



# Trouble-Free ICP: Maximize Performance and Minimize Downtime



**Ryan Brennan**  
President  
Glass Expansion, Inc.



[www.geicp.com](http://www.geicp.com)

# Introduction: About Glass Expansion

- GE has been specializing in sample introduction components for ICPs since 1985
- Global recognition for manufacturing precision and reliability

## Three Glass Expansion offices providing global support:



**Glass Expansion – Asia-Pacific**  
Melbourne, Australia  
Email: [enquiries@geicp.com](mailto:enquiries@geicp.com)



**Glass Expansion - Americas**  
Cape Cod, Massachusetts  
Email: [geusa@geicp.com](mailto:geusa@geicp.com)



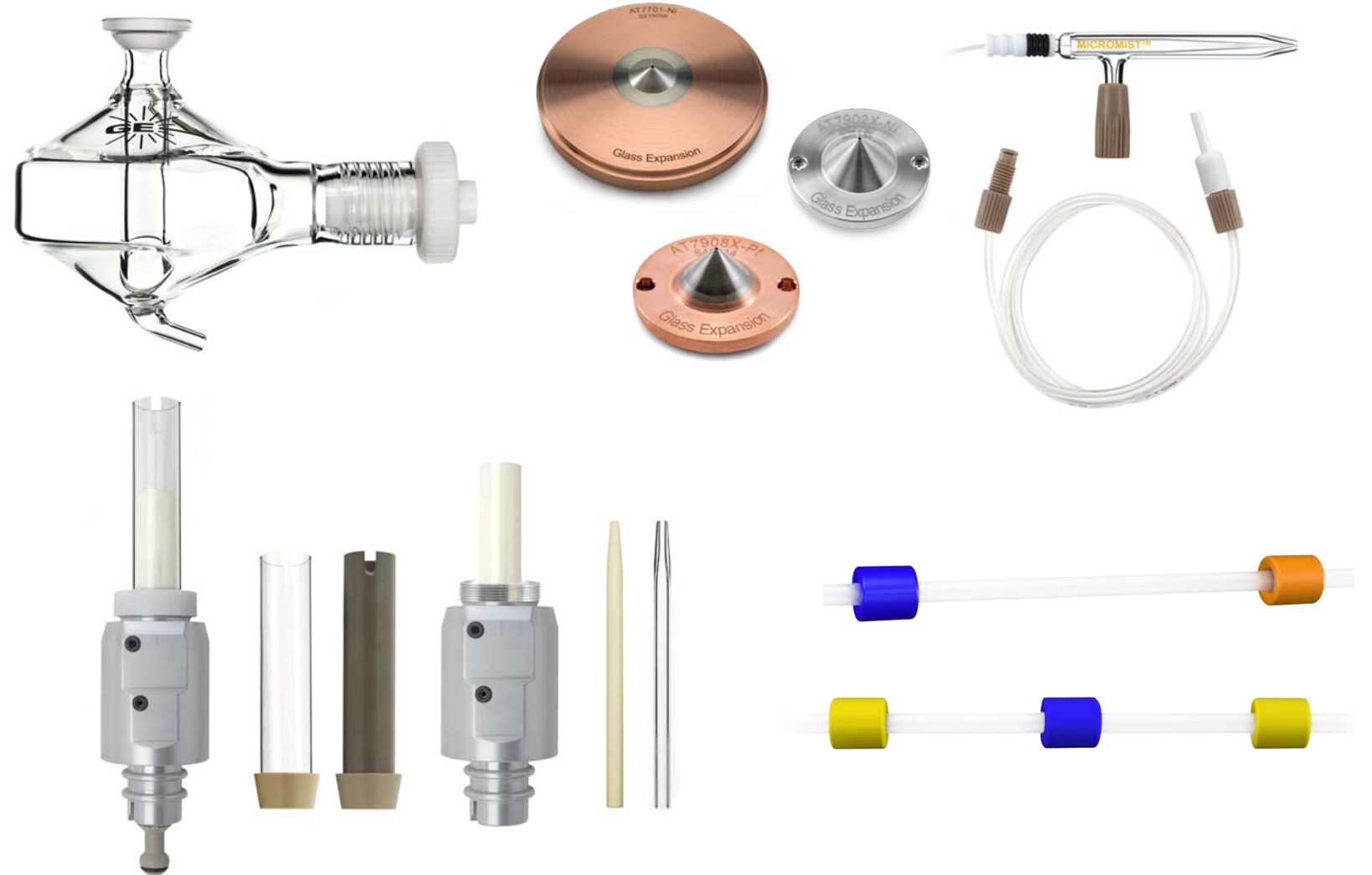
**Glass Expansion - Europe**  
Weilburg, Germany  
Email: [gegmbh@geicp.com](mailto:gegmbh@geicp.com)

