mL. At 1.0 mL/min, it will take about 5 minutes to fill the mixer with the  $K_2CO_3$  eluent of the set concentration upon initial installation.

**Figure 11** Plumbing Diagram for filling the EGC Carbonate Mixer with the  $K_2CO_3$  eluent of desired concentration.



Proceed to Section 2.1.5 to install the optimal pressure restrictor tubing.

### 2.2.2 Installing the Continuously Regenerated Trap Column (CR-TC)



**NOTE**

- *For analytical scale anion exchange applications use CR-ATC 500 P/N 075550. For capillary scale anion exchange applications use CR-ATC (Capillary) P/N 072078. For analytical scale cation exchange applications use CR-CTC 500 P/N 075551. For capillary scale cation exchange applications use CR-CTC (Capillary) P/N 072079.*
- *When making final plumbing connections all fittings should be finger tight plus ¼ turn.*
- *The CR-ATC 500 is not compatible with an EGC III K<sub>2</sub>CO<sub>3</sub>.*
- *The guidelines here are intended to supplement, not to replace the information in the CR-TC manual.*

- Turn off power to the pump, EGC, CR-TC, and the suppressor (SRS/AES/CES).
- Disconnect the following:
  - Trap columns (CR-ATC 500 or CR-CTC 500) installed between the EG and the Degas Assembly.
  - Trap columns (ATC or CTC) installed between the pump and the EG module.
- Remove the plugs on the CR-TC ports.
- Find the tubing with the red label on one end and a white label on the other end (supplied with the EG module).
- Connect the end with the white label to the Eluent Out port of the EGC.
- Connect the end with the red label to the Eluent In port of the CR-TC.
- Connect the tubing with the orange label to the Regen In port of the CR-TC.
- Connect the tubing with the blue label to the blue Regen Out port of the CR-TC.
- Connect the tubing with the yellow label to the yellow Eluent Out port of the CR-TC.



**NOTE**

*The CR-TC should be hydrated after first installation before operation, or after long-term storage. The process ensure the CR-TC resin and membranes are fully hydrated and ready for operation.*



- J. Disconnect the ELUENT OUT line protruding from the Degas Assembly at the end labeled TO INJECTION VALVE IN-P.
- K. If hydrating an analytical CR-TC connect this end to a 10-32 to 1/4-28 coupler (P/N 042806).
- L. If hydrating an analytical CR-TC:
  - i. Connect the free end of the tubing, labeled TO SRS/AES REGEN OUT, to the 1/4-28 end of the coupler.
- M. If hydrating a CR-TC (Capillary):
  - i. Connect 2.1 m (7 ft) of 1-58 mm (0.062 in) ID clear Tefzel tubing to the REGEN OUT port of the capillary CR-TC. Direct the other end of the tubing to waste.
- N. Ensure that the current to the EGC cartridge and suppressor are turned off.
- O. If hydrating an analytical CR-TC:
  - i. From the pump front panel, turn on the pump flow rate to hydrate the CR-TC by pumping DI water at the flow rate of your application for at least 10 minutes.
  - ii. Turn off the pump flow.
  - iii. Disconnect the coupler.
- P. If hydrating a CR-TC (Capillary):
  - i. Set the pump flow rate to 0.1 mL/min and flush the CR-TC for 3 minutes.
  - ii. Change the pump flow rate to 0.02 mL/min.
  - iii. Set the EGC concentration to 50 mM and turn on the EGC and CR-TC power for 30 minutes.
  - iv. Turn off the EGC and CR-TC power.
  - v. Turn off the pump flow.

**Figure 12 CR-TC Plumbing Diagram for Hydration.**

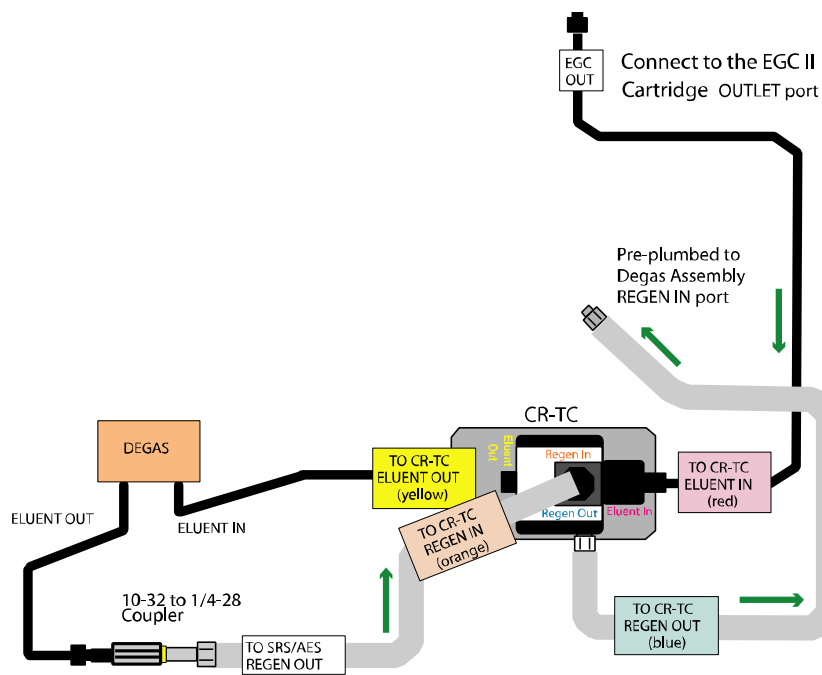
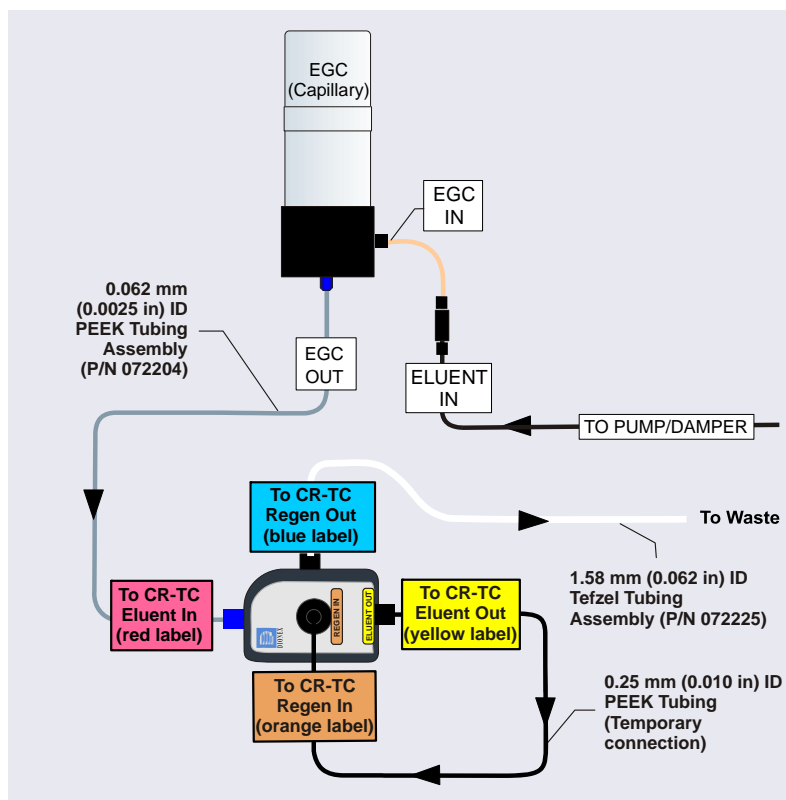


Figure 13 CR-TC (Capillary) Plumbing Diagram for Hydration.

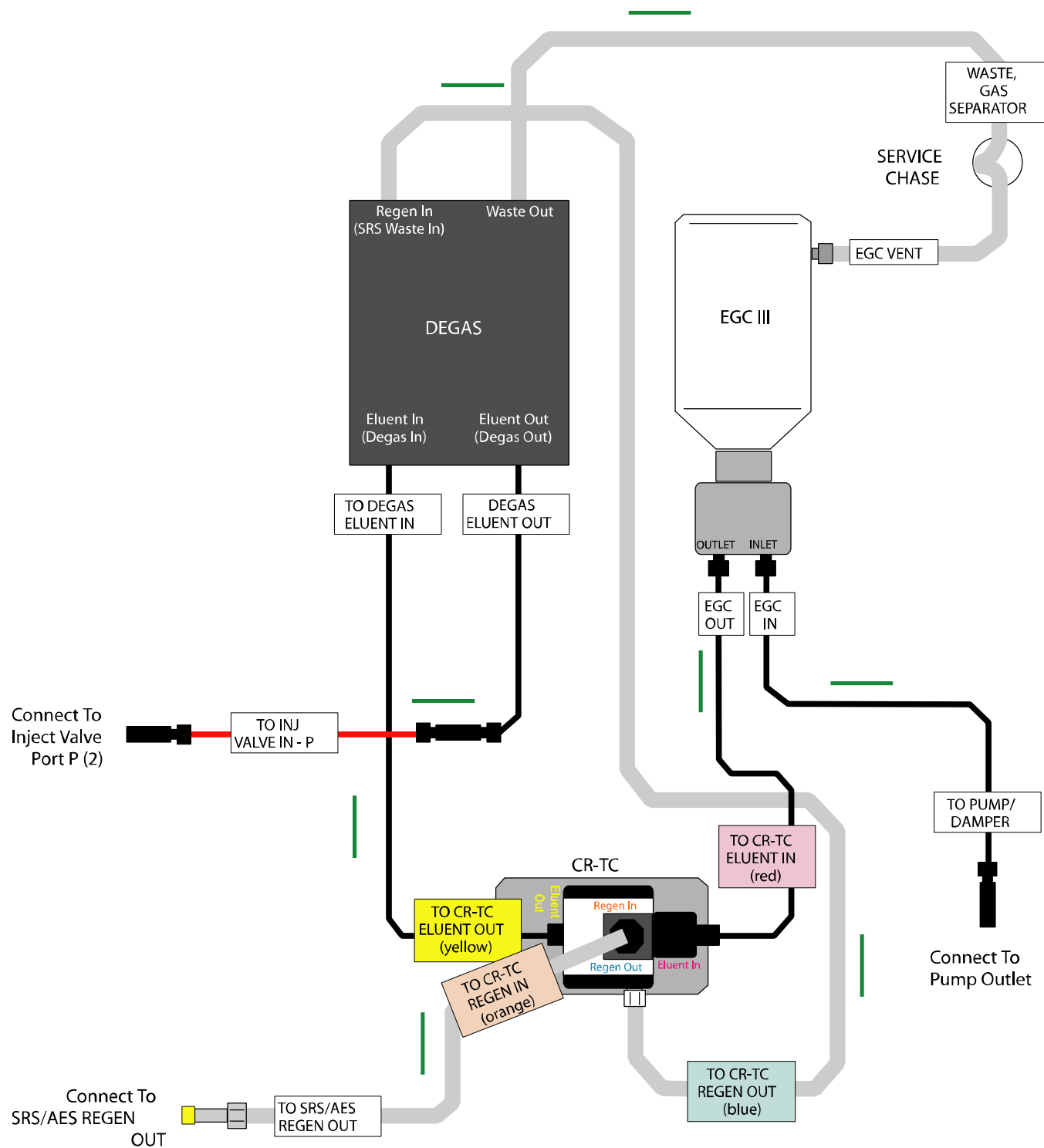


- A. Verify the tubing labeled “TO INJECTION VALVE IN-P” is connected to the injection valve.
- B. Verify that the tubing with the Red label (TO CR-TC ELUENT IN) is connected to the Eluent In port of the CR-TC.
- C. Verify that the other end of this tubing with the White label (EGC OUT) is connected to the OUTLET port of the EGC.
- D. Verify that the tubing with the Yellow label (TO CR-TC ELUENT OUT) is connected to the CR-TC Eluent Out port.
- E. Verify that the tubing with the Orange label (TO CR-TC REGEN-IN) is connected to the CR-TC Regen In port.
- F. Connect the other end of this tubing with the White label (TO SRS/AES, REGEN OUT) to the suppressor REGEN OUT port.
- G. Verify that the tubing with the Blue label (TO CR-TC REGEN-OUT) is connected to the CR-TC Regen Out port.
- H. Mount the CR-TC.

**NOTE**

*The CR-TC is mounted onto the mounting plate or underneath the EGC Cartridge Holder by aligning the hole on the CR-TC back plate with the ball stud on the mounting plate and pushing the CR-TC firmly onto the mounting ball stud. The CR-TC will click into place when properly installed.*

Figure 14 Plumbing schematic for the EGC III with CR-TC on a 3000 psi System.



**Figure 15 Plumbing schematic for the EGC (Capillary) with CR-TC (Capillary).**

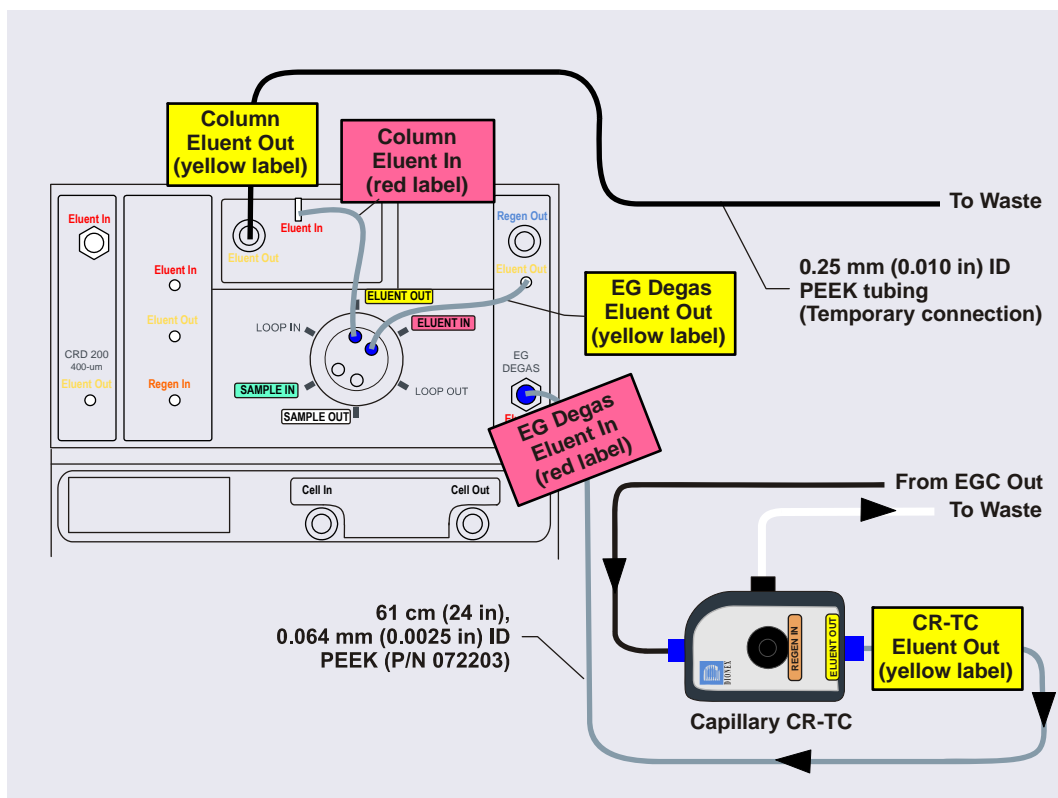
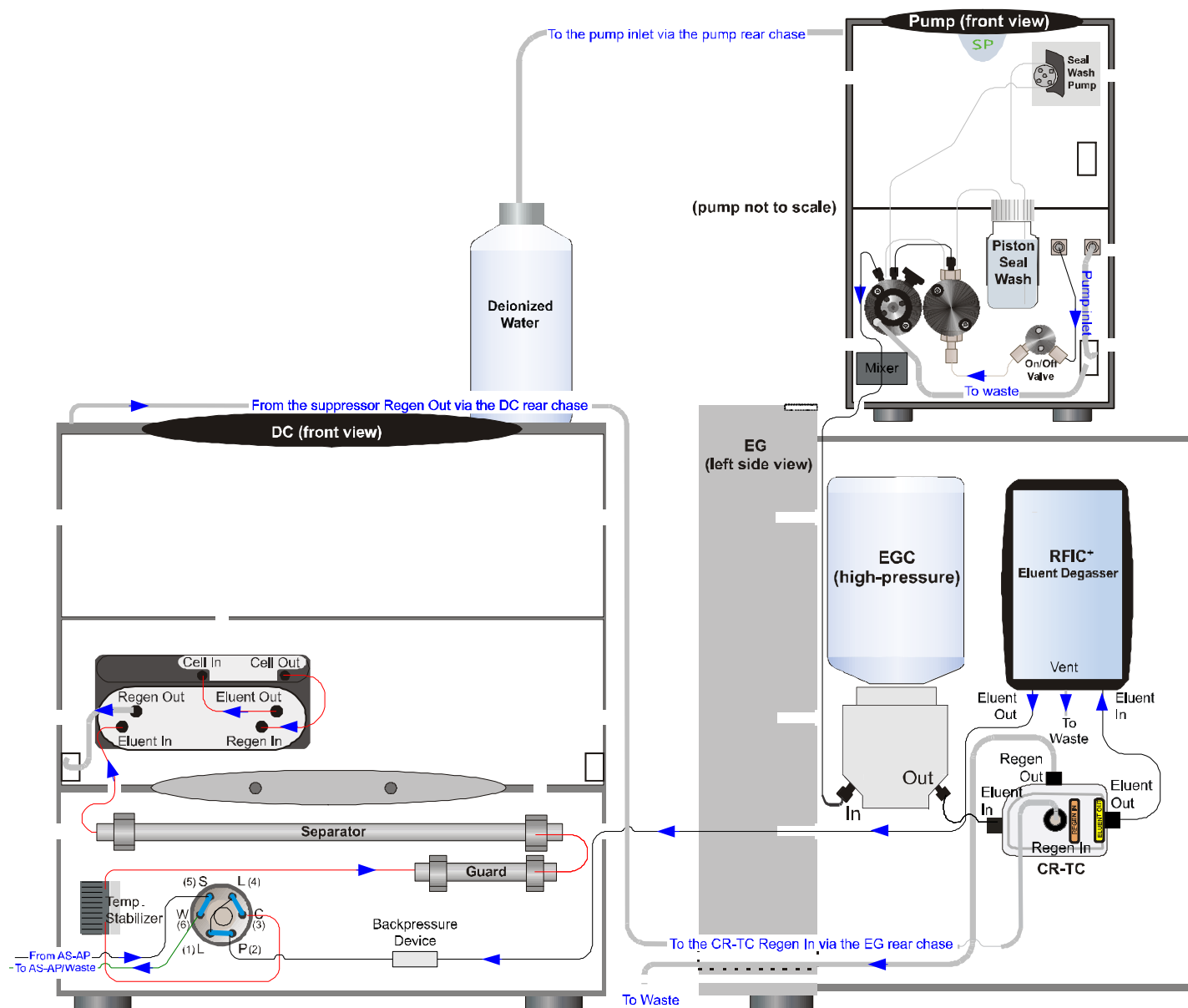


Figure 16 Plumbing schematic for the EGC 500 with CR-TC 500 on a 5000 psi System.



### 2.2.3 Optional Pressure Restrictor Tubing

The degas tubing assembly requires at least 2,000 psi (14 MPa) of back pressure for optimal removal of electrolysis gas from the eluent produced by the EGC III. A system backpressure of 2,300 psi is ideal. The degas tubing is functional at pressures below 2,000 psi (14 MPa); however, this low system pressure may result in high baseline noise as the eluent concentration increases in the gradient. If a restrictor is required, the following procedure will assist in determining the correct back pressure restrictor tubing to use.



NOTE

*The capillary degas tubing assembly requires only 1,000 psi (7 MPa) of backpressure for optimal removal of electrolysis gas. Degas tubing is thus not required for systems using an EGC (Capillary) with a capillary degas module. The minimum backpressure value applies during normal operation and during stand-by. Do not operate the EGC for an extended period of time below the minimum backpressure value, even when the system is not being used.*

- A. Turn the pump flow on.
- B. Confirm the eluent flows at the desired flow rate.



NOTE

*If the method is a gradient method, it should be run to completion.*

- C. Monitor the pump pressure and note the maximum and minimum system pressures for the duration of the method.
- D. If the maximum and minimum pressures are between 2,000 and 3,000 psi (EGC III) or between 2,000 and 5,000 psi (EGC 500), the system back pressure is adequate.
- E. If the maximum pressure exceeds 3,000 psi (EGC III) or 5,000 psi (EGC 500), the method will terminate prematurely.
  - i. Locate the source of the excessive pressure and eliminate it.



NOTE

*Several analytical and guard columns generate system pressures above 3,000 psi, especially when solvents are used in the eluent or the column uses 4µm particles. An EGC III cannot be used with these columns unless the flow rate is reduced so that the maximum system pressure is between 2,000 and 3,000 psi.*

- F. If the minimum system pressure is below 2,000 psi, a pressure restrictor should be used (except capillary systems). Table 2 can be used to determine the appropriate pressure restrictor to adjust the system pressure between 2,000 to 3,000 psi (14-21 MPa) or 2,000 to 5,000 psi (14 - 34.5 MPa). A system back pressure of 2,300 psi is ideal.
- G. The backpressure restrictors listed in Table 2 are supplied in the EG Module ship kit. If necessary, trim a back pressure coil to the desired length to provide adequate backpressure restriction.
  - i. Install the back pressure restrictor between the degas assembly "ELUENT OUT" port and the injection valve.

**NOTE**

*The back pressure restrictor tubing may be installed directly into the injection valve "IN" port.*

- ii. Secure the back pressure restrictor coils to the two coil clips which are provided on the left lower wall of the EG Module.

**Table 2 Optional Back Pressure Restrictors.**

Part Number	Description	Flow Rate	Approx. Back Pressure Added	Flow Rate	Approx. Back Pressure Added
AAA-053763	4 mm Pressure Restrictor	2.0 mL/min	1,000 psi (7 MPa)	1.0 mL/min	500 psi (3.5 MPa)
AAA-053762	4 mm Pressure Restrictor	2.0 mL/min	500 psi (3.5 MPa)	1.0 mL/min	250 psi (1.75 MPa)
053765	2 mm Pressure Restrictor	0.5 mL/min	1,000 psi (7 MPa)	0.25 mL/min	500 psi (3.5 MPa)
053764	2 mm Pressure Restrictor	0.5 mL/min	500 psi (3.5 MPa)	0.25 mL/min	250 psi (1.75 MPa)

### 2.3 Procedure for EGC III K<sub>2</sub>CO<sub>3</sub> Cartridge and EPM III Installation

The section outlines the procedure for installing an EGC III K<sub>2</sub>CO<sub>3</sub> cartridge (P/N 074536) and an EPM III (P/N 080135).

#### 2.3.1 Preparation for Installation

- A. Remove the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge (P/N 074536) from the shipping box. Save the box and the foam for future storage.
- B. Remove the EPM III (P/N 080135) from the shipping box.
- C. Configure the EG module to operate the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge and the EPM III by entering the serial numbers for the cartridge and EPM. Please refer to the EG or System and Chromeleon user manuals for detailed procedures for entering the cartridge and EPM serial numbers.



#### NOTE

- The ICS-5000 EG module will automatically detect the cartridge type and does not require the serial number to be entered manually.
  - The ICS-5000 EG module requires an EGC III and EPM III cartridge. EGC II and EPM cartridges will not be recognized by the ICS-5000 and will not function.
- D. Place the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge on a flat surface in front of the EG module with the Eluent Generator Chamber and the EGC INLET and OUTLET fittings facing up.
  - E. Remove the plugs from the EGC INLET and OUTLET fittings.
  - F. Remove the plugs from the EPM ELUENT and REGEN liquid fittings.
  - G. Turn over the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge (fittings facing down). Shake the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge vigorously, and tap it with the palm of your hand 10 to 15 times to dislodge any air bubbles that may be trapped in the electrolysis chamber.
  - H. Connect the pump outlet to the EGC INLET port of the EGC II K<sub>2</sub>CO<sub>3</sub> cartridge.
  - I. Connect the OUTLET port of the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge to the ELUENT IN port of the EPM III.
  - J. Connect the ELUENT OUTLET port of the EPM III to the ELUENT IN port of the RFIC Eluent Degasser Assembly.
  - K. Connect the ELUENT OUT port of the RFIC Eluent Degasser Assembly to a yellow PEEK backpressure restrictor tubing (P/N 053765).
  - L. Orient the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge with the cable aligned with the slot in the holder of the EG enclosure or ICS system and then slide the EGC III K<sub>2</sub>CO<sub>3</sub> down into the holder until secured.
  - M. Connect the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge electrical cable to the EGC-1 port of the EG enclosure or ICS system.
  - N. Connect the EPM III electrical cable to the EGC-2 port of the EG enclosure or ICS system.



### 2.3.2 Conditioning the EGC III K<sub>2</sub>CO<sub>3</sub> Cartridge and EPM III

- A. Fill a 2-L eluent reservoir bottle (P/N 044129) with deionized water. Use ASTM filtered, Type I (18 megohm) deionized water. Connect the reservoir to the eluent inlet line of the pump.
- B. Prime the pump as instructed by the system operation manual. Set the pump flow rate to 1.0 mL/min.
- C. Unscrew and remove the plug from the vent opening on the side of the EGC III K<sub>2</sub>CO<sub>3</sub> cartridge.
- D. Connect the outlet of the yellow PEEK backpressure restrictor tubing (P/N 053765) to the REGEN IN port of the EPM III.
- E. Connect the REGEN OUT port of the EPM III to the REGEN IN port of the RFIC Eluent Degasser Assembly and connect the WASTE OUT port of the RFIC Eluent Degasser Assembly to waste.
- F. Complete the system plumbing as shown in Figure 17.

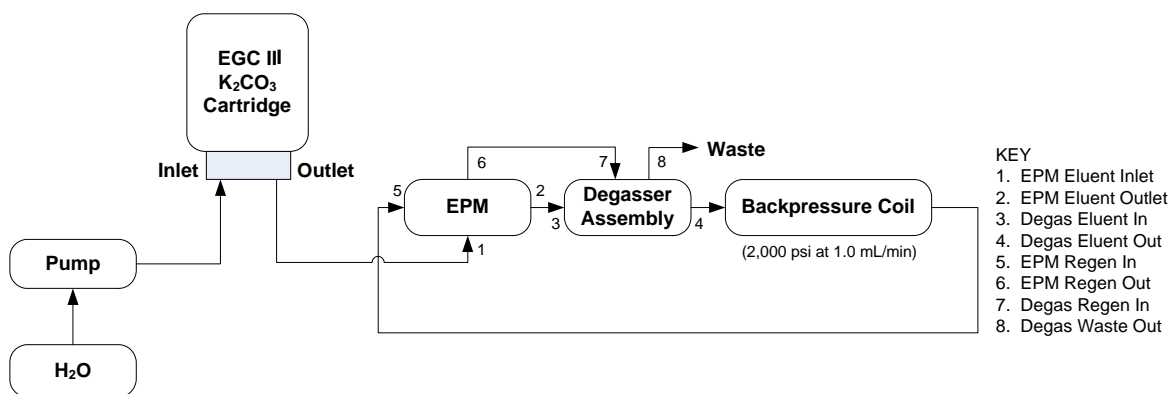


#### NOTE

*The system plumbing shown in Figure 17 is a temporary connection which is only used during the EGC III K<sub>2</sub>CO<sub>3</sub> and EPM III conditioning step.*

- G. Set the pump flow rate at 1.0 mL/min.
- H. Turn on the pump for 5 min to hydrate the EPM III.
- I. Set 9 mM for EGC III K<sub>2</sub>CO<sub>3</sub> (EGC-1) and 1 mM for EPM III (EGC-2) from the control panel and turn on the EGC-1 and EGC-2 current controls.
- J. Run the EGC III K<sub>2</sub>CO<sub>3</sub> and EPM III under these conditions for 30 min.
- K. Turn off the EGC-1 and EGC-2 current controls, and then turn off the pump.

**Figure 17** Plumbing Diagram for Conditioning the EGC III K<sub>2</sub>CO<sub>3</sub> Cartridge and EPM III.



### 2.3.3 Filling the EGC Carbonate Mixer with the $K_2CO_3$ / $KHCO_3$ Eluents of Desired Concentration

- A. Install the EGC Carbonate Mixer in the EG enclosure or the side of the EGC cartridge holder by pushing the mixer onto the Mixer holder clip. The outlet of the EGC Carbonate Mixer must point upward to ensure thorough mixing of the eluent.
- B. Disconnect the pump outlet from the INLET of the EGC III  $K_2CO_3$  cartridge.
- C. Connect the pump outlet to the inlet of EGC Carbonate Mixer and fill the EGC Carbonate Mixer with deionized water by operating the pump in the ICS-3000 or ICS-2000 system at 5.0 mL/min. Operate the pump for 5 minutes to fill a 4-mm EGC Carbonate Mixer and 2 minutes to fill a 2-mm EGC Carbonate Mixer or until there is a consistent flow of water coming out the outlet of the Mixer.



#### WARNING

*Please ensure that both EGC-1 and EGC-2 current controls are turned off in this step.*

- D. Disconnect the pump outlet from the inlet of the EGC Carbonate Mixer.
- E. Connect the pump outlet to the INLET of the EGC III  $K_2CO_3$  cartridge.
- F. Connect the outlet of the yellow PEEK backpressure restrictor tubing (P/N 053765) to the union attached to the inlet of the EGC Carbonate Mixer.
- G. Connect the OUTLET of the mixer to the REGEN IN port of the EPM III. Connect the REGEN OUT port of the EPM III to the REGEN IN port of the RFIC Eluent Degasser Assembly. Divert the WASTE OUT port of the RFIC Degasser Assembly to waste.
- H. Complete the system plumbing as shown in x.
- I. Operate both the EGC III  $K_2CO_3$  cartridge and EPM III under the conditions to generate carbonate and bicarbonate eluent of desired  $K_2CO_3$  /  $KHCO_3$  concentration. The main purpose of this step is to fill the EGC Carbonate Mixer with the eluent of the desired concentration (e.g. 4.5 mM  $K_2CO_3$ /1.4 mM  $KHCO_3$  for AS22 columns) for your application.
- J. The 4-mm EGC Carbonate Mixer has a void volume of about 16 mL. At 1.0 mL/min, it will take about 45 minutes to displace the deionized water and fill the mixer with the  $K_2CO_3$  /  $KHCO_3$  eluent having the desired concentration upon initial installation. The 2-mm EGC Carbonate Mixer has a void volume of approximately 5.0 mL. At 1.0 mL/min, it will take about 15 minutes to displace the deionized water and fill the Mixer with the  $K_2CO_3$  /  $KHCO_3$  eluents of the set concentration upon initial installation.

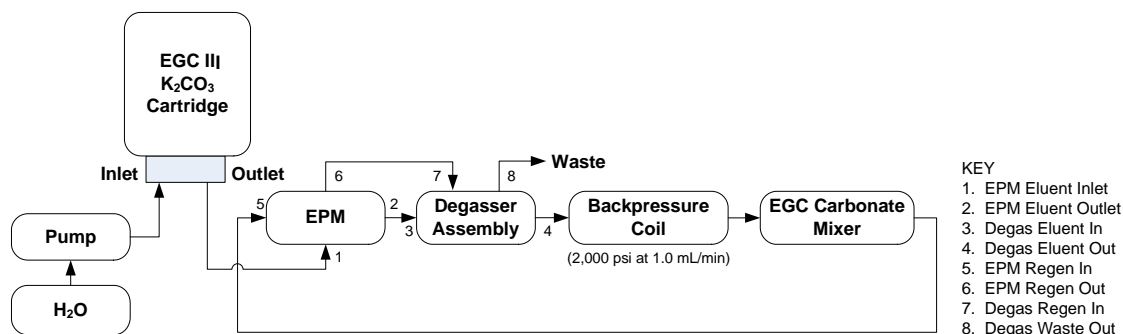


#### NOTE

*The system backpressure should be adjusted between 2000 – 2300 psi at a flow rate of 1 mL/min. This step is very important to ensure fast system equilibration and startup.*

- K. Turn off the EG-1 and EG-2 current controls, and then turn off the pump.
- L. Replace the yellow backpressure tubing with a piece of 0.010-inch ID black PEEK tubing of appropriate length to connect between the ELUENT OUT port of the RFIC Eluent Degasser Assembly to the union attached to the inlet port of the EGC Carbonate Mixer.

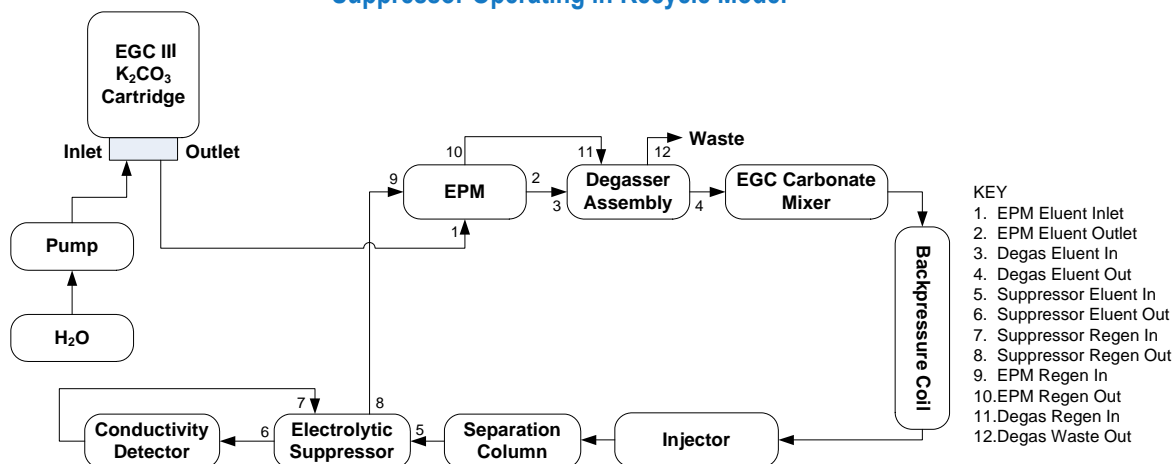
**Figure 18** Plumbing Diagram for Filling the EGC Carbonate Mixer with the  $K_2CO_3$  /  $KHCO_3$  Eluents of Desired Concentration.



### 2.3.4 Operation of the Electrolytic $K_2CO_3$ / $KHCO_3$ Eluent Generator for Ion Chromatographic Application

- Complete the entire system plumbing as shown in x for your application.
- Adjust the length of the backpressure tubing between the INLET of the injection valve and the OUTLET of the EGC Carbonate Mixer if needed to ensure the system backpressure is adjusted between 2000 – 2300 psi at the system operation flow rate.
- Make sure to connect the REGEN OUT port of the suppressor to the REGEN IN port of the EPM III.
- Turn on the pump at the flow rate recommended for your application.

**Figure 19** Plumbing Diagram for Electrolytic Generation of Carbonate / Bicarbonate Eluents Using  $K_2CO_3$  and Electrolytic pH Modifier with Electrolytic Suppressor Operating in Recycle Mode.



## 3. Operation

### 3.1 Routine Operation for analytical scale systems

For analytical scale operation ( $\geq 1$  mm), the recommended system backpressure is 2,000 – 3,000 psi (14 - 21 MPa) for the EGC III, or 2,000 - 5,000 psi (14 - 34.5 MPa) for the EGC 500; a system back pressure of 2,300 psi is ideal. If necessary, add a backpressure restrictor to increase the pressure. The pressure restrictor tubing is located in the Eluent Generator Module or System ship kit. See Section 2.1 for instructions.

### 3.2 Routine Operation for capillary scale systems

For capillary scale operation ( $< 1$  mm), the recommended system backpressure is 1,000 – 5,000 psi (7 - 35 MPa); a system back pressure of 2,000 psi is ideal. Backpressure restrictor tubing is not recommended for capillary systems.

### 3.3 Operating Precautions

- A. The EG Module generates eluent by means of electrolysis which results in the production of small amounts of oxygen or hydrogen gas. Ensure that the Gas Separator Waste Tube, provided with your conductivity detector, is installed.
- B. Operate the EG in properly ventilated areas only.
- C. Ensure a vent line is attached to the EGC vent port. The end of the vent line should be placed in a waste container in case of electrolyte overflow.



#### NOTE

*Under certain conditions it is normal for the EGC electrolyte level to increase or decrease over time. A small amount (10's of mL) of electrolyte discharge through the vent port is normal and should not affect operation.*

- D. DO NOT CAP THE WASTE RESERVOIR! The small amount of gas generated by the EG and the Electrolytic Suppressor (SRS, AES or CES) is not dangerous unless the gas is trapped in a closed container and allowed to accumulate. The Gas Separator Waste Tube must be open to the atmosphere in order to operate properly.
- E. Do not operate a chromatography system where the Eluent Generator (EG) is plumbed into the system, but not software controlled. The excessive pressures that are allowed in systems without an EG can damage components.
- F. The pressure limits protect the degas tubing assembly from mechanical failure. Excessive backpressure may cause the degas tubing assembly to rupture.
  - i. For analytical scale operation ( $\geq 1$  mm), the recommended maximum operating pressure for the EG Module is 3,000 psi (21 MPa) (EGC III) or 5,000 psi (34.5 MPa) (EGC 500), however 2,300 psi is ideal.
  - ii. For capillary scale operation ( $< 1$  mm), the recommended maximum operating pressure for the EG Module is 5,000 psi (34.5 MPa).
- G. Due to the high backpressure, exercise care when using solvents with the following columns: the IonPac AS11-HC or CarboPac™ PA10.

**NOTE**

*For analytical scale operation ( $\geq 1$  mm), solvents may be used if the flow rate is reduced sufficiently to reduce the system pressure to less than 3,000 psi (21 MPa) (EGC III) or 5,000 psi (34.5 MPa) (EGC 500).*

- H. Due to the high backpressure, do not operate the EG with the following columns: the IonPac AS5A, IonPac AS10, OmniPac® PAX-100, or OmniPac PAX-500 unless the flow rate has been reduced to lower the system pressure to less than 3,000 psi (21 MPa) or an EGC 500 is used in a high pressure IC system such as the ICS-5000+. Excessive backpressure may cause the degas tubing assembly to rupture.
- I. Do not operate the EGC 500 KOH, EGC III KOH, NaOH, LiOH or EGC-KOH (Capillary) with solvents other than methanol (maximum 25%) for anion separations.
- J. Do not operate the EGC III K<sub>2</sub>CO<sub>3</sub>, EGC 500 MSA, EGC III MSA, EGC-MSA (Capillary) or EPM III with any solvent content.
- K. To prevent the buildup of hydrogen and oxygen gases, install the EG Module in a well-ventilated site.
- L. Make sure the Suppressor Gas Separator Waste Tube (P/N 045460) is correctly installed. The tube is used to dissipate the small amounts of hydrogen and oxygen gases that are generated during EG and Suppressor operation.
- M. Do not allow the flow rate of the EGC III or EGC 500 to drop to a level where the backpressure can fall below 2,000 psi (14 MPa). The degas assembly will not properly degas the eluent if the system pressure is below 2,000 psi and gas will build up on the analytical column.
- N. For anion exchange separations, carbonate may accumulate on the columns at low hydroxide concentrations. This accumulated carbonate will elute from the column when the hydroxide concentration is increased.