[www.geicp.com](http://www.geicp.com)

# Our Product Offerings

- Autosampler Probes
- Pump Tubing
- **Nebulizers:** Custom manufactured for optimal performance with each ICP
- **Spray Chambers:** Pioneered cyclonic design
- **Torches:** Introduced the FDT
- **Cones, RF Coils**
- **Other Accessories**

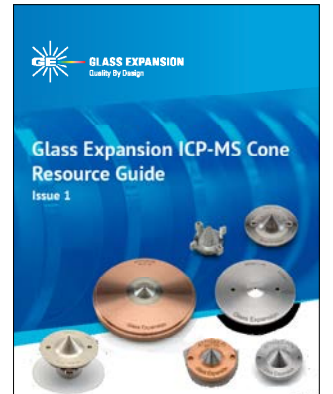
**Manufacturers Supported:** Thermo®, Agilent®, PerkinElmer®, Shimadzu®, SPECTRO, Analytik Jena®, Horiba®, Others



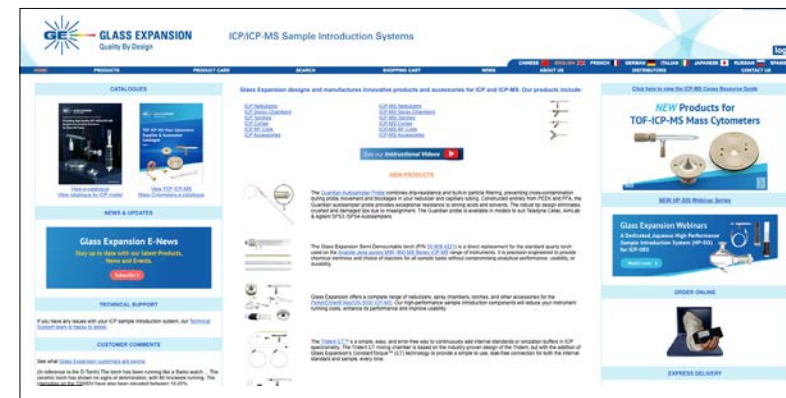
# ICP Resources

1. **Sales Support:** Pre-sales, inventory management; Post-sales
2. **Trainings:** Detailed sessions on product features, benefits and application
3. **Technical Support:** Online resources; Newsletters & Customer feedback

- Application Notes
- Newsletters
- Catalogs
- Product Flyers
- Website
- Product care advice
- Operating instructions
- Videos



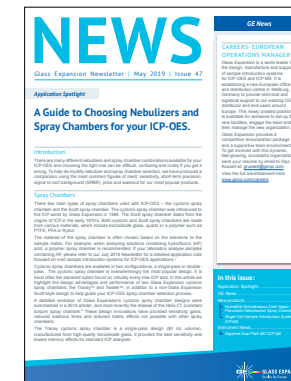
Catalogs



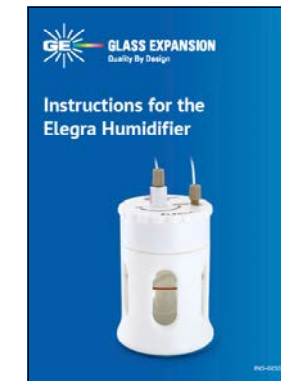
Website



Flyers



Newsletters



Instructions



Application Notes



# Overview of Key Components for ICP SIS

*The **sample-introduction area** has been called the **Achilles heel** of ICP because it is considered the weakest component of the instrument, with only 1-2% of the sample finding its way into the plasma.”*