## 3.4 System Shutdown

### 3.4.1 Short-Term Shutdown

Dionex recommends continuous operation of your IC system for the most trouble-free operation. For analytical scale operation ( $\geq 1$  mm), a microbore system will provide the most economical operation. Capillary scale systems ( $< 1$  mm) are designed to be operated non-stop for months at a time and provide the ultimate in economical operation.

The EGC 500, EGC III, EGC (Capillary) or EPM III may be left in the EG Module for short-term storage up to three months. The system should be shutdown using the following methods:

- A. Turn System OFF Completely:
  - i. Turn the pump, EGC, CR-TC, and Suppressor off.
  - ii. Check that the current to the EGC, CR-TC and Suppressor are off.

**NOTE**

*The suppressor should only be stored for up to 1 week with eluent in the chambers. See the suppressor user's guide for further instructions.*

- B. To restart the system:
- Apply the required system settings.
  - Allow the system to equilibrate for 30-45 minutes prior to collecting data.



### NOTE

*If the system has been shut down for more than 3-4 days, the Suppressor should be rehydrated prior to starting pump flow.*

See the appropriate Suppressor manual for Suppressor start-up details.

### 3.4.2 Long-Term Shutdown

For long-term storage, the EGC III may be left in the EG module, but the EGC cable should be disconnected. If you need to remove the cartridge and store it, follow the directions in Section 5.1 (a-f). Cap all vents and liquid connections. The pump may be used for conventional delivery of eluents by connecting the outlet of the pump pressure transducer to the INJ IN port on the Rheodyne injection valve.

## 4. Example Applications

### 4.1 Principles of Operation

#### 4.1.1 Hydroxide based Applications

The Eluent Generator Cartridges – EGC 500 KOH, EGC III KOH, EGC III NaOH, EGC III LiOH and EGC-KOH (Capillary) – may be used to generate isocratic or gradient eluents. The EGC 500, EGC III KOH and EGC III NaOH can generate up to 100 mM KOH or NaOH at 1.0 mL/min. The EGC III LiOH can generate up to 80 mM LiOH at 1.0 mL/min. The EGC-KOH (Capillary) cartridge may be used to generate up to 200 mM KOH at 0.010 mL/min.

Eluent concentrations up to 50 mM KOH or NaOH can be produced at 2.0 mL/min. Eluent concentrations up to 40 mM LiOH can be produced at 2.0 mL/min. Eluent concentrations up to 100 mM KOH can be produced at 0.020 mL/min.

Up to 25% methanol may be used in the eluent with an EGC 500 KOH or EGC III KOH, NaOH or LiOH.

#### 4.1.2 Carbonate based Applications

The Eluent Generator Cartridges – EGC III  $K_2CO_3$  and EPM III – may be used to generate isocratic eluents; gradient eluents are not recommended. The EGC III  $K_2CO_3$  can generate up to 15 mM  $K_2CO_3$  at 1.0 mL/min. The EPM III can convert up to 10 mM  $K_2CO_3$  to  $KHCO_3$  at 1.0 mL/min.

Eluent concentrations up to 7.5 mM  $K_2CO_3$  can be produced at 2.0 mL/min. Up to 5.0 M  $K_2CO_3$  can be converted to  $KHCO_3$  at 2.0 mL/min.

No solvents can be used in the eluent with an EGC III  $K_2CO_3$  or EPM III.

#### 4.1.3 Methanesulfonic acid based Applications

The Eluent Generator Cartridges – EGC 500 MSA, EGC III MSA and EGC-MSA (Capillary) – may be used to generate isocratic or gradient eluents. The EGC 500 MSA and EGC III MSA can generate up to 100 mM MSA at 1.0 mL/min. The EGC-MSA (Capillary) cartridge may be used to generate up to 200 mM MSA at 0.010 mL/min.

Eluent concentrations up to 50 mM MSA can be produced at 2.0 mL/min. Eluent concentrations up to 100 mM MSA can be produced at 0.020 mL/min.

No solvents can be used in the eluent with an EGC 500 MSA, EGC III MSA or EGC-MSA (Capillary)

#### 4.1.4 EGC and EPM Operating Conditions

The EGC and EPM products may be used with the columns and eluent conditions listed below. Verify the performance of the entire system by duplicating the column test chromatogram.

##### A. EGC General Operating Conditions:

Maximum Flow Rate (4 mm operation):	3.0 mL/min.
Maximum Flow Rate (2 mm operation):	0.75 mL/min.
Maximum Flow Rate (Capillary operation):	0.030 mL/min.
Maximum System Pressure (EGC III):	3,000 psi (21 MPa).
Maximum System Pressure (EGC 500 and EGC (Capillary)):	5,000 psi (35 MPa).
Minimum Recommended System Pressure (EGC 500 and EGC III):	2,000 psi (14 MPa); use optional Pressure Restrictor as required.
Minimum Recommended System Pressure (Capillary):	1,000 psi (7 MPa); Pressure Restrictor is not recommended.

##### B. Anion Exchange EGC 500 KOH, EGC III KOH and NaOH and EGC-KOH (Capillary):

Concentration Range for 4 mm operation:	Up to 100 mM KOH or NaOH at 1.0 mL/min; 50 mM at 2.0 mL/min.
Concentration Range for 2 mm operation:	Up to 100 mM KOH or NaOH at 0.25 mL/min.
Concentration Range for capillary operation:	Up to 200 mM KOH at 0.010 mL/min; 100 mM at 0.020 mL/min.
Solvent Concentration Range:	Up to 25% Methanol.
Columns:	All hydroxide selective columns.



#### NOTE

*The EGC III NaOH can be used with equivalent results to the EGC III KOH.*

##### C. Anion Exchange EGC III LiOH:

Concentration Range for 4 mm operation:	Up to 80 mM LiOH at 1.0 mL/min; 40 mM at 2.0 mL/min.
Concentration Range for 2 mm operation:	Up to 80 mM LiOH at 0.25 mL/min.
Solvent Concentration Range:	Up to 25% Methanol.
Columns:	All hydroxide selective columns.

##### D. Anion Exchange EGC III K<sub>2</sub>CO<sub>3</sub>:

Concentration Range for 4 mm operation:	Up to 15 mM K <sub>2</sub> CO <sub>3</sub> at 1.0 mL/min; 7.5 mM at 2.0 mL/min.
Concentration Range for 2 mm operation:	Up to 15 mM K <sub>2</sub> CO <sub>3</sub> at 0.25 mL/min.
Solvent Concentration Range:	Not compatible with any solvents.
Columns:	All carbonate based anion exchange columns.



## E. Anion Exchange EPM III:

Concentration Range for 4 mm operation:	Convert up to 10 mM $K_2CO_3$ to $KHCO_3$ at 1.0 mL/min; 5.0 mM at 2.0 mL/min.
Concentration Range for 2 mm operation:	Convert up to 10 mM $K_2CO_3$ to $KHCO_3$ at 0.25 mL/min.
Solvent Concentration Range:	Not compatible with any solvents.
Columns:	All carbonate based anion exchange columns.

## F. Cation Exchange EGC 500 MSA, EGC III MSA and EGC-MSA (Capillary)

Concentration Range for 4 mm operation:	Up to 100 mM MSA at 1.0 mL/min; 50 mM at 2.0 mL/min.
Concentration Range for 2 mm operation:	Up to 100 mM MSA at 0.25 mL/min.
Concentration Range for capillary operation:	Up to 200 mM MSA at 0.010 mL/min; 100 mM at 0.020 mL/min.
Solvent Concentration Range:	Not compatible with any solvents.
Columns:	All cation exchange columns compatible with MSA eluents.

#### 4.1.5 Duplication of Conventional Gradient Methods using the Offset Volume

If the Eluent Generator system is connected to a gradient pump, gradients can be generated from both the pump and from the Eluent Generator system. Because the Eluent Generator system is downstream from the pump, gradients generated by the Eluent Generator system reach the column faster than gradients generated at the pump. PeakNet or Chromeleon software can automatically compensate for this timing difference by using an offset volume value. The offset volume is the fluid volume between the pump gradient mixing chamber outlet and the Eluent Generator outlet. Once this value is determined and entered the system software will synchronize the pump and Eluent Generator system operation, allowing gradients from both the pump and the Eluent Generator system to reach the column at the same time.

**Dionex recommends an offset volume of 0  $\mu\text{L}$  for most applications.** However, an offset volumes of 0 - 2000  $\mu\text{L}$  may be specified in the Eluent Generator system software. The default value is 0  $\mu\text{L}$ . The actual offset volume may be different depending on the system configuration (tubing lengths, and whether the system is 2 mm or 4 mm). To determine the volume, follow the instructions below.

The offset volume has no effect when using isocratic eluent generation but does delay the Eluent Generator system timed events. For isocratic Methods the offset volume value should be set to 0  $\mu\text{L}$ .

##### **Determining the Offset Volume Value:**

Before starting this procedure, set up the system for normal operation.

- A. Fill pump reservoir A with 100% deionized water.
- B. Fill a reservoir with 10 mM KOH or MSA (whichever eluent the Eluent Generator system will be generating) and connect the reservoir to the pump as reservoir B.
- C. In the PeakNet pump/Eluent Generator system Method Setup dialog box, enter an Offset Volume of 0  $\mu\text{L}$ .
- D. In the Method Editor dialog box, set the same concentration step change for both the pump and the Eluent Generator system to start at the same timed event. The step change should be large enough to affect the detector output readings, but not so large that the output goes off scale.

##### For example:

At time INIT, select 100% from reservoir A (deionized water) for the pump eluent and 0 mM for the Eluent Generator system generated eluent.

At time 0.0, select 10% from reservoir B (a 1.0 mM solution of eluent) and select 1.0 mM for the Eluent Generator system eluent concentration.

- E. Connect the pump outlet directly to a length of 0.005" ID tubing which generates a system back pressure of about 2,000 psi (14 MPa) at the chosen flow rate (e.g. 1.0 mL/min) Connect to the inlet of the conductivity cell.
- F. Monitor the conductivity detector response.
  - i. The first increase in detector response is the new eluent concentration arriving from the Eluent Generator system. Note the time this occurs.
  - ii. The second increase in detector response is the new eluent concentration arriving from the pump. Note the time this occurs.
  - iii. Calculate the time difference between the first and second increases in detector response.
  - iv. Multiply the time difference (in minutes) by the flow rate (in mL/min x 1,000) to get the offset volume value (in  $\mu\text{L}$ ).
- G. After calculating the offset volume, enter its value into the pump/Eluent Generator software control.

## 4.2 Verifying the System Configuration

After configuring the system, run the standard chromatogram for your column. Be sure to run the analysis at the temperature given for the chromatogram, if one is listed. If no temperature is listed, the chromatogram should be run at room temperature. If the chromatogram obtained matches the test chromatogram included with the column, the system is operating correctly for that set of system operating parameters. If the chromatogram obtained does not match the sample chromatogram, see Section 6 for troubleshooting information.

## 4.3 Using the EGC 500 KOH or EGC III KOH Cartridge for IonPac AS11 Hydroxide Gradients

This application demonstrates the comparison of an IonPac AS11 gradient separation using conventional gradient pump delivery with the gradient separation using EG50 gradient delivery. Figure 20, “Conventional Hydroxide Gradient on the IonPac AS11,” illustrates the use of a conventional pump method. Since the EGC is located close to the injection valve, the gradient reaches the head of the column more quickly resulting in a shift in the gradient as shown in Figure 21, “EGC KOH Gradient on the IonPac AS11.” Figure 21 illustrates the use of and EGC with an identical gradient program using the default OFFSET VOLUME of 0  $\mu\text{L}$ . In Figure 22, “EGC KOH Gradient on the IonPac AS11 (OFFSET VOLUME = 400  $\mu\text{L}$ ),” the value for the OFFSET VOLUME is set to 400  $\mu\text{L}$ . Chromeleon uses this value to delay the EGC gradient program by 0.2 minutes (0.400 mL / 2 mL per minute).

Note that the baseline shift using the gradient pump is approximately 1.5  $\mu\text{S}$ . Using the EGC to generate carbonate-free hydroxide reduces the baseline shift to approximately 50 nS.

Trap Column: ATC-3, (Located between pump and injection valve);



NOTE

*The ATC-3 Trap Column may be replaced with an ATC-HC Trap Column after the pump.*



NOTE

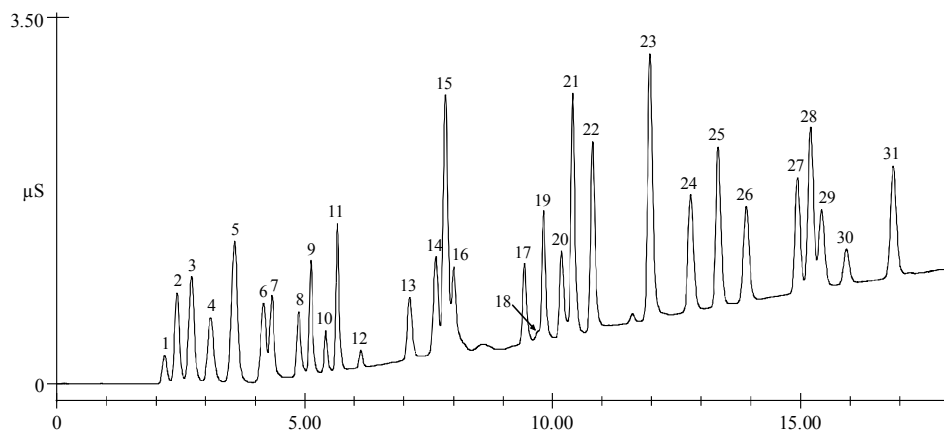
*For systems other than the EG40, use the CR-ATC 500 continuously Generated Trap Column instead of the ATC-3 or ATC-HC Trap Columns. The CR-ATC 500 is located after the EGC KOH cartridge.*

## 4 – Example Applications

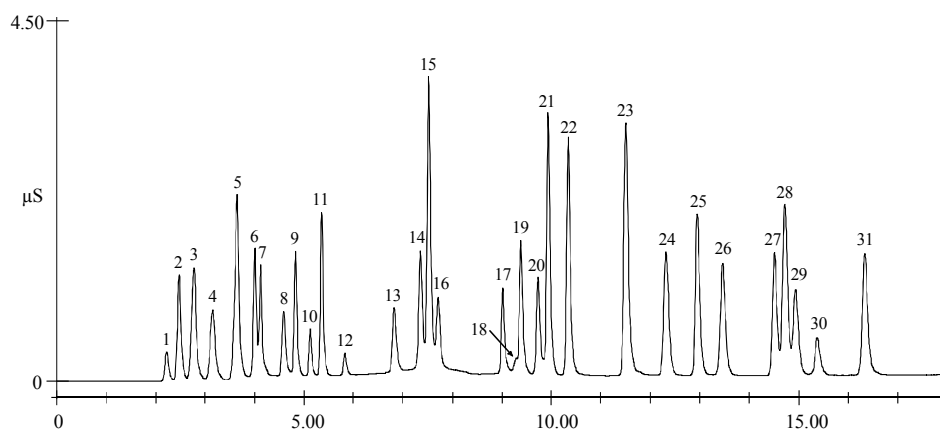
Sample Volume:	10 µL
Column:	IonPac AS11 Analytical and AG11 Guard (4-mm)
Eluent:	See table of conditions
Eluent Flow Rate:	2.0 mL/min
Suppressor:	Anion Self-Regenerating Suppressor 300 (4-mm) AutoSuppression® Recycle Mode
Expected Background Conductivity: (GP40 or GP50) (EG50)	0.5 mM NaOH: 1 µS      35 mM NaOH: 2.5 µS 0.5 mM NaOH: 0.7 µS      35 mM NaOH: 0.75 µS
Typical Operating Back Pressure: (GP40 or GP50) (EG50)	1850 psi (12.75 MPa) 2200 psi (15.15 MPa) Pressure Restrictor, (P/N 53762) was used with the EG50

Analyte		mg/L(ppm)	GP50GP40 Conditions				
1.	Quinate	5	E1:	Deionized water			
2.	Fluoride	1	E2:	5.0 mM NaOH			
3.	Acetate	5	E3:	100 mM NaOH			
4.	Propionate	5	Time	%E1	%E2	%E3	Comments
5.	Formate	5	(min)				
6.	Methylsulfonate	5	Equilibration				
7.	Pyruvate	5	0	90	10	0	0.5 mM NaOH for 7 min
8.	Valerate	5	7.0	90	10	0	
9.	Monochloroacetate	5	Analysis				
10.	Bromate	5	0.0	90	10	0	0.5 mM NaOH, Inject
11.	Chloride	2	0.2	90	10	0	Inject Valve to Load Position
12.	Nitrite	5	2.5	90	10	0	0.5-5.0 mM NaOH in 3.5 min
13.	Trifluoroacetate	5	6.0	0	100	0	5.0-38.25 mM NaOH in 12 min
14.	Bromide	3	18.0	0	65	35	
15.	Nitrate	3					
16.	Chlorate	3					
17.	Selenite	5					
18.	Carbonate	trace	EG50 Conditions				
19.	Malonate	5	Eluent: Deionized water				
20.	Maleate	5	Time	Eluent		Comments	
21.	Sulfate	5	(min)	Conc. (mM)			
22.	Oxalate	5	Equilibration				
23.	Tungstate	10	0	0.5		0.5 mM KOH for 7 min	
24.	Phthalate	10	7.0	0.5			
25.	Phosphate	10	Analysis				
26.	Chromate	10	0.0	0.5		0.5 mM KOH, Inject	
27.	Citrate	10	0.2	0.5		Inject Valve to Load Position	
28.	Tricarballoylate	10	2.5	0.5		0.5-5.0 mM KOH in 3.5 min	
29.	Isocitrate	10	6.0	5.0		5.0-38.3 mM KOH in 12 min	
30.	cis-Aconitate	10	18.0	38.3			
31.	trans-Aconitate	10					

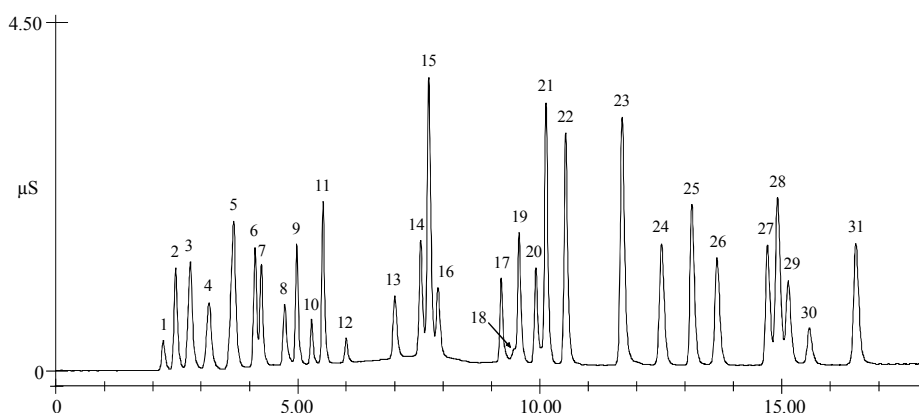
**Figure 20 Conventional Hydroxide Gradient on the IonPac AS11**



**Figure 21 EGC II KOH Gradient on the IonPac AS11 (OFFSET VOLUME = 0  $\mu$ L)**



**Figure 22 EGC II KOH Gradient on the IonPac AS11 (OFFSET VOLUME = 400  $\mu$ L)**

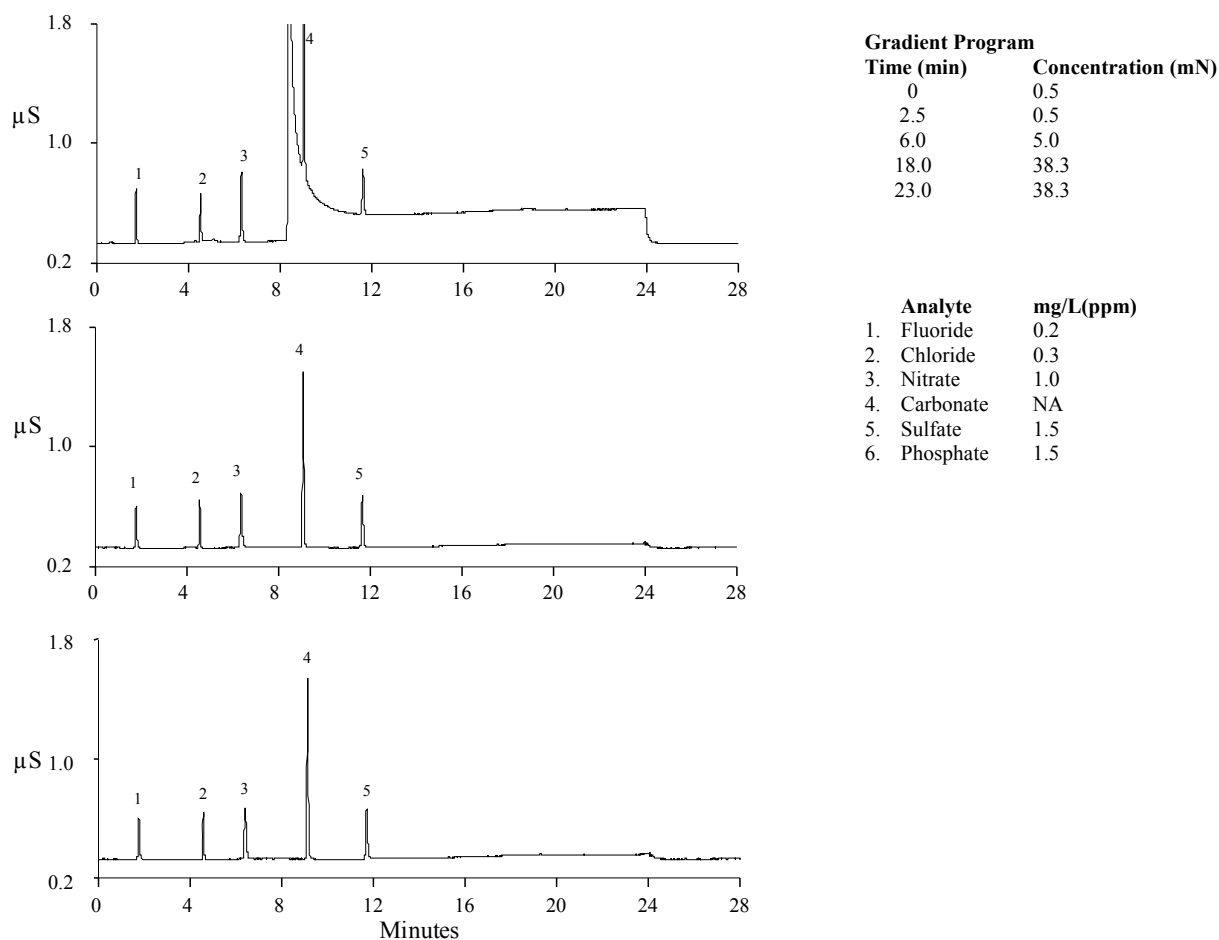


## 4.4 Comparison of Eluent Generation with ATC-HC and CR-ATC for IonPac AS11 Gradient

This set of chromatograms demonstrates the decrease in baseline shift during a gradient when the ATC-HC or CR-ATC is used. The CR-ATC does not require off-line chemical regeneration.

Column: IonPac AS11 Analytical (4-mm)  
 Eluent: EG50 generated KOH  
 Flow Rate: 2.0 mL/min  
 Inj. Volume: 10  $\mu$ L  
 Detection: Suppressed Conductivity  
 Temperature: 30°C  
 Suppressor: ASRS® 300 (4-mm), Recycle Mode

**Figure 23 Comparison of EG50 with ATC-HC and CR-ATC for IonPac AS11 Gradient**



Background ( $\mu$ S/cm)

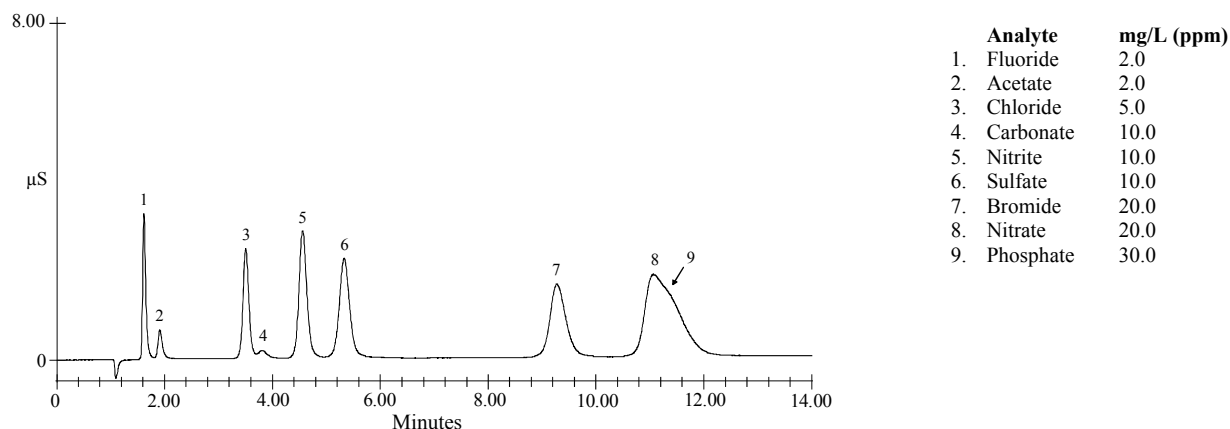
	Start	End	Drift
EG50	0.33	0.56	0.23
ATC-HC	0.32	0.36	0.04
CR-ATC	0.32	0.36	0.04

## 4.5 Using the EGC III KOH or EGC 500 KOH Cartridge for IonPac AS15 Isocratic Elution

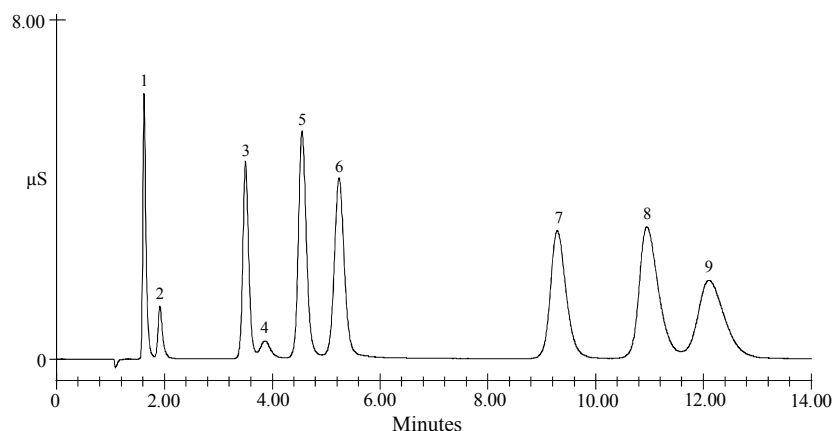
This application demonstrates the comparison of an IonPac AS15 isocratic separation using conventional pump delivery to EG50 eluent delivery. Figure 24, “Conventional Hydroxide Eluent on the IonPac AS15,” illustrates use of a conventional method. Figure 25, “EGC KOH Eluent on the IonPac AS15,” illustrates the use of the EGC with an identical isocratic program using an OFFSET VOLUME of 400  $\mu$ L. The offset volume has no effect on isocratic EGC eluent delivery. In Figure 25, the chromatogram generated using the GP50 with conventional delivery of KOH was contaminated from carbonate in the DI reagent water used to make the KOH eluent. This contamination decreases the pH of the eluent and causes phosphate to coelute with nitrate. Use of the EGC eliminates the eluent contamination problem, resulting in baseline resolution of nitrate and phosphate.

Sample Volume: 25  $\mu$ L  
 Column: IonPac AS15 analytical (4-mm) and AG15 guard (4-mm)  
 Eluent: 40 mM KOH  
 Eluent Flow Rate: 2.0 mL/min  
 Suppressor: Anion Self-Regenerating Suppressor 300 (4-mm)  
 Temperatures: 30°C  
 Expected Background Conductivity: AutoSuppression® Recycle Mode  
 0.8-1.2  $\mu$ S (EG50) 2-3  $\mu$ S (GP40, GP50, or GS50)  
 Typical Operating Back Pressure: 2100 psi (EG50) 1700 psi (GP40, GP50, or GS50)  
 Back pressure restrictor was not used with the EG50

**Figure 24 Conventional Hydroxide Eluent on the IonPac AS15**



**Figure 25 EGC II KOH Eluent on the IonPac AS15**

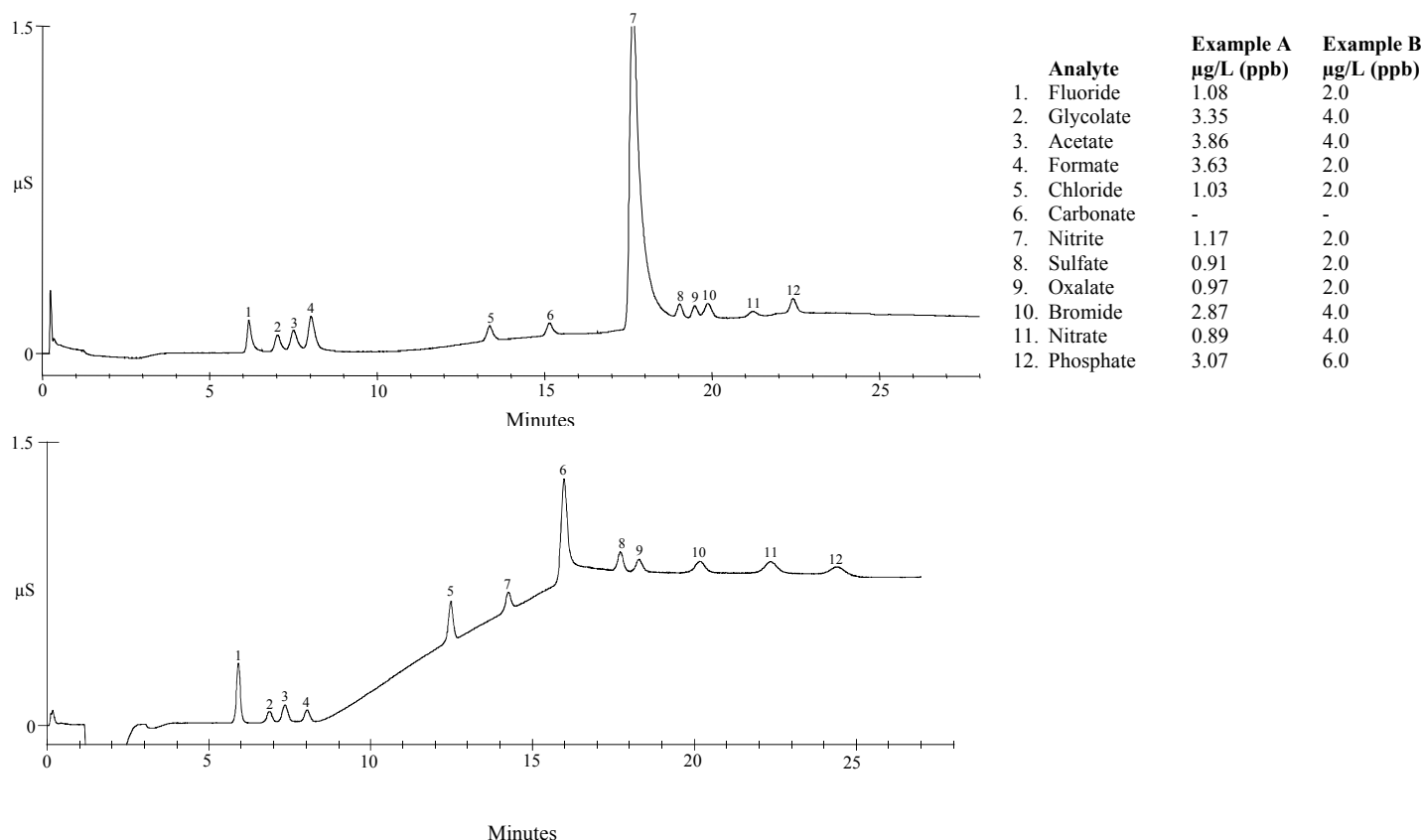


## 4.6 Comparison of Conventional Bottle Eluent System and Eluent Generator System

The following example illustrates a comparison of a gradient delivered using conventional pump delivery and using an EGC. When using the conventional gradient delivery, dissolved carbonate causes a baseline shift of approximately 1  $\mu\text{S}$ . The carbonate-free potassium hydroxide gradient produced by the EGC results in a very low baseline shift ( $< 0.1 \mu\text{S}$ ). This low baseline shift allows easy integration of trace components.

Sample Loop Volume:	2 mL
Trap Columns:	IonPac ATC-1 (2), 1 after pump; 1 between EG50 degas assembly and injector. NOTE: The ATC-1 Trap Columns should be replaced with one ATC-HC Trap Column after the pump. NOTE: For systems with the on Kit or RFC-30 Module, use the CR-ATC continuously Generated Trap Column instead of the ATC-1 or Trap Columns. The CR-ATC is located after the EGC II KOH cartridge.
EG50, EG40 Add-ATC-HC Column:	IonPac AS15 + IonPac AG15 (4-mm)
Eluent:	See Chromatogram
Eluent Source:	See chromatogram
Eluent Flow Rate:	1.6 mL/min.
Temperature:	30° C
SRS Suppressor:	Anion Self-Regenerating Suppressor 300 AutoSuppression Recycle Mode
MMS Suppressor	Anion MicroMembrane Suppressor, AMMS 300
MMS Regenerant:	50 mN H <sub>2</sub> SO <sub>4</sub>
Expected Background Conductivity:	EG50 eluent: 0.8-1.2 $\mu\text{S}$ Bottle eluent: 2-3 $\mu\text{S}$

**Figure 26 Comparison of Eluent Generator System with Conventional Bottle Eluent System**



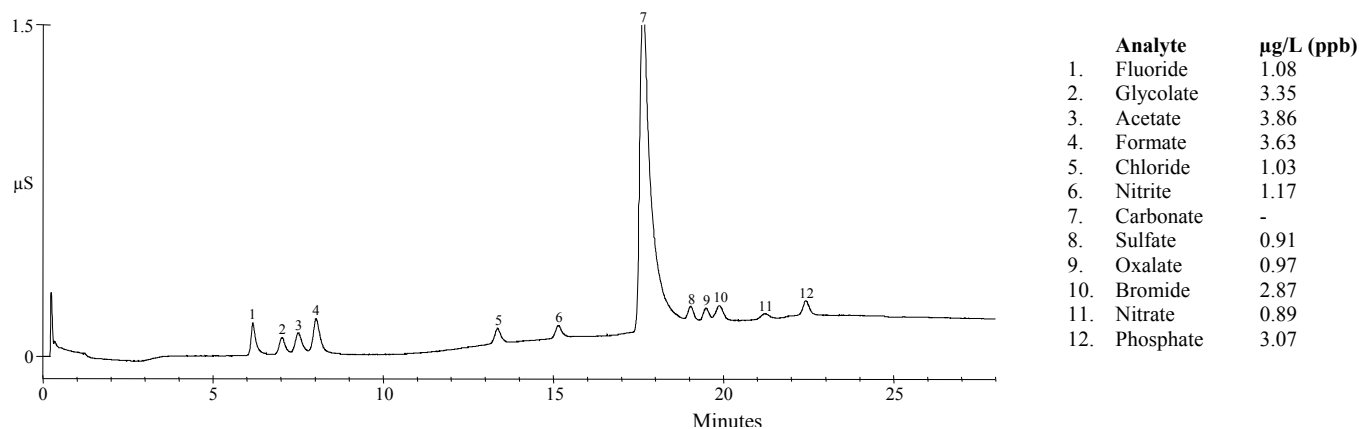


## 4.7 Large Loop Injection for µg/L (ppb) Level Analysis on a 2 mm AS15

High capacity of the AS15 column allows for the determination of trace inorganic anions and low molecular weight organic acids in high purity water matrices using a large loop injection. This chromatogram illustrates the separation of inorganic anions and low molecular weight organic acids in a high purity water sample using a large loop injection with a hydroxide linear gradient coupled with suppressed conductivity detection. Low ppb levels of these analytes can easily be determined using a 1 mL injection loop on a 2-mm AS15 column. Notice the much lower baseline shift produced when using the EG50 as the eluent source. To ensure reproducible retention times, the AS15 column must be operated at an elevated temperature (30° C).

Sample Loop Volume: 1 mL  
 Trap Columns: IonPac ATC-1 (2), 1 after pump; 1 between EG50 degas assembly and injector. NOTE: The ATC-1 Trap should be replaced with one ATC-HC Trap Column after the pump. NOTE: For systems with the EG50, on Kit or RFC-30 Module, use the CR-ATC continuously Generated Trap Column instead of the ATC-1 or Trap Columns. The CR-ATC is located after the EGC II KOH cartridge.  
 Columns: IonPac AS15 + IonPac AG15 (2-mm).  
 Eluent Source: EG50  
 Eluent: 8 mM KOH (0-6 min.)  
 8-60 mM KOH (6-16 min.)  
 Eluent Flow Rate: 0.5 mL/min.  
 Temperature: 30° C  
 SRS Suppressor: Anion Self-Regenerating Suppressor 300  
 AutoSuppression External Water Mode  
 or MMS Suppressor: Anion MicroMembrane Suppressor, AMMS 300  
 MMS Regenerant: 50 mN H<sub>2</sub>SO<sub>4</sub>  
 Expected Background Conductivity: 0.8-1.2 µS

**Figure 27 Large Loop Injection for µg/L (ppb) analysis on 2-mm AS15**



## 4.8 Comparison of Conventional Eluent System and Eluent Generator System for Gradient Elution on the IonPac AS16

Figure 28, “Separation of Polarizable Anions and Inorganic Anions using Gradient Elution,” illustrates the separation of a wide variety of inorganic anions including polarizable anions. Weakly retained anions such as acetate, propionate, and formate are resolved using an isocratic hydroxide eluent and the highly retained anions such as thiosulfate, thiocyanate, and perchlorate are eluted with a hydroxide gradient. Peak shape and efficiency are greatly improved for the polarizable anions on the IonPac AS16 column.

The following example also illustrates a comparison of a gradient delivered using a bottle eluent system and using the EGC Eluent Generator system. When using the conventional bottle eluent delivery, dissolved carbonate causes a baseline shift of approximately 1  $\mu$ S. The carbonate free potassium hydroxide gradient produced by the EGC results in a very low baseline shift (<0.3  $\mu$ S). This low baseline shift allows easy integration of trace components.