The primary purpose of the SIS is to generate a **consistent aerosol** containing fine droplets:

**They key components of a SIS include:**

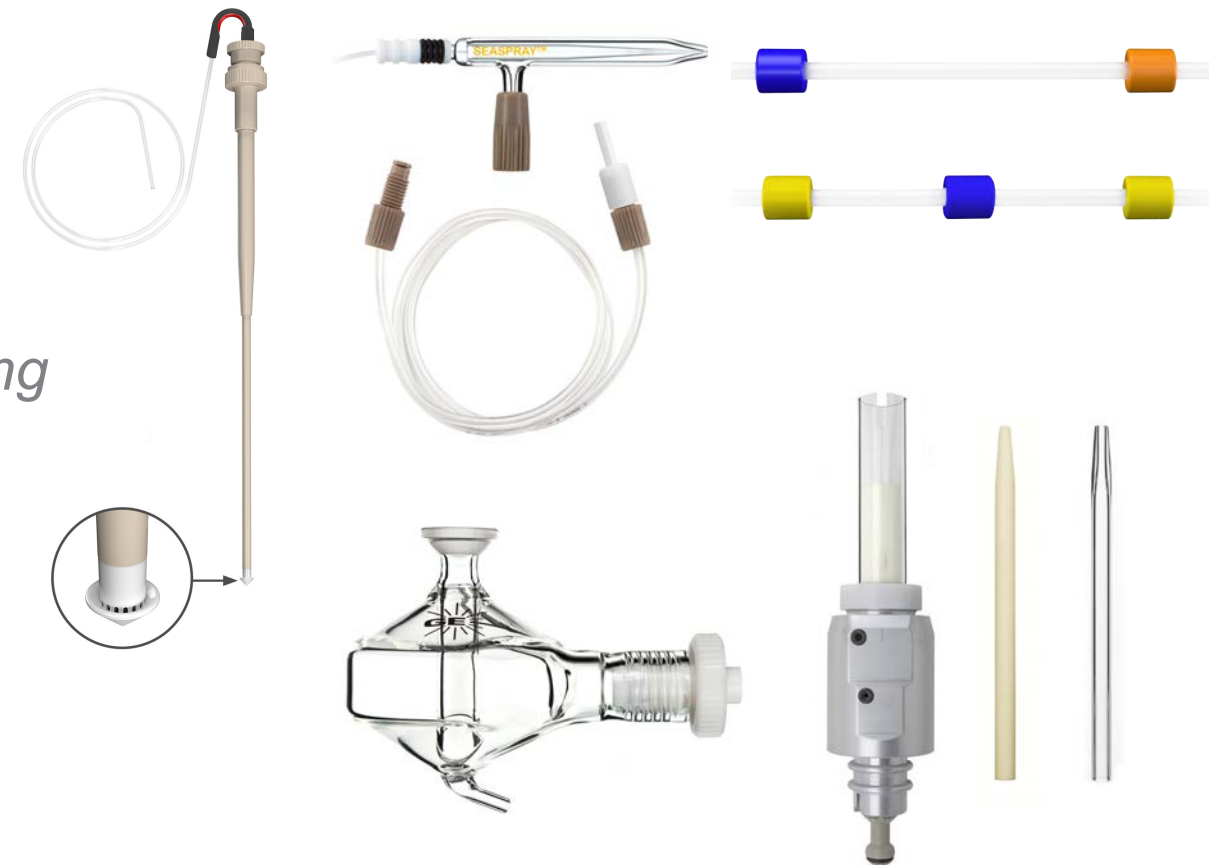
- **Sample Probe** (manual or autosampler)