Trap Column:  
replaced with an  
located between  
one ATC-HC Trap  
Module, use the CR-  
The CR-ATC is  
Sample Volume:  
Column:  
Eluent:

Eluent Flow Rate:  
Operating Temperature:  
SRS Suppressor:

or MMS Suppressor:  
MMS Regenerant:  
Expected Background Conductivity:  
Typical Operating Back Pressure:

Analyte	mg/L (ppm)
1. Fluoride	2.0
2. Acetate	10.0
3. Propionate	10.0
4. Formate	10.0
5. Chlorite	10.0
6. Bromate	10.0
7. Chloride	5.0
8. Nitrite	10.0
9. Nitrate	10.0
10. Selenite	10.0
11. Carbonate	20.0
12. Sulfate	10.0
13. Selenate	10.0
14. Iodide	20.0
15. Thiosulfate	10.0
16. Chromate	20.0
17. Phosphate	20.0
18. Arsenate	20.0
19. Thiocyanate	20.0
20. Perchlorate	30.0

Bottle Eluent System, ATC-1 located after pump. NOTE: The ATC-1 Trap Column should be ATC-3 (4-mm) Trap Column (P/N 059660). EG50 system, ATC-1 (2), 1 located after pump; 1 EG50 degas assembly and injector. NOTE: The ATC-1 Trap Columns should be replaced with Column after the pump. NOTE: For systems with the EG50, EG40 Add-on Kit or RFC-30 ATC continuously Generated Trap Column instead of the ATC-1 or ATC-HC Trap Columns.

10  $\mu$ L  
IonPac AS16 4-mm analytical and AG16 4-mm guard  
E1: 5.0 mM NaOH  
E2: Deionized water  
E3: 100 mM NaOH

1.5 mL/min  
30° C  
Anion Self-Regenerating Suppressor 300 (4-mm)  
AutoSuppression® Recycle Mode  
Anion MicroMembrane Suppressor, AMMS 300

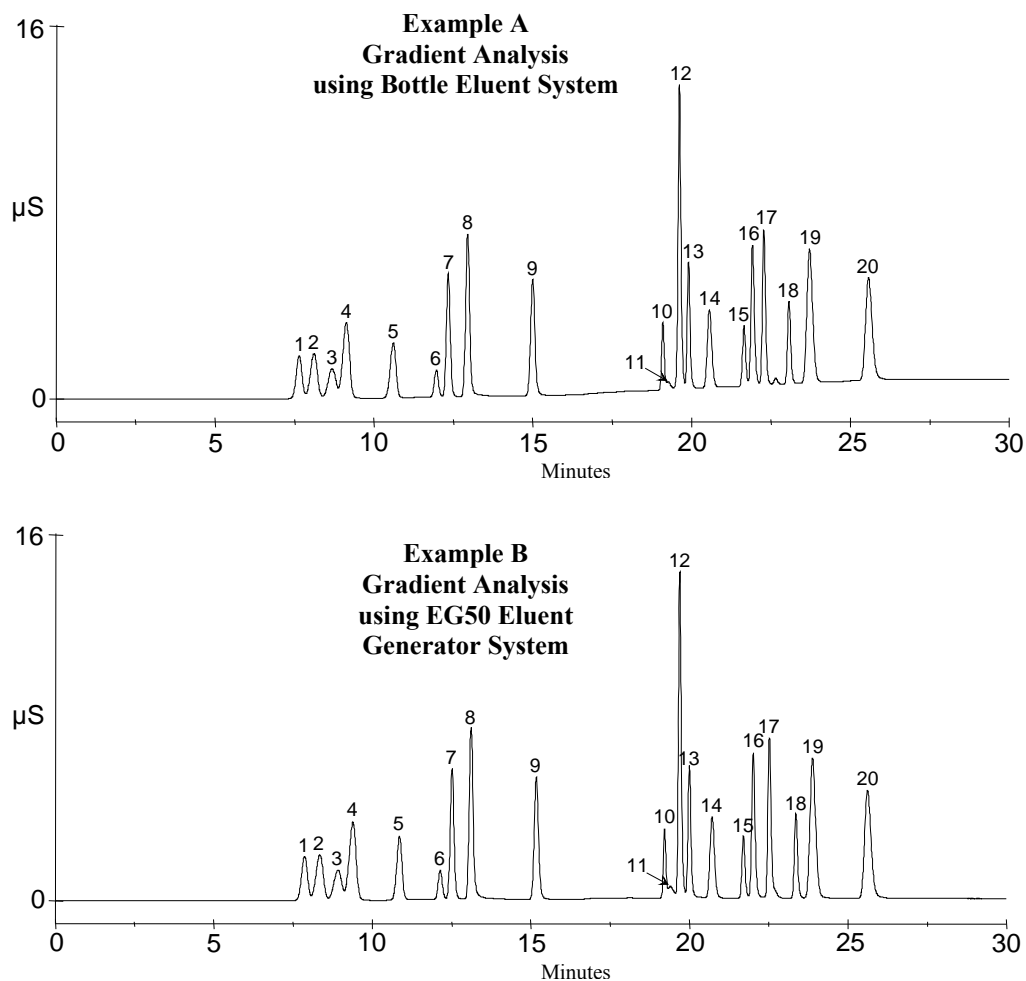
50 mN H<sub>2</sub>SO<sub>4</sub>  
1.5 mM NaOH: 1  $\mu$ S      55 mM NaOH: 2.5 - 3.5  $\mu$ S  
2,300 psi (15.15 MPa)

Gradient Conditions with bottle eluent system				
Time (min)	%E1	%E2	%E3	Comments
Equilibration				
0	30	70	0	1.5 mM NaOH for 7 min.
7.0	30	70	0	
Analysis				
7.1	30	70	0	Start isocratic analysis
7.5	30	70	0	Inject Valve to Load Position
14.0	30	70	0	End Isocratic analysis, Begin Gradient analysis
20.0	0	90	10	
30.0	0	45	55	

**EG50 Conditions**  
Eluent: Deionized water  
Offset volume = 0.0  $\mu$ L

Time (min)	Eluent Conc. (mM)	Comments
Equilibration		
0	1.5	1.5 mM KOH for 7 min
7.0	1.5	
Analysis		
7.1	1.5	Start isocratic analysis
7.5	1.5	Inject Valve to Load Position
15.3	1.5	End Isocratic analysis, Begin Gradient analysis
21.3	10.0	
31.3	55.0	

**Figure 28 Separation of Polarizable Anions and Inorganic Anions using Gradient Elution**



## 4.9 Using an Eluent Generator System for KOH Elution of Inorganic Anions, Oxyhalides, and Organic Acids on the IonPac AS17

The following chromatograms compare the EGC eluent delivery system with the bottle eluent delivery system at room temperature (22°C) for the determination of inorganic anions, oxyhalides, and organic acids. Notice, due to the large system void volume with the bottle eluent system, a longer equilibration time is required before injection.

Trap Column: Bottle Eluent System, ATC-1 located after pump. NOTE: The ATC-1 Trap Column should be replaced with an ATC-3 (4-mm) Trap Column (P/N 059660). EG50 Eluent System, ATC-1 (2), 1 located after pump; 1 located at eluent outlet of EG50 degas assembly and before injector. NOTE: For systems other than the EG40 use the CR-ATC 500 continuously Generated Trap Column instead of the ATC-1 or ATC-HC Trap Columns. The CR-ATC 500 is located after the EGC KOH cartridge.

Sample Volume: 4-mm: 10 µL Loop + 0.8 µL Injection valve dead volume  
 Column: IonPac® AG17, AS17 4-mm  
 Eluent Source: See table  
 Eluent: See table  
 Eluent Flow Rate: 1.5 mL/min (4-mm)  
 Temperature: Room temperature (22°C)  
 SRS Suppressor: Anion Self-Regenerating Suppressor 300 (4-mm)  
 AutoSuppression® Recycle Mode  
 MMS Suppressor: AMMS III  
 MMS Regenerant: 50 mN H<sub>2</sub>SO<sub>4</sub>  
 Expected Background  
 Conductivity: 0.5-1.0 µS  
 Storage Solution: Eluent

Eluent: Deionized water  
 Offset volume = 0.0 µL

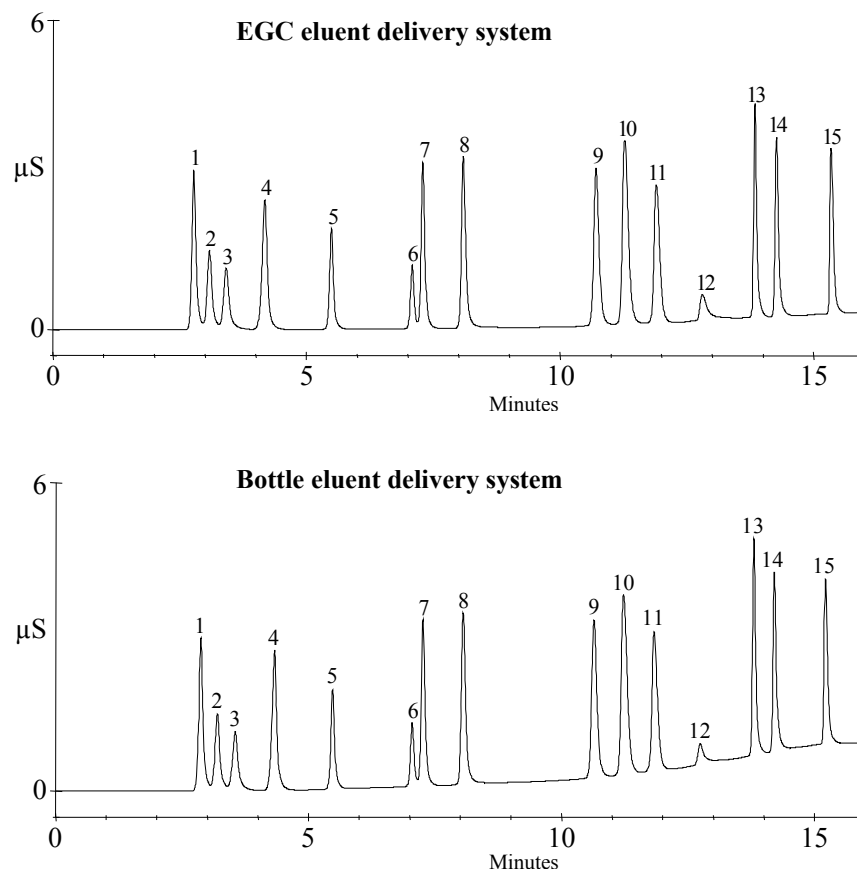
Analyte	mg/L(ppm)	Time (min)	Eluent Conc. (mM)	Comments
1. Fluoride	2.0	<b>Equilibration</b>		
2. Acetate	5.0	0	1.0	1.0 mM KOH for 4 min
3. Propionate	5.0	4.0	1.0	
4. Formate	5.0	<b>Analysis</b>		
5. Chlorite	5.0	4.1	1.0	Start isocratic analysis
6. Bromate	5.0	4.5	1.0	Inject valve to load position
7. Chloride	3.0	7.0	1.0	Begin gradient analysis
8. Nitrite	5.0	14.0	10.0	
9. Bromide	10.0	18.0	35.0	End gradient
10. Nitrate	10.0			
11. Chlorate	10.0			
12. Carbonate	20.0			
13. Sulfate	5.0			
14. Oxalate	5.0			
15. Phosphate	10.0			

### Gradient Conditions:

E1: 5 mM NaOH  
 E2: DI water  
 E3: 100 mM NaOH

Time (min)	%E1	%E2	%E3	Comments
<b>Equilibration</b>				
0	20	80	0	1.0 mM NaOH for 5 min
5.0	20	80	0	
<b>Analysis</b>				
5.1	20	80	0	Start isocratic analysis
5.5	20	80	0	Inject valve to load position
7.0	20	80	0	Begin gradient analysis
14.0	0	90	10	
18.0	0	65	35	End gradient

**Figure 29** Determination of Inorganic Anions, Oxyhalides, and Organic Acids at Room Temperature

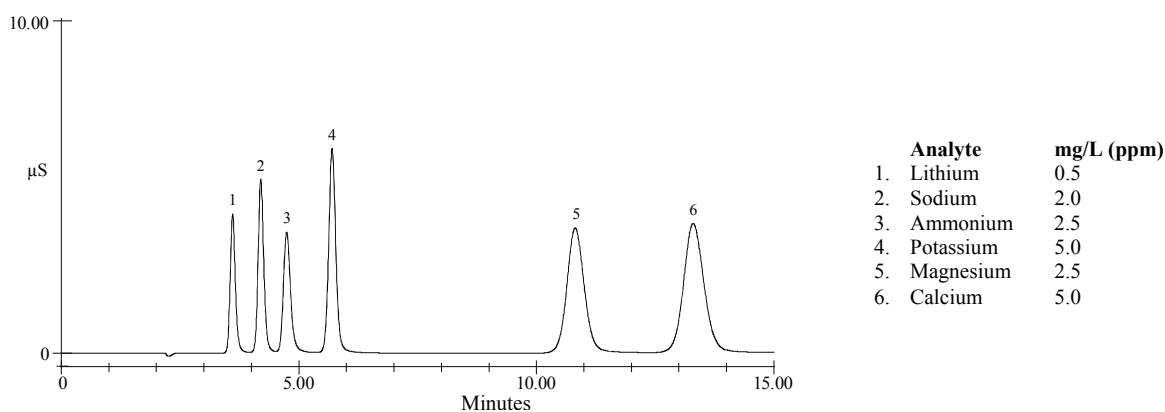


## 4.10 Using the EGC 500 MSA or EGC III MSA Cartridge for IonPac CS12A Isocratic MSA Elution on the IonPac CS12A

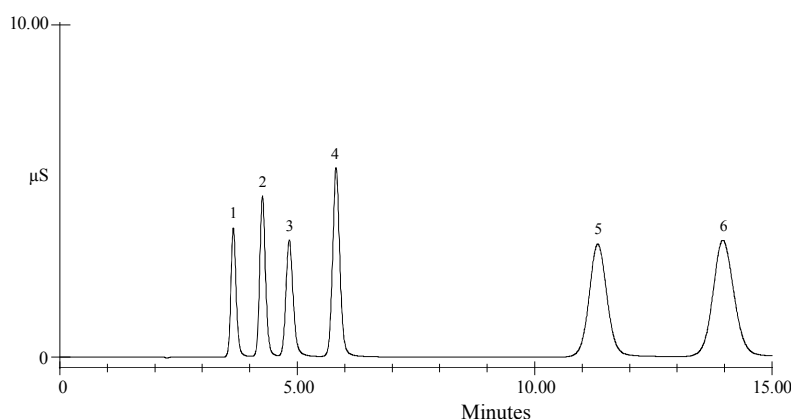
This application demonstrates the comparison of an IonPac CS12A isocratic separation using conventional isocratic pump delivery with EGC isocratic delivery. Figure 30, “Conventional MSA Isocratic Elution on the IonPac CS12A,” illustrates the use of a conventional pump method. Figure 31, “EGC MSA Isocratic Elution on the IonPac CS12A,” illustrates the use of an EGC with an identical isocratic program using an OFFSET VOLUME of 0.0  $\mu$ L.

Sample Volume: 25  $\mu$ L  
 Column: IonPac CS12A analytical (4-mm) and CG12A guard (4-mm)  
 Eluent: 18 mM MSA  
 Eluent Flow Rate: 1.0 mL/min  
 Oven Temperature: 30° C  
 Cell Temperature: 35° C  
 Suppressor: Cation Self-Regenerating Suppressor 300 (4-mm)  
 AutoSuppression® Recycle Mode  
 Expected Background Conductivity: 0.3  $\mu$ S (EG50) 0.4  $\mu$ S (GP40, GP50, or GS50)  
 Typical Operating Back Pressure: 1980 psi (EG50) 970 psi (GP40, GP50, or GS50)  
 Back pressure restrictor (P/N 53763) was used with the EG50

**Figure 30 Conventional MSA Isocratic Elution on the IonPac CS12A.**



**Figure 31 EGC II MSA Isocratic Elution on the IonPac CS12A.**



## 4.11 Using the EGC 500 MSA or EGC III MSA Cartridge for IonPac CS12A MSA Gradient

This application demonstrates the comparison of an IonPac CS12A gradient separation using conventional gradient pump delivery to the gradient separation using EGC gradient delivery. Figure 32, “Conventional MSA Linear Gradient on the IonPac CS12A,” illustrates the use of a conventional pump method. Figure 33, “EGC MSA Linear Gradient on the IonPac CS12A,” illustrates the use of an EGC with an identical gradient program using the OFFSET VOLUME of 0  $\mu$ L. Note the smaller baseline shift during the gradient when using the EGC. Since the EGC delivers the gradient with a much smaller delay volume, the peaks elute more quickly. By increasing the OFFSET VOLUME from 0  $\mu$ L to 400  $\mu$ L, the start of the gradient will be delayed 0.2 minutes and the retention times of the peaks eluted by the gradient will increase.