*\*Teflon tubing connecting the sample probe to the persitaltic pump tubing*

- **Peristaltic Pump Tubing** (for sample and waste)

*\*Teflon tubing connecting the persitaltic pump tubing to the nebulizer*

- **Nebulizer**
- **Spray Chamber**
- **Torch + Injector**
- **RF Coil**
- **ICP-MS Cones**



# Sample Probe: Common Challenges

- **Effective Sample Digestion:** Clear liquids and consistent results (RSDs and spike recoveries).
  - **Ineffective Sample Digestion:** Precipitates (e.g., Ag, Fe, Si) and undigested particles.
1. **Clogging and Blockages:** Particulate matter from anode and cathode materials can obstruct sample flow.
  2. **Cross-Contamination:** Residues from different samples, such as anode and cathode, increase the risk of contamination.
  3. **Viscosity and Flow Issues:** Slurries or viscous electrolytes can cause uneven sample uptake and inconsistent measurements.

# Sample Probe: Selection

## 1. Standard Option: Carbon Fibre Probe

- Encapsulated carbon fibre tube with continuous PFA tubing
- Available for most common Autosampler models, with IDs of 0.50, 0.75 and 1.00 mm



## 2. Advanced Option: Guardian Autosampler Probe Features:

- **Robust tip** design prevents crushed and damaged tips due to misalignment
- **Combines drip-resistance and built in filter** to minimize cross-contamination, while protecting the nebulizer and capillary tubing
- **Completely inert design**, Ceramic, PEEK and PTFE construction
- **Interchangeable UniFit™ sample lines** IDs: 0.3, 0.50, 0.75 and 1.0mm
- **Autosamplers:** Teledyne Cetac®, Agilent®, PerkinElmer®, Shimadzu®, Aim Lab and Thermo Fisher Scientific™ Autosamplers.



# Guardian™ Probe Performance Comparison Video





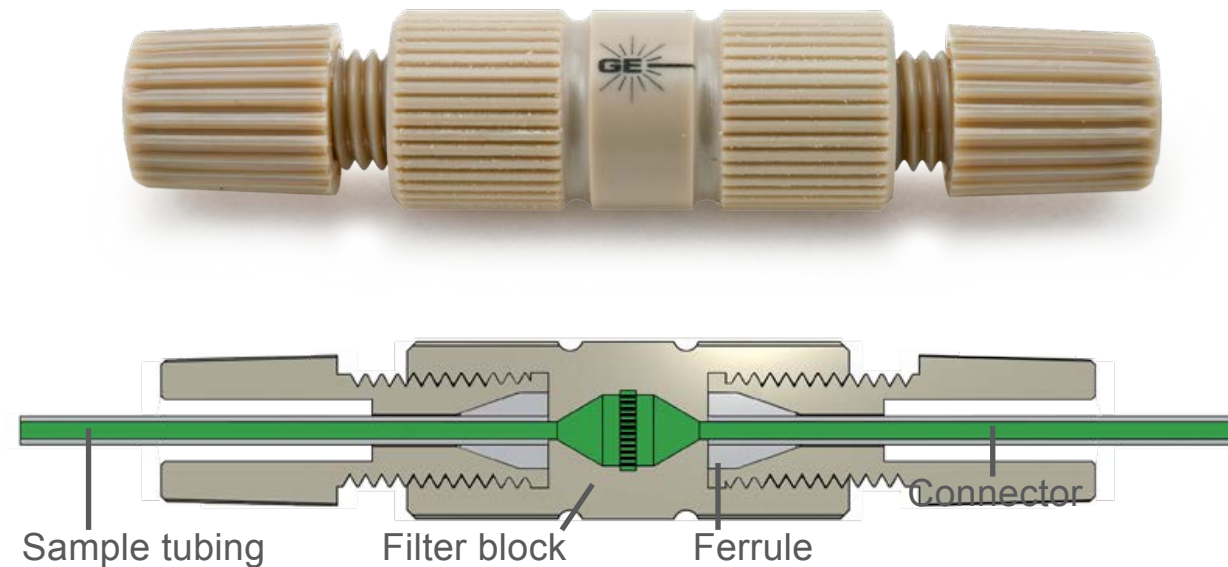
# Helpful Tools to Minimize Blockage In the Sample Path