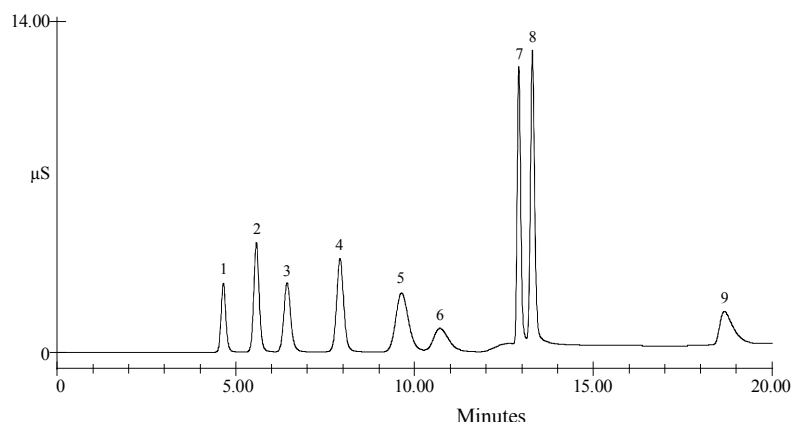
**NOTE: Solvents should not be used with an EGC MSA cartridge.**

Sample Volume:	25 $\mu$ L
Column:	IonPac CS12A analytical and CG12A guard (4-mm)
Eluent:	See table of conditions
Eluent Flow Rate:	1.0 mL/min
Cell Temperature:	35° C
Oven Temperature:	30° C
Suppressor:	Cation Self-Regenerating Suppressor 300 (4-mm) AutoSuppression® Recycle Mode
Expected Background Conductivity:	(GP40 or GP50) 11 mM MSA: 0.4 $\mu$ S 57 mM MSA: 0.8 $\mu$ S (EG50) 11 mM MSA: 0.4 $\mu$ S 57 mM MSA: 0.44 $\mu$ S
Typical Operating Back Pressure:	(GP40 or GP50) 960 psi (6.61 MPa) (EG50) 1880 psi (12.95 MPa) Pressure Restrictor, (P/N 53763) was used with the EG50
Offset Volume:	0.0 $\mu$ L

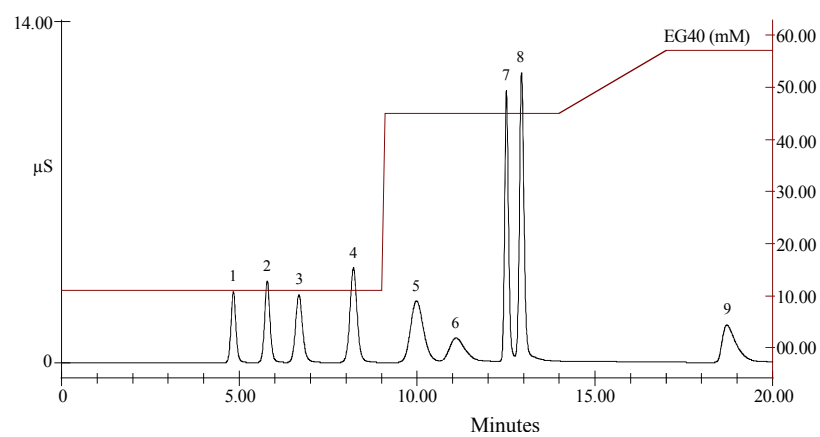
GP40 Conditions					
E1:	Deionized water			<b>Analytes</b>	<b>mg/L (ppm)</b>
E2:	100 mM MSA			1. Lithium	0.5
	<b>Time</b>	<b>%E1</b>	<b>%E2</b>	2. Sodium	2.0
	(min)		<b>Comments</b>	3. Ammonium	5.0
				4. Potassium	5.0
<b>Equilibration</b>				5. 5-Amino-1-pentanol	20.0
0	89	11	11 mM MSA for 7 min.	6. Morpholine	15.0
7.0	89	11		7. Magnesium	2.5
<b>Analysis</b>				8. Calcium	5.0
0.0	89	11	11 mM MSA	9. 3-Dimethylamino-propylamine	10.0
0.1	89	11	Inject Valve to Load Position		
9.1	55	45	Step change to 45 mM MSA		
14.0	55	45	45-57 mM MSA in 3.0 min.		
17.0	43	57	57 mM MSA		
20.0	43	57	57 mM MSA (end)		

EG50 Conditions			
E1:	Deionized water		
	<b>Time</b>	<b>Eluent</b>	<b>Comments</b>
	(min)	conc. (mM)	
<b>Equilibration</b>			
0	11	11 mM MSA for 7 min.	
7.0	11		
<b>Analysis</b>			
0.0	11	11 mM MSA	
0.1	11	Inject Valve to Load Position	
9.1	45	Step change to 45 mM MSA	
14.0	45	45-57 mM MSA in 3.0 min.	
17.0	57	57 mM MSA	
20.0	57	57 mM MSA (end)	

**Figure 32** Conventional MSA Linear Gradient on the IonPac CS12A.



**Figure 33** EGC II MSA Linear Gradient on the IonPac CS12A.



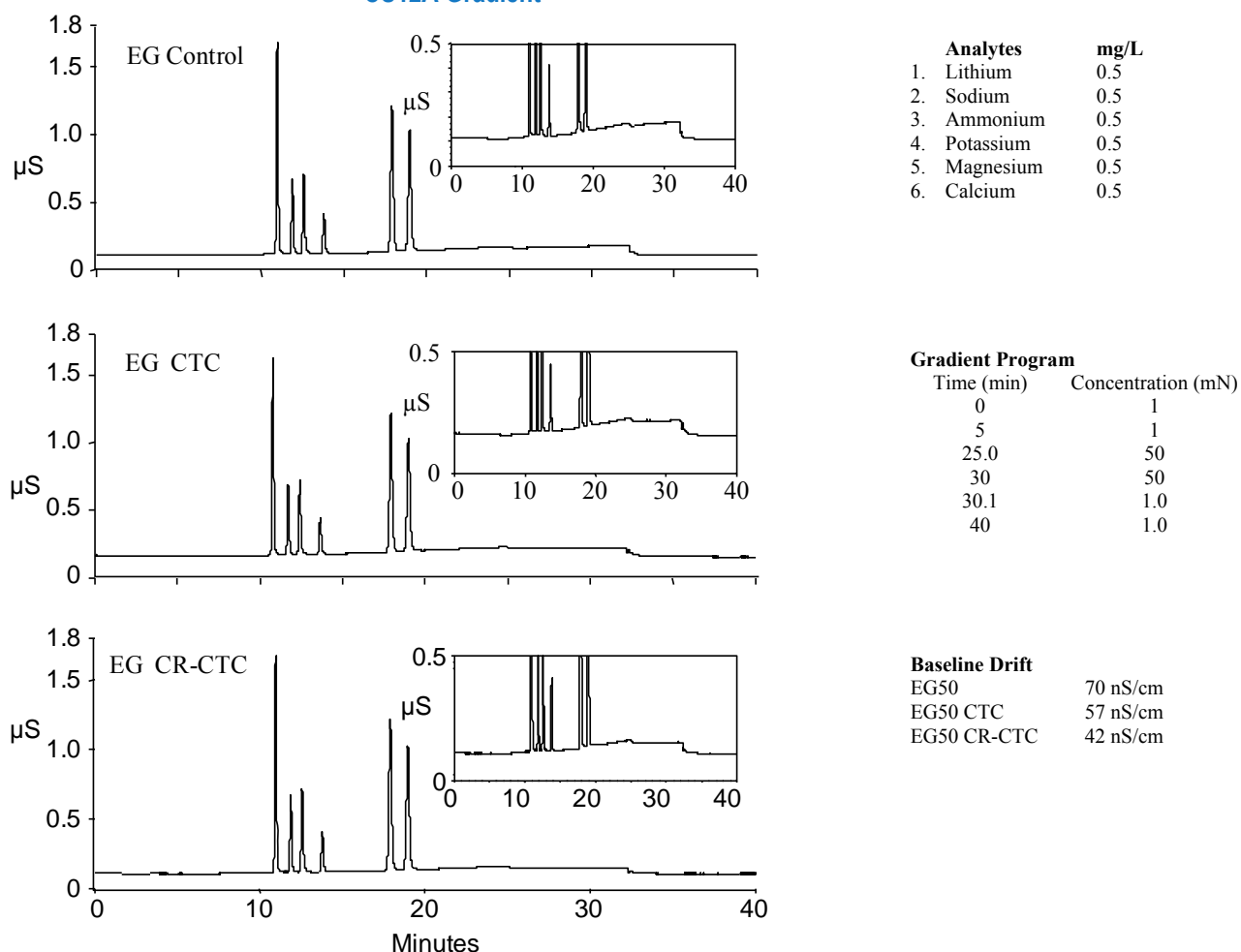


## 4.12 Comparison of Eluent Generation using a CTC and a CR-CTC 500 for IonPac CS12A Gradient

The set of chromatograms in Figure 34 demonstrates the decrease in baseline shift during a gradient when the CTC-3 or CR-CTC 500 is used. The CR-CTC 500 does not require off-line chemical regeneration.

Column: IonPac® CS12A (4-mm)  
 Eluent: EG50 generated MSA  
 Flow Rate: 1.0 mL/min  
 Inj. Volume: 10 µL  
 Detection: Suppressed Conductivity  
 Temperature: 30°C  
 Suppressor: CSRS® 300 (4-mm), Recycle Mode

**Figure 34 Comparison of the EGC Using a CTC and a CR-CTC Trap Column in IonPac CS12A Gradient**

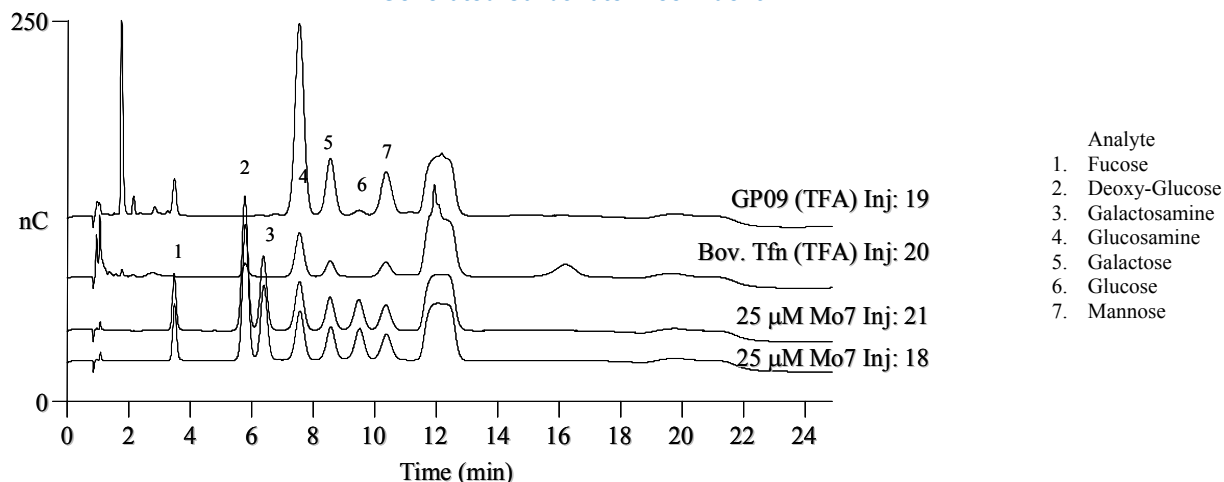


### 4.13 Glycoconjugate Monosaccharide Analysis with the EGC 500 KOH or EGC III KOH Generator

This application demonstrates the use of the EGC KOH generator for resolving glycoconjugate-derived monosaccharides in the Biotechnology and Pharmaceutical industries. The conventional method, using manual or pump-generated eluent, requires a step to 200 mM NaOH for 10 minutes to remove carbonate from the column, followed by a 15 minute re-equilibration to force a 50 minute cycle time. The EGC KOH method, (see Figure 35, “Analysis of Monosaccharide Standards Showing a Fast Cycle Time with EG50-Generated Carbonate-Free Eluent”) employs a 5 minute step at 80 mM to remove amino acids or late eluting components, and a short re-equilibration to support a 30 minute cycle time. This demonstrates that control of carbonate anion results in a 40% gain in throughput for this application.

Sample: 10  $\mu$ L, 20  $\mu$ M standards  
 Eluent: Deionized Water  
 Column: CarboPac PA10 (Analytical) and AminoTrap  
 Flow: 1.0 mL/min  
 Pressure: 2,800 psi

**Figure 35 Analysis of Monosaccharide Standards Showing a Fast Cycle Time with EGC-Generated Carbonate-Free Eluent**



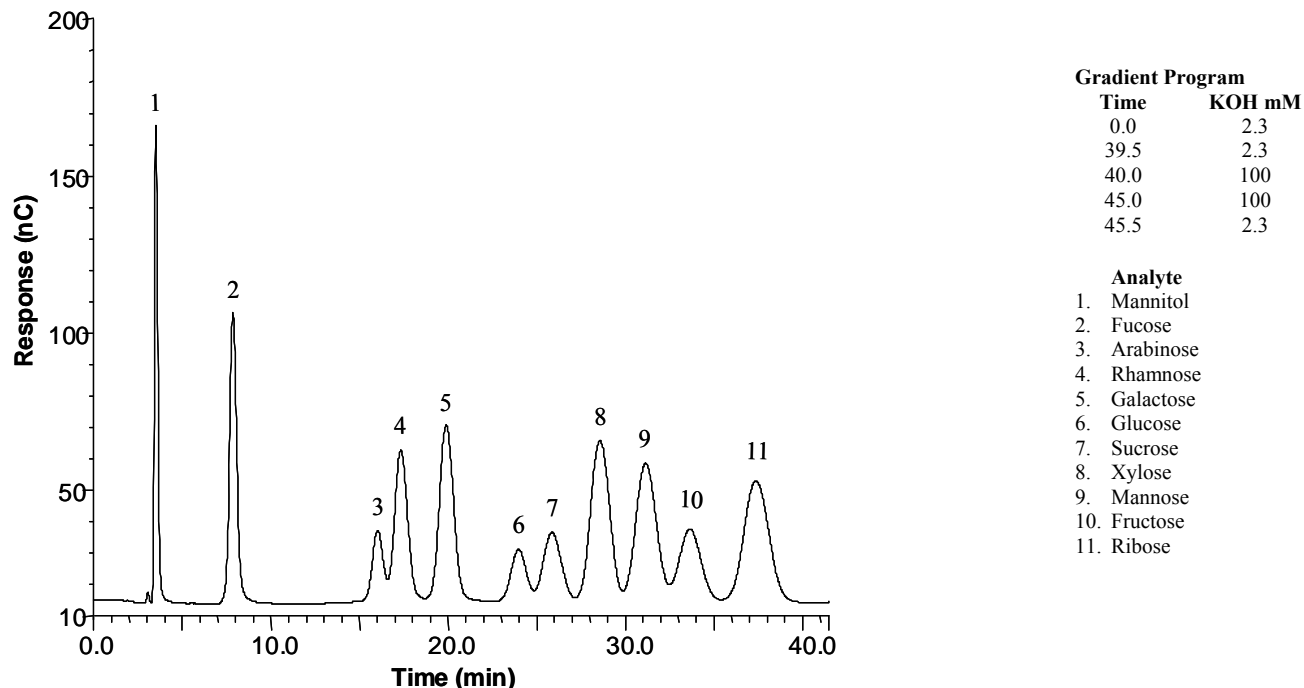
## 4.14 Analysis of Mono- and Disaccharides Found in Foods and Beverages Using Generated KOH as Eluent

This application demonstrates the use of the EGC KOH generator for resolving carbohydrates found in foods and beverages (Figure 36, “Analysis of Monosaccharides in Foods and Beverages with the EGC-Generated Carbonate-Free Eluent”). Resolution of galactose, glucose, mannose and xylose, as well as other carbohydrates, is impacted by carbonate ion. This divalent anion is present to varying degrees in hydroxide-containing eluents due to dissolution of carbon dioxide in the basic eluent. Use of KOH, generated electrolytically at the time of use, prevents the application and accumulation of carbonate on the column. When hydroxide-containing eluents in system reservoirs are used, separation of these carbohydrates can only be accomplished following the completion of the following steps: (1) 15 min wash with 300 mM NaOH to remove carbonate from the column, (2) 15 min rinse with DI water. The sample can then be injected.

When 2.3 mM KOH is generated by the EGC KOH cartridge, these carbohydrates are well resolved by a system that requires neither post-column base addition, nor preparation of caustic eluents. A 5 min step to 100 mM KOH at the end of the carbohydrate elution window is employed to remove organic acids and other late eluting compounds. With the step and time for equilibration, cycle time is reduced from 80 min to 60 min, demonstrating that control of carbonate results in a 33% gain in throughput.

Sample: 10  $\mu$ L, 20  $\mu$ M standards  
 Eluent: Deionized Water  
 Column: CarboPac PA10 (4-mm) + AminoTrap (4-mm)  
 Flow: 1.0 mL/min  
 Pressure: 2,800 psi

**Figure 36 Analysis of Monosaccharides in Foods and Beverages with EGC-Generated Carbonate-Free Eluent**



## 4.15 Analysis of Carbohydrates using both Eluent Generated KOH and Manually Prepared NaOH or KOH as Eluent

This application demonstrates the use of the EGC KOH generator with manually prepared 200 mM NaOH eluent for resolving carbohydrates found in foods, beverages, lignocellulosic hydrolysates where determination of more strongly retained carbohydrates or more effective column washing is desired. Figure 37, "Analysis of carbohydrates in corn stover hydrolysate with EGC-Generated Carbonate-Free and Manually Prepared Eluent" shows the resolution of arabinose, galactose, glucose, xylose, mannose, fructose using EGC-generated 0.5 mM KOH, and the rapid elution of cellobiose and other more strongly retained carbohydrates using manually prepared 200 mM KOH or NaOH eluent. Carbohydrate applications that require greater than 100 mM (the upper concentration limit for the EGC), but less than 200 mM KOH or NaOH eluent concentration may use manually prepared eluent to supplement the hydroxide produced by the EG. For example, the EG can be used to produce 0.5 to 20 mM concentrations of hydroxide eluent, used to separate weakly retained carbohydrates or alter their selectivity, and then change the proportioning valve on the pump to use another eluent channel (other than water) that contains manually prepared 200 mM KOH or NaOH to elute the more highly retained carbohydrates or other substances. The combined use of EGC and manually prepared eluent enable many of the benefits of eluent generation, and also provide the ability to rapidly elute highly retained compounds and more effectively clean the column. When manually prepared eluent is allowed to pass through the EG cartridge and the CR-ATC 500, the EG must be left on at low eluent concentration (e.g., 0.5 mM) to ensure polarization of the EG cartridge membranes and ensure longevity of the device. The use of combined EGC and manually prepared eluent does not require any additional plumbing or system configuration, but does require a gradient pump with two or more eluent channels and a proportioning valve. The manually prepared eluents should be prepared follow the procedures described in Dionex Technical Note 71.

Sample: 1) Carbohydrate standards, 0.2 µL  
2) Undiluted corn stover acid hydrolysate, 0.2 µL  
Eluent: A: Water  
B: 200 mM NaOH  
Column: CarboPac PA1 (4-mm)  
Flow: 1.0 mL/min  
Pressure: 1400 psi  
Gradient Program:

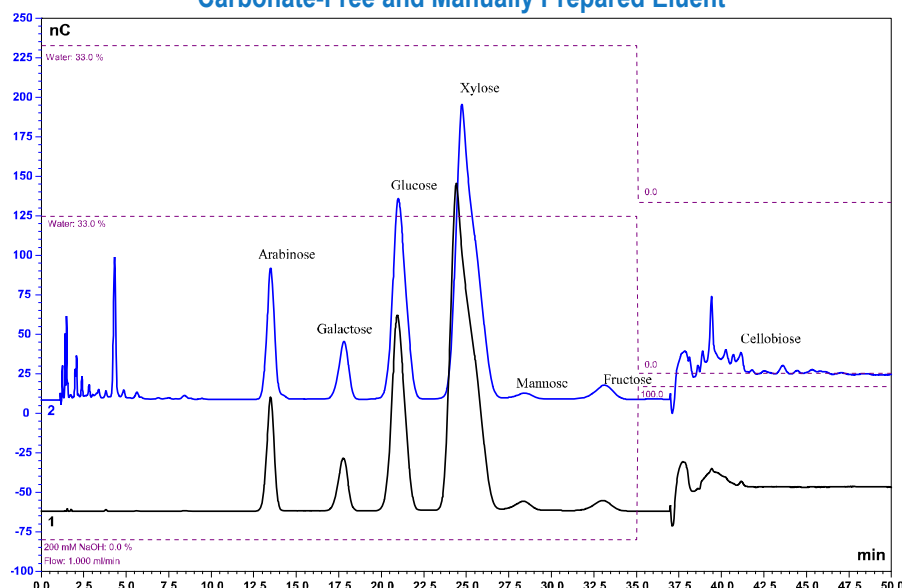
Time	%A	%B	mM KOH (EG)	mM NaOH*
0.0	100	0	0.50	0
35.0	100	0	0.50	0
35.1	0	100	0.50	200
50.0	0	100	0.50	200
50.1	100	0	0.00	0
55.0	100	0	0.00	0
55.1	100	0	0.50	0

### Analyte:

1. Arabinose
2. Galactose
3. Glucose
4. Xylose
5. Mannose
6. Fructose
7. Cellobiose

\* Manually prepared eluent

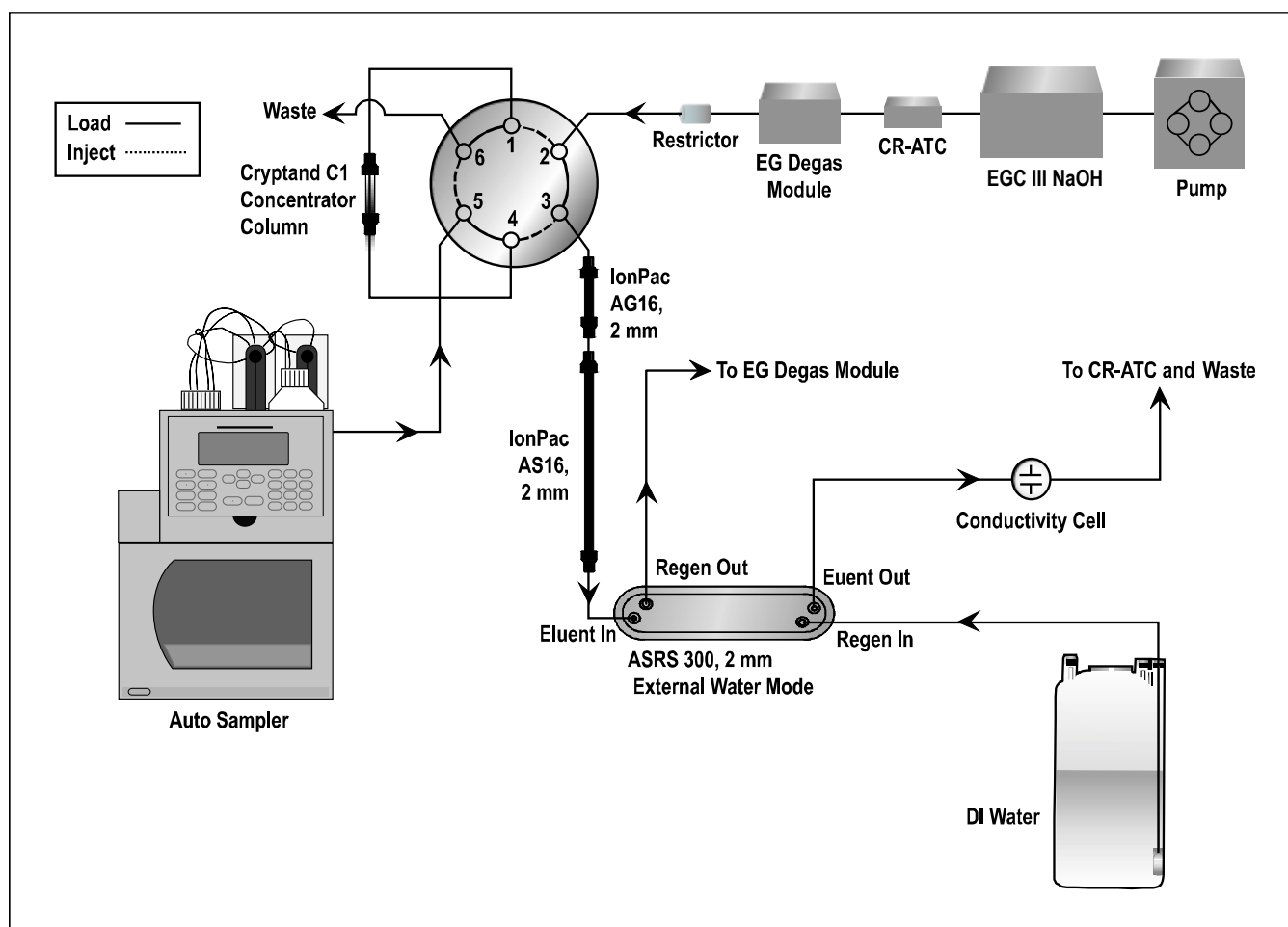
**Figure 37 Analysis of carbohydrates in corn stover hydrolysate with EGC-Generated Carbonate-Free and Manually Prepared Eluent**



## 4.16 Determination of Trace Perchlorate using the Cryptand C1 concentrator column

Figure 38 illustrates the basic system configuration for the determination of trace perchlorate using Cryptand C1 concentrator column, 2-mm AS16 separation column, and EGC NaOH. In this system, the deionized water is pumped into the EGC NaOH cartridge where a high-purity NaOH eluent is generated electrolytically. The CR-ATC and the degas unit serve the same functions as described previously. A 5-mL aqueous sample containing trace perchlorate is first loaded onto a Cryptand C1 concentrator (P/N 062893) to concentrate perchlorate from the sample matrix using a Dionex AS40 auto sampler which comes in two versions (5 mL vials P/N 046029 and 0.5 mL vials P/N 046028). The AS40 auto sampler is then used again to deliver 1.0 mL of 10 mM NaOH to rinse the majority of matrix ions off the concentrator column. After the rinse, the concentrator column is switched on-line with the 2-mm AS16 separation column where perchlorate is separated from the matrix ions using the NaOH eluent.

**Figure 38** System Configuration for Determination of Trace Perchlorate

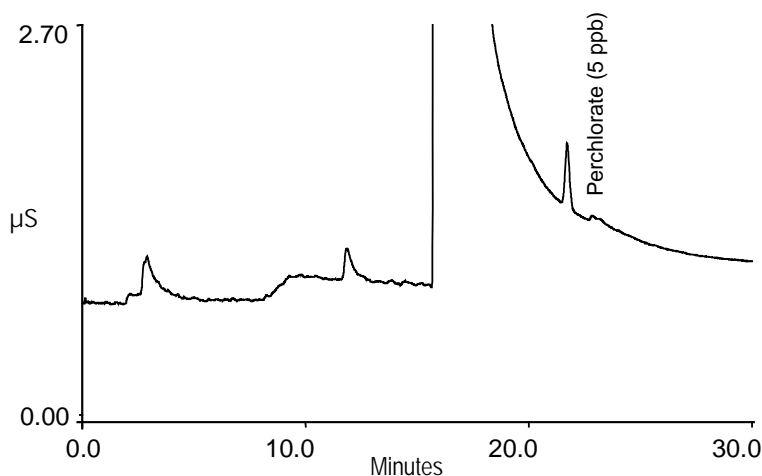


## 4 – Example Applications

This example demonstrates the determination of trace perchlorate in a synthetic water sample using the Cryptand C1 concentrator column, 2-mm AS16 separation column, and EGC NaOH cartridge. In this example, 5-mL of the sample, which contains 5 µg/L perchlorate in 1000 mg/L (each) chloride, sulfate, and bicarbonate, is first loaded onto a Cryptand C1 concentrator (P/N 062893) to concentrate perchlorate from the sample matrix. The concentrator column is then rinsed with 1.0 mL of 10 mM NaOH. The concentrator column then is switched on-line with the 2-mm AS16 separation column. The EGC II-NaOH cartridge is programmed to generate a 0.5 mM NaOH for 12 minutes and the concentration of the eluent is increased to 60 mM to elute perchlorate from the AS16 column as shown in Figure 39.

Column:	IonPac AG16/AS16, 2 x 250 mm
Concentrator:	Cryptand C1 Concentrator
Eluent:	0.5 mM sodium hydroxide step to 60 mM sodium hydroxide at 12 min
Eluent Source:	EGC with a CR-ATC
Flow Rate:	0.25 mL/min
Inj. Volume:	5 mL concentrated on Cryptand C1 concentrator
Rinse	1 mL of 10 mM NaOH
Temperature:	35 °C
Detection:	Suppressed conductivity, ASRS 300 2 mm, recycle mode
Sample:	Cl <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , HCO <sub>3</sub> <sup>-</sup>

**Figure 39** Determination of Trace Perchlorate

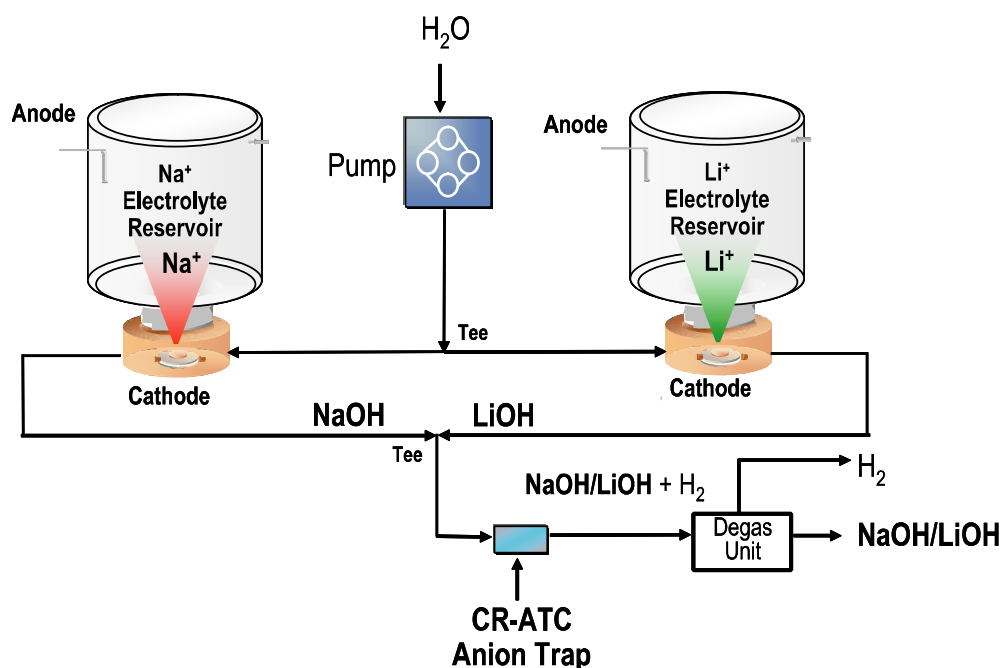


## 4.17 Dual EGC III-NaOH and EGC III-LiOH Applications

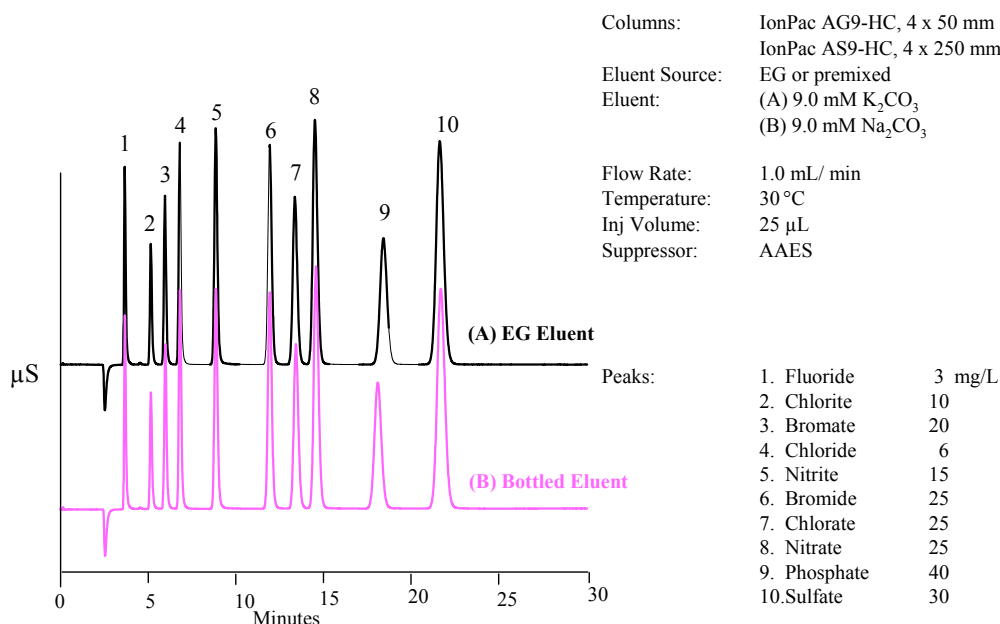
### 4.17.1 System Requirements

Figure 40 illustrates the system setup for electrolytic generation of dual component hydroxide eluents using EGC NaOH and EGC LiOH cartridges. In this system, the deionized water from the pump is first split equally into two flowing streams through the use of the "Dionex Dual EG Splits/Mixing Tee" kit (P/N 063049). One deionized (DI) water stream goes through the EGC NaOH cartridge to generate NaOH eluent and the other stream goes through the EGC LiOH cartridge to generate LiOH eluent. The two hydroxide streams are recombined using another Dual EG Splits/Mixing Tee kit to form a dual cation hydroxide eluent. The CR-ATC and the degas unit serve the same functions as described previously.

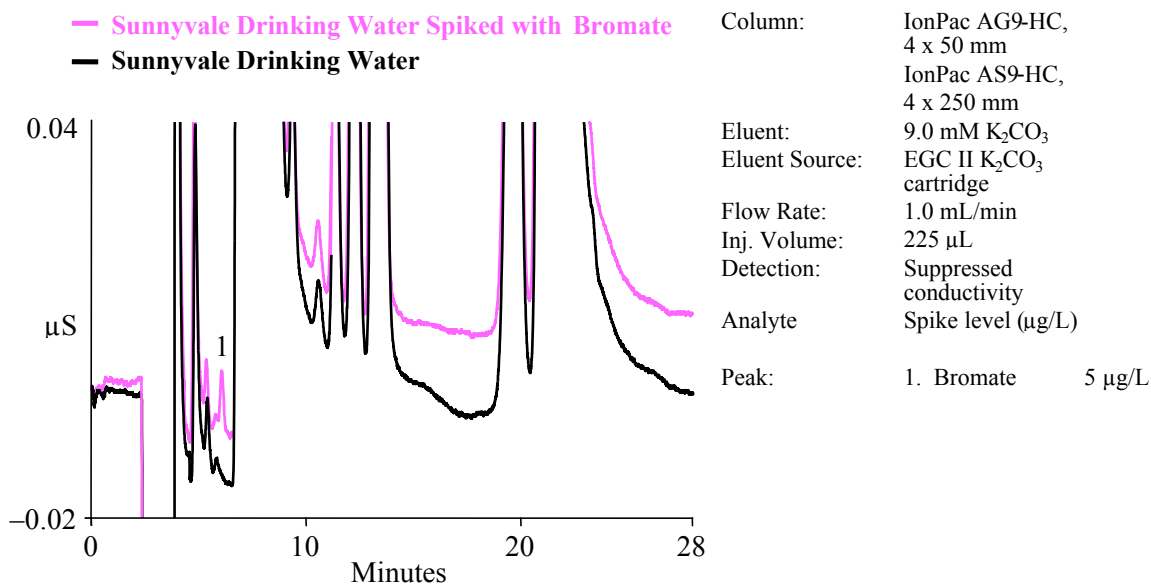
**Figure 40** Electrolytic Generation of NaOH/LiOH Eluents



### 4.18 Separation of Ten Anions on a 4 mm IonPac AS9-HC Column using an EGC $K_2CO_3$

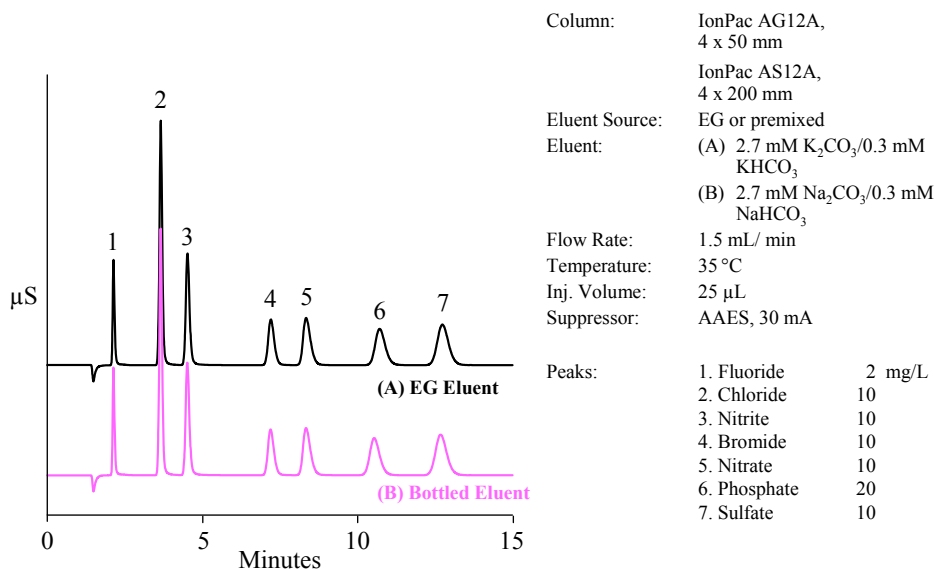


### 4.19 Determination of Trace Bromate in Drinking Water using a 4 mm AS9-HC Column and an EGC $K_2CO_3$

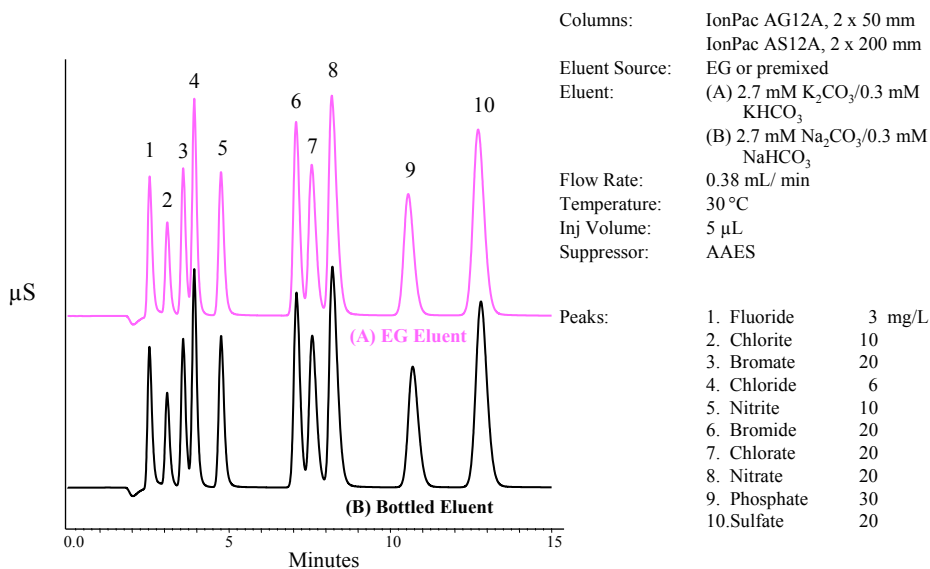




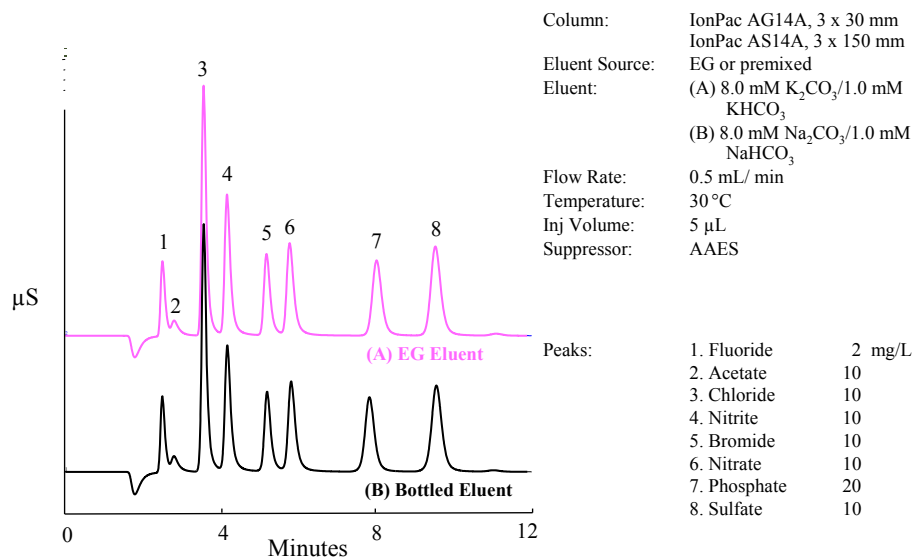
## 4.20 Separation of Seven Anions on a 4 mm IonPac AS12A Column using an EGC $K_2CO_3$ and EPM



## 4.21 Separation of Ten Anions on a 2 mm IonPac AS12A Column using an EGC $K_2CO_3$ and EPM



## 4.22 Separation of Eight Anions on a 3 mm IonPac AS14A Column using an EGC $K_2CO_3$ and EPM



## 5. Maintenance

### 5.1 Replacing the EGC III or EGC 500 cartridge

The EGC III or EGC 500 must be replaced when the cartridge is expended, when it leaks, or in order to switch between anion and cation separations with a single Eluent Generator (EG) Module.