## Guardian In-Line Particle Filter P/N 70-803-1108:

### Benefits

- Prevent large particles from clogging your nebulizer
- Insert between probe and nebulizer
- Re-usable PEEK filter (120 µm)
- Easily backflush to remove build up

**In-Line particle filter:** *“So far it has worked great, we have noticed significantly less clogged lines.”*  
**Fertilizer manufacturer - USA**



## Eluo Nebulizer Cleaning Tool P/N 70-ELUO

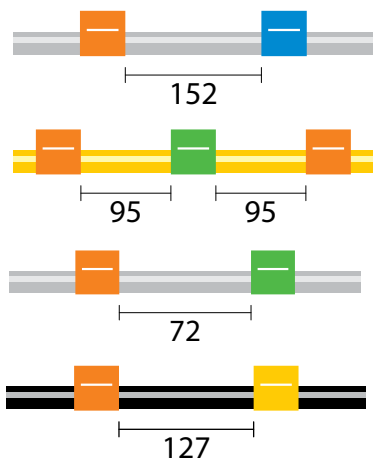
P/N 70-803-1160



### If you have the Eluo:

- Add adaptor P/N 70-803-1160

# Peristaltic Pump Tubing: Selection



## Tubing Material:

- PVC Tubing
- Solva Tubing
- Viton Tubing

## 2-Tag/Stop vs. 3-Tag/Stop:

**3-Tag/Stop:** When one section wears out, a fresh section is ready to use, extending tubing life

## Flared vs. Non-Flared Options:

**Flared-end pump tubing** makes it easier to insert larger sample capillary tubing

## Internal Diameter (ID):

**Smaller ID Tubing** (0.2-0.4 mm): Ideal for precise, low-flow applications

**Larger ID Tubing:** Suitable for higher flow rates and larger sample volumes

		Tag Colours	ID (mm)
		orange/black	0.13
		orange/red	0.19
		orange/blue	0.25
		orange/green	0.38
		green/yellow	0.44
		orange/yellow	0.51
		white/yellow	0.57
		orange/white	0.64
		black/black	0.76
		orange/orange	0.89
		white/black	0.95
		white/white	1.02
		white/red	1.09
		red/red	1.14
		red/grey	1.22
		grey/grey	1.30
		yellow/yellow	1.42
		yellow/blue	1.52
		blue/blue	1.65
		blue/green	1.75
		green/green	1.85
		purple/purple	2.06
		purple/black	2.29
		purple/orange	2.54
		purple/white	2.79
		black/white	3.17

# Pump Tubing: Common Challenges and Suggestions

## Common Challenges with Pump Tubing:

- Wear and Tear
- Neglected Maintenance
- Contamination Risk

## Suggestions for Maintaining Pump Tubing:

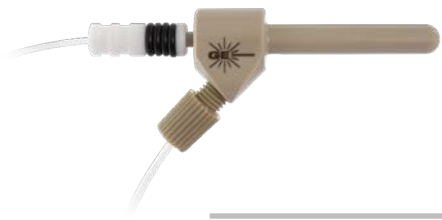
- Pre-Stretch Tubing and Maintain the proper tension on tubing
- Frequent Replacements: Pump and capillary tubing can be a source of contamination
- **Lubricate pump rollers (EzyGlide Cloth):**
  - Reduce wear and increase lifespan by minimizing friction
  - Stabilize sample delivery by reducing pulsations
- **TruFlo Sample Monitor:** eliminates guesswork and reduces the need to repeat measurements due to blocked nebulizers, worn pump tubing, or improper clamping.



# Nebulizers

What are the common challenges encountered when using nebulizers?

## Application Suitability



- HF, high dissolved solids, and suspended solids
- Can lead to reduced DLs, extended washout times, and poor precision

## Blockages



- Loss of Sensitivity and Poor Precision
- ICP Backpressure  
Nebulizer test verifies nebulizer performance

Self-washing Tip



## Sample Cross-Contamination

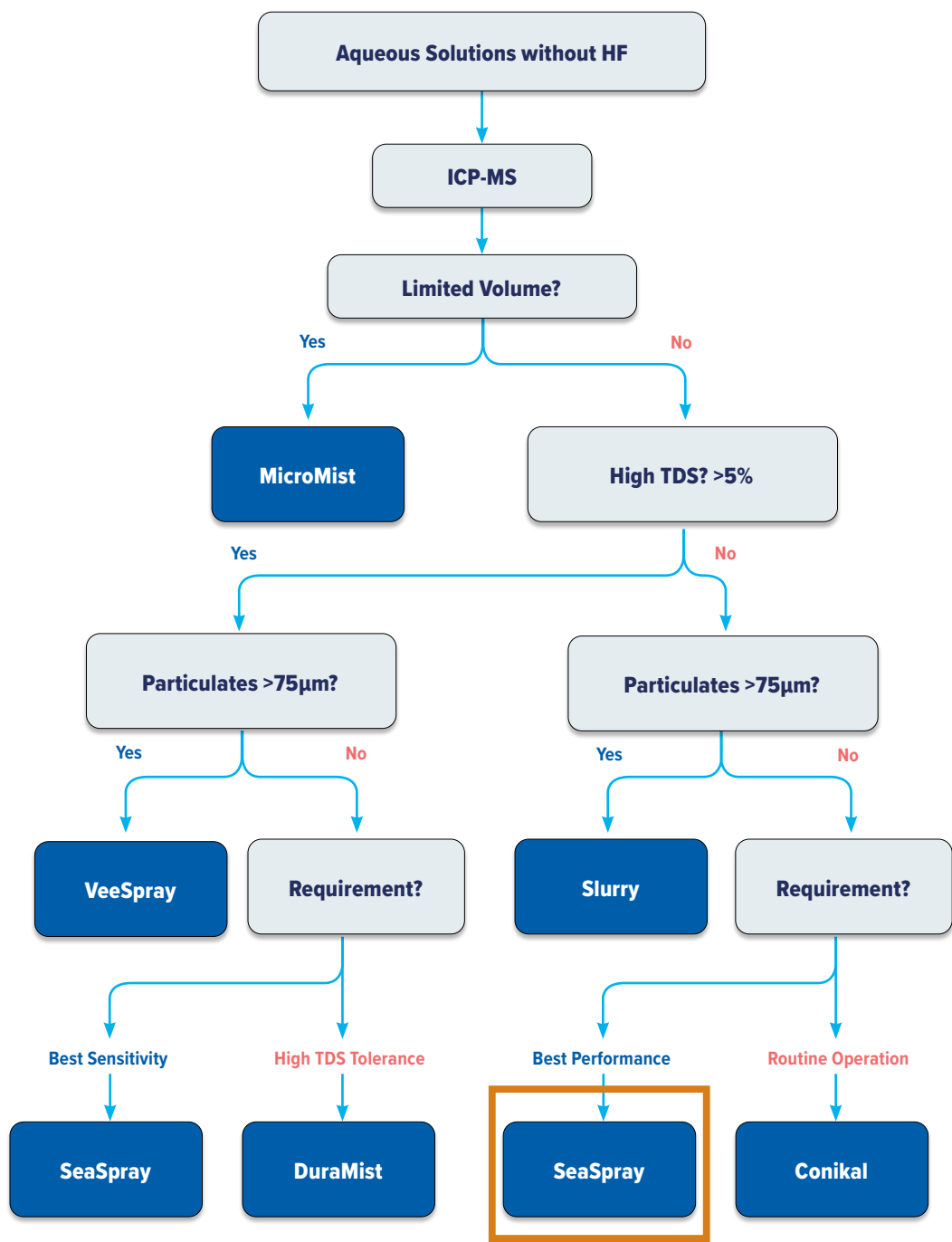


- Poor connections
- Dead volume
- Affecting analysis accuracy



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Quality By Design

# Nebulizer: Selection



Nebulizer		TDS (%)	Particulates (µm)	HF	Precision	Purity	Material
SeaSpray™		20	75	No	High	Good	Glass
MicroMist™		15	40*	No	High	Good	Glass
Conikal™		5	75	No	High	Good	Glass
Slurry™		1	150	No	High	Good	Glass
OpalMist™		15	75*	Yes	High	Excellent	PFA
DuraMist™		30	75*	Yes	High	Good	PEEK
VeeSpray™		30	300	Yes	Moderate	Good	Ceramic

\* Varies with nebulizer uptake

[Click here for Other Sample Types](#)



# SeaSpray™ Direct Connect (DC) Nebulizer

## High Performance and Tolerance

- Material: Borosilicate glass.
- High physical reproducibility ~ 1%.
- TDS tolerance, typically up to 20%.
- Standard available uptake: 0.4 and 2.0 mL/min.
  - (1 mL/min uptake available on request)
- Designed for 40psi, 0.7 L/min argon flow.

The SeaSpray™ nebulizer is the best choice when samples contain high concentrations of dissolved solids. Seawater, brines, and plating baths are just a few examples of SeaSpray™ applications. A number of ICP-OES manufacturers also select the SeaSpray™ as part of their standard configuration due to its excellent sensitivity and combined tolerance to dissolved solids.



# DuraMist™ DC Nebulizer

## Ideal for HF and High TDS Samples

- PEEK body and capillary.