**NOTE**

*When switching between anion and cation separations on the same system, flush the entire system (excluding the EGC, column, and suppressor, but including the high pressure degas tubing assembly) with 5 to 10 mL of DI water at 1.0 or 2.0 mL/min before connecting the new cartridge, column, and suppressor.*

To remove the old cartridge:

- A. Turn off the pump flow either manually or via direct control in the PeakNet or Chromeleon software. The power to the EGC III, EGC 500, EPM III and SRS suppressor will automatically shut off.
- B. The electrical connector cable for the cartridge is plugged into a connector. Unscrew the plug counter clockwise and pull it straight out of the connector.
- C. Unscrew the Luer lock from the Luer adaptor at the top corner of the EGC III and detach the gas vent line.
- D. Install the plastic plug in the gas vent port. Use the plug removed from the port during initial installation of the EGC. The plug should be in the drip tray.
- E. With the eluent lines still attached, and the electrical contacts facing you, lift the EGC from the EGC shelf and turn it so that the electrolysis chamber and liquid line fittings are upward.
- F. Unscrew the cartridge inlet line from the EGC INLET fitting. This line leads to the pump transducer (or to the anion trap column, if present). Unscrew the cartridge outlet line from the OUTLET fitting on the EGC.
- G. Prepare an expended EGC III or EGC Capillary cartridge for disposal by completing the following:
  - i. Hold the cartridge with the generator chamber upward.
  - ii. Unscrew the eluent generation chamber from the electrolyte reservoir.
  - iii. Pour the remaining electrolyte solution into an appropriate hazardous waste container.



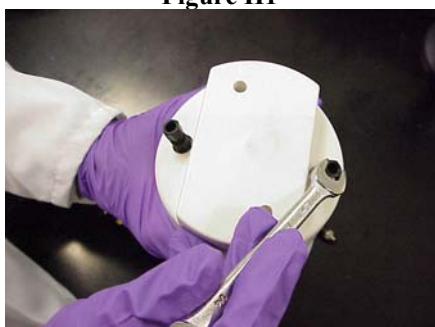
**NOTE**

*Refer to the Material Safety Data Sheet (MSDS) shipped with the EGC III or EGC 500 for the chemical description.*

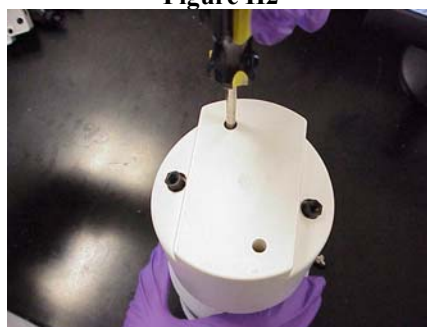
- iv. Rinse the electrolyte reservoir and membranes with DI water three times.

- H. Prepare an expended EGC 500 cartridge for disposal by completing the following:
- Wear protective laboratory gloves and remove two 10-32 fittings from eluent inlet and outlet ports as shown in Figure H1.
  - Use a Philips screwdriver to remove the two screws used to attach the EGC pod cover to the EGC reservoir as shown in Figure H2. Detach the EGC pod cover from the EGC reservoir.
  - Use a Philips screwdriver to detach the EGC cable clamp from the EGC reservoir as shown in Figure H3.
  - Use a Philips screwdriver to remove the three screws used to attach one of the the EGC pods to the EGC reservoir in Figure H4 and Figure H5. Either pod can be removed.
  - Detach the EGC pod from the EGC reservoir as shown in Figure 6. Dispose of the electrolyte solution into an appropriate hazardous waste container following the local hazard material disposable procedures

**Figure H1**



**Figure H2**



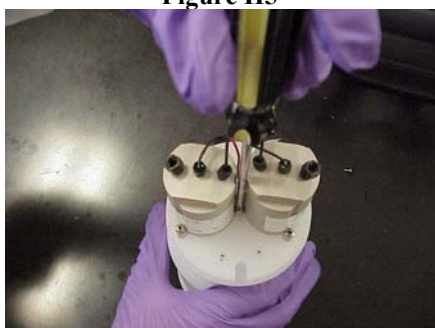
**Figure H3**



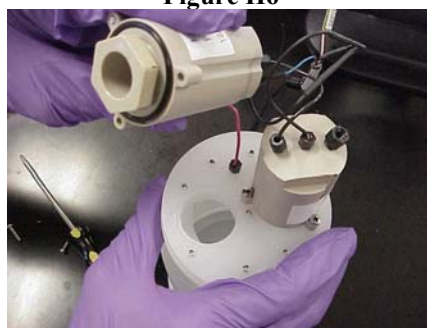
**Figure H4**



**Figure H5**



**Figure H6**





*Rinsing should render the reservoir and the membranes nonhazardous; however, check with local, state, and federal regulatory agency regulations for proper disposal.*

- I. If the cartridge is not expended, plug all fittings.
- J. Store the cartridge in a standing position (with the electrolyte reservoir at top) at 4 to 40°C (39 to 104°F) until its next use. The original shipping container is ideal for storage. The cartridge may be stored for up to two years.
- K. To install a new cartridge, follow the procedure in Section 2.



*It is recommended the EPM III should be replaced with each third EGC III  $K_2CO_3$ .*

## 5.2 Replacing the EGC III Outlet Frit

If the source of the system high backpressure is isolated to the EGC III, the outlet frit should be replaced. The EGC III should add < 100 psi of backpressure.

- A. Unscrew the Luer lock from the Luer adaptor at the top corner of the EGC III electrolyte reservoir and detach the gas vent line.
- B. Install the plastic plug in the gas vent port. Use the plug removed from the port during initial installation of the EG. The plug should be in the drip tray.
- C. Turn off the pump flow.
- D. With the eluent lines and electrical connects still attached, lift the EGC III from the cartridge shelf, and turn it so the eluent generation chamber and liquid line fittings are upward.
- E. Unscrew the cartridge outlet line from the outlet fitting on the EGC III.



*The outlet frit is located in the electrolysis chamber at the base of this fitting.*

- F. Using a sharp or pointed tool, such as the mini screwdriver (P/N 046985), carefully puncture and remove the frit body and seal ring.
- G. Replace with a new frit assembly (P/N 042310) provided with the EGC III.
- H. Reattach the outlet line.



**NOTE**

*Invert the EGC III with the Eluent Generation (EG) Chamber downward. Shake the EGC III vigorously, and tap the eluent generation chamber with the palm of your hand 10 to 15 times. Watch to be sure all bubbles trapped in the electrolysis chamber are dislodged. Be sure to repeat this process each time the EGC III is turned with the eluent generation chamber upward.*

- I. Position the EGC III in the eluent generator controller Module, such as the EG module, with the eluent generation chamber downward by positioning the EG chamber just below the shelf and sliding the cartridge through the opening in the shelf.

## 6. Troubleshooting Guide

The purpose of the Troubleshooting Guide is to help solve operating problems that may arise while using the Eluent Generator (EG). For more information on problems that originate with the Ion Chromatograph (IC), column, or suppressor, refer to the Troubleshooting Guide in the appropriate operator's manual. If you cannot solve the problem on your own, contact the Dionex North America Technical Call Center at 1-800-DIONEX-0 (1-800-346-6390) or the nearest Dionex Office (see "Dionex Worldwide Offices" on the Reference Library CD-ROM).

### 6.1 ICS-3000, 5000 and 5000+ EG Error Messages and Troubleshooting

#### 6.1.1 EG1 Cartridge Disconnected and EG2 Cartridge Disconnected

This error occurs if Chromeleon or Chromeleon Xpress sends a command to set an EG parameter when the cartridge is disconnected. To troubleshoot: (1) Connect the cartridge and (2) If the error message appears again, contact Dionex for assistance. The cartridge control electronics may have malfunctioned.



**NOTE**

*The ICS-3000, 5000 and 5000+ EG Ion Chromatography System electronics components cannot be serviced by the user.*

#### 6.1.2 EG1 Invalid Concentration and EG2 Invalid Concentration

This error occurs if the eluent concentration is outside the concentration range allowed for the type of cartridge used. This may be a user setting error. This may also indicate corrupted memory or a problem in the EG Moduleware (the instrument control firmware installed in the EG). To troubleshoot: set the correct EG concentration. If failed with correct concentration settings, contact Dionex for assistance.



**NOTE**

*The ICS-3000, 5000 and 5000+ EG Ion Chromatography System electronics components and Moduleware cannot be serviced by the user.*

This error may also occur due to the incorrect linking of the EG to the correct pump in the Chromeleon server configuration. To troubleshoot, re-link the EG to the correct pump using the Chromeleon server configuration.

#### 6.1.3 EG1 Invalid Flow and EG2 Invalid Flow

This error occurs if the flow rate is set to a value not supported by the EG. The DP/SP flow rate range is 0.001 to 10.0 mL/min; however, when an EG is installed, the allowed range is 0.01 to 3.00 mL/min. The recommended operating range is 0.25 to 2.00 mL/min. To troubleshoot: set the flow rate to a value within the allowed range.

This error may also occur due to the incorrect linking of the EG to the correct pump in the Chromeleon server configuration. To troubleshoot, re-link the EG to the correct pump using the Chromeleon server configuration.

#### 6.1.4 EG1 Invalid Flow Rate-Concentration and EG2 Invalid Flow Rate-Concentration

This error occurs if the selected concentration is too high for the set flow rate. To troubleshoot: set the flow rate to a value within the allowed range. The allowable eluent concentration for a particular application depends on several factors: the flow rate, suppressor type, cartridge type, and cartridge configuration.

This error may also occur due to the incorrect linking of the EG to the correct pump in the Chromeleon server configuration. To troubleshoot, re-link the EG to the correct pump using the Chromeleon server configuration.

#### 6.1.5 EG1 over Current, EG2 over Current, EG1 over Power, and EG2 over Power

This error occurs when the current applied to the cartridge exceeds the maximum current allowed. (The current is automatically turned off to prevent damage to the cartridge.). If the error message appears, contact Dionex for assistance. The cartridge control electronics may have malfunctioned.



NOTE

*The ICS-3000, 5000 and 5000+ EG Ion Chromatography System electronics components and Moduleware cannot be serviced by the user.*

#### 6.1.6 EG1 over Voltage and EG2 over Voltage

This error occurs when the cartridge is not connected properly to the EG1 and EG2 current source. To troubleshoot: check the cartridge cable connection to the electrical bulkhead. If the error message appears again, contact Dionex for assistance. The cartridge or ICS-3000 EG control electronics may have malfunctioned.



NOTE

*The ICS-3000, 5000 and 5000+ EG Ion Chromatography System electronics components and Moduleware cannot be serviced by the user.*



## 6.2 EG Alarm Light is Lighted

- CAUSE:** Leaking fitting.  
**ACTION:** Locate the source of the leak. Tighten or replace liquid line connections as needed.
- CAUSE:** Blocked or improperly installed waste line.  
**ACTION:** Check the EG waste lines to be sure they are not crimped or otherwise blocked. Ensure the lines are not elevated at any point after they exit the EG.
- CAUSE:** Cartridge leaks.  
**ACTION:** Replace the cartridge.
- CAUSE:** RFIC Eluent Degasser leaks.  
**ACTION:** Replace the RFIC Eluent Degasser.
- CAUSE:** Cartridge electrical connection is open.  
**ACTION:** Tug gently on the cartridge electrical cable; the locking connector should hold the cable in place. If the cable is fully seated and the problem persists, the cartridge is defective and must be replaced.
- CAUSE:** Cartridge input electrical connection has shorted out.  
**ACTION:** Replace the cartridge.
- CAUSE:** Cartridge input electrical connection has shorted out.  
**ACTION:** Replace the cartridge.
- CAUSE:** Electrical error. The EG current and/or voltage may have become unstable.  
**ACTION:** Contact Dionex for assistance.



### NOTE

*The ICS-3000 EG Ion Chromatography System electronics components cannot be serviced by the user.*

### 6.3 EG Power LED Fails to Light

**CAUSE:** No power

**ACTION:** Check that the POWER button on the front of the EG is turned on. Check that the EG main power switch (on the rear panel) is turned on. Check that the main power cord is plugged into both the EG rear panel connector and the power source. Check that the wall outlet has power. If the POWER LED still fails to light, contact Dionex for assistance.

### 6.4 Liquid Leaks in the EG

**CAUSE:** Leaking fitting

**ACTION:** Locate the source of the leak. Tighten or replace liquid line connections as needed.

**CAUSE:** Blocked or improperly installed waste line.

**ACTION:** Check the EG waste lines to be sure they are not crimped or otherwise blocked. Make sure the lines are not elevated at any point after they exit the EG.

**CAUSE:** Cartridge leaks.

**ACTION:** Replace the Cartridge.

**CAUSE:** RFIC Eluent Degasser leaks.

**ACTION:** Replace the RFIC Eluent Degasser.

### 6.5 No Flow

**CAUSE:** DP/SP power is off. Turning off the DP/SP automatically turns off the EG and the suppressor.

**ACTION:** Check that the power to the DP/SP is turned on. Prime the pump and then resume operation.

**CAUSE:** DP/SP pressure limit tripped. When a system includes an EG, the high pressure limit for the DP/SP is 21 MPa (3000 psi) and the low pressure limit is 1.4 MPa (200 psi).

**ACTION:** Check that the Current Pressure (under Pressure Display on the pump Control panel) is within this range.



**NOTE**

*The cartridge requires at least 14 MPa (2000 psi) of backpressure for optimal removal of electrolysis gas from the eluent produced by the cartridge. A system backpressure of 16 MPa (2300 psi) is ideal.*

**CAUSE:** RFIC Eluent Degasser tubing is ruptured. If flow from the EG waste line is normal, but there is no flow through the columns, the tubing assembly inside the RFIC Eluent Degasser has ruptured.

**ACTION:** Replace the degasser.

## 6.6 EG Stops Operation

- CAUSE:** DP/SP power is off. Turning off the DP/SP automatically turns off the EG and the suppressor.
- ACTION:** Check that the power to the DP/SP is turned on. Prime the pump and then resume operation.
- CAUSE:** DP/SP pressure limit tripped. When a system includes an EG, the high pressure limit for the DP/SP is 21 MPa (3000 psi) and the low pressure limit is 1.4 MPa (200 psi).
- CAUSE:** DP/SP flow rate is too low or too high.
- ACTION:** Select a flow rate between 0.1 and 3.0 mL/min.
- CAUSE:** Electrical error detected (Alarm LED is lighted). To prevent damage to the Cartridges, the DP/SP automatically turns off electrical power to the cartridge when excessive current or voltage is detected.
- ACTION:** Ensure the Cartridge electrical cable is properly connected to the ICS 3000 EG module. If failure persists, contact Dionex for assistance.



### NOTE

*The ICS-3000, 5000 and 5000+ EG Ion Chromatography System electronics components cannot be serviced by the user.*

- CAUSE:** Cartridge is expended.
- ACTION:** Replace the cartridge.
- CAUSE:** No communication with Chromeleon or Chromeleon Xpress.
- ACTION:**
1. Check that the POWER button on the front of the EG is turned on.
  2. Check that the EG main power switch (on the rear panel) is turned on.
  3. Check that the main power cord is plugged into both the EG rear panel connector and the power source.
  4. Check that the wall outlet has power.
  5. Check the USB connections. The EG should be connected to the DP/SP (or other ICS-3000 EG module) via a USB cable (P/N 960777). In addition, one module in the system must be connected to the PC on which Chromeleon or Chromeleon Xpress is installed.
  6. Check that the EG is configured in the software and assigned to a timebase.

## 6.7 Excessive System Backpressure

*CAUSE:* Restriction in the liquid line plumbing.

*ACTION:*

1. Begin pumping eluent through the system (including the columns) at the flow rate normally used.
2. Work backward through the system, beginning at the cell exit. One at a time, loosen each fitting and observe the pressure. The connection at which the pressure drops abnormally indicates the point of restriction.
3. If the EGC III Cartridge is identified as the source of the high backpressure, the outlet frit should be replaced. A restriction often causes such high pressure that the entire system cannot be operated. In that case, work forward through the system starting at the EGC III, adding parts one at a time until an abnormal pressure increase (and hence, the restriction) is found.

## 6.8 No Peaks

*CAUSE:* EGC current may not be on. The Chromeleon program may not be started.

*ACTION:* Make sure EG current is applied. Configure EGC correctly using Chromeleon software.

## 6.9 Peak Retention Times are Too Short

*CAUSE:* Concentration settings are too high. Pump flow rate is low.

*ACTION:* Check the Chromeleon program for correct concentration and flow rate combinations. Check the pump flow rate.

## 6.10 Peak Retention Times are Too Long

*CAUSE:* Concentration settings are too low. Pump flow rate is high. The OFFSET VOLUME in the EG II program is too large.

*ACTION:* Check the Chromeleon program for correct concentration and flow rate combinations. Check the pump flow rate.

## 6.11 Low System Backpressure

*CAUSE:* Loose fitting. High pressure degas tubing assembly ruptured. Internal EGC leak in the membrane barrier. (This leak will not be detected immediately by the EG II leak sensor since the liquid leak will pass out through the vent line)

*ACTION:* Check all system fittings. If there is no flow through the columns, although flow from the waste line remains normal, the degas tubing assembly has ruptured and must be replaced. This type of leak may trip the pump pressure limit and the pump will shut off. The cartridge must be replaced.

## Appendix A

### Optional Anion Trap Column – High Capacity (ATC-HC) or Cation Trap Column II (CTC II)

As an alternative to the CR-ATC 500, the ATC-HC or ATC-HC 500 can be used for anion applications (EGC 500 KOH, EGC III KOH, NaOH or LiOH). The ATC-HC and ATC-HC 500 will require off line chemical regeneration. See the ATC-HC Trap Column Product Manual (Document No. 032697) for details.

The CTC-1 and CTC 500 can be used as an alternative to the CR-CTC 500 for cation applications (EGC 500 MSA and EGC III MSA). The CTC-1 and CTC 500 will require off-line chemical regeneration. See the CTC-1 Trap Column Product Manual (P/N 031910) for details.



#### NOTE

***Do not use the ATC-HC or CTC II for capillary applications. Capillary RFIC-EG systems are only compatible with the CR-TC trap columns.***

- A. Prepare the ATC-HC (P/N 059604) or ATC-HC 500 (P/N 075978) for use by flushing the trap column with 200 mL of 2.0 M NaOH or KOH at 2 mL/min. Alternatively, prepare the CTC-1 or CTC 500 (P/N 075977) for use by flushing the trap column with 200 mL of 1.0 M H<sub>2</sub>SO<sub>4</sub> or 2.0 M MSA at 2 mL/min.
- B. Rinse the ATC-HC, ATC-HC 500, CTC 500 or CTC-1 with degassed DI water for 20 minutes at 2 mL/min.
- C. Attach the ATC/CTC Bracket (P/N 046384) found in the EG Ship Kit.
- D. Connect the pump pressure transducer outlet to the ATC-HC, ATC-HC 500, CTC-1 or CTC 500 inlet using the tubing connected to the exit of the pump pressure transducer.
- E. Connect the outlet of the ATC-HC, ATC-HC 500, CTC-1 or CTC 500 to the inlet of the EGC using the tubing labeled TO PUMP OUT / DAMPER at one end and EGC IN at the other end.
- F. Connect the tubing, labeled, DEGAS ELUENT IN, extending from the Degas Assembly to the outlet of the EGC labeled EGC OUT.