- Particulates up to 75µm.
- Tolerance to harsh chemicals, up to 5% HF.
- TDS tolerance, typically ~ 30%.
- 0.4 and 1.0 mL/min uptake models.
- Designed for 40psi, 0.7 L/min argon flow.

The DuraMist™ is the most economical inert nebulizer for high-precision analysis. It is highly sensitive, with excellent short-term precision and the highest tolerance to dissolved solids of any concentric nebulizer. It is a great “all-rounder” and ideal for high-throughput labs that require a good balance between durability and sensitivity.



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# Nebulizer Selection - Glass Expansion eNews



## How to Select an Inert Nebulizer for your ICP

Authors: Ryan Brennan and Justin Masone

### Abstract

Nebulizers made of glass or quartz are unsuitable for:

- Ultra-trace ICP-MS determination of some elements such as silicon
- Use with caustic solutions
- Samples containing free-HF acid

For these challenging analyses, a high-quality ceramic or polymeric nebulizer is the best choice.

As the nebulizer is a critical component of your ICP sample introduction system, you need to make the right choice to get the best results out of your instrument. The following guide details Glass Expansion's high-quality inert nebulizer designs and provides guidance on which nebulizer is best suited to your laboratory's requirements.

### Introduction

When choosing an inert nebulizer, key selection criteria should include: nebulization efficiency, purity, and tolerance to HF, particulates and total dissolved solids (TDS). Nebulization efficiency will affect overall ICP performance, e.g. sensitivity and precision. Inert nebulizers are available in different designs; the most popular include concentric, cross-flow, and parallel path (or V-groove).

The cross-flow and V-groove nebulizer designs typically produce an aerosol that has larger droplets with a wider droplet size distribution. Larger droplets can pass through the plasma without desolvating or completely evaporating, resulting in poor precision, reduced nebulization efficiency, increased matrix effects and reduced plasma robustness, whereas concentric nebulizer designs produce a smaller, more uniform droplet size, providing higher transport efficiency (sensitivity) and improved precision (RSD).

The trade-off with nebulization efficiency is that the cross-flow and V-groove designs will provide a greater tolerance to particulates. An incomplete sample digestion can result in remaining particulates; these particulates can block the smaller capillary and gas annulus of a concentric nebulizer.

The raw material of the inert nebulizer will have an effect on purity and chemical resistance. Inert nebulizers can be made from ceramic or various plastic materials, which include:

- Perfluoroalkoxy alkane (PFA)
- Polyphenylene sulfide (PPS)
- Polypropylene (PP)
- Polyether ether ketone (PEEK)
- Polyimide (PI)

Glass Expansion currently offers three inert nebulizer designs: the DuraMist (Figure 1), OptaMist (Figure 2) and VeeSpray (Figure 3). Taking all of your analytical criteria into consideration will allow your laboratory to select the best nebulizer for your application and sample matrix.

A nebulizer made of high-purity PFA will provide the greatest chemical resistance to HF acid and the lowest elemental background levels. However, PFA is expensive if the highest purity and best chemical resistance are not requirements of your laboratory.



## A Dedicated, Aqueous High-Performance Sample Introduction System (HP-SIS) for ICP-OES

Author: Ryan Brennan

### Abstract

In this article, we highlight the superior performance of an aqueous high-performance sample introduction system (HP-SIS) from Glass Expansion, compared to a standard aqueous sample introduction system (SIS), using the Thermo Fisher Scientific® PRO Duo ICP-OES.

### Introduction

The goal of Glass Expansion's HP-SIS series ([www.geicp.com/HP-SIS](http://www.geicp.com/HP-SIS)) is to help your ICP laboratory make the right choice to achieve the best results and reduce both operating costs and downtime. In Part II of our HP-SIS series, we tackle how to achieve higher performance with your routine aqueous samples. When selecting our Aqueous HP-SIS, we shift our focus to obtaining the best possible sensitivity, precision, and detection limits, as we are no longer concerned with the challenges associated with sample matrices containing hydrofluoric acid (HF), volatile organic solvents, particulates, or high total dissolved solids (TDS).

### Nebulizer Selection

The nebulizer is a critical choice, as the quality of the aerosol produced relates directly to the analytical performance of your ICP. The smaller the overall mean diameter of the aerosol, the better the sensitivity you will achieve, and with a narrower size distribution, the better detection limits and precision (RSD) you will have. Glass Expansion offers the largest range of concentric nebulizer designs by any manufacturer, with each model having a variety of applications for which it is ideally suited. In a 2019 report<sup>1</sup>, Glass Expansion evaluated all of its ICP-OES nebulizer models, with the SeaSpray™ Direct Connect (DC) nebulizer providing the best overall precision, sensitivity, and detection limits. Due to its well-rounded overall performance and excellent sensitivity, we chose Glass Expansion's trademark SeaSpray™ DC nebulizer for our Aqueous HP-SIS.

The unique and proprietary design features of the SeaSpray™ DC nebulizer are shown in Figure 1. Glass Expansion's SeaSpray™ DC nebulizer is made from borosilicate glass, featuring our patented VitriCone™ sample capillary. The VitriCone™ sample capillary is entirely different from those of other manufacturers, which use a hand-drawn glass sample capillary that is not only fragile and easily broken, but often results in poor precision because it can vibrate from the high-speed carrier gas. In comparison, the VitriCone™ is machined from a thick-walled glass capillary, providing a highly reproducible geometry and constant internal diameter – from sample inlet to tip. The DC gas line provides an inert, metal-free, instrument-specific gas line. In addition to a reliable ratchet fitting to ensure a leak-free gas connection between the nebulizer and ICP, the DC fitting assists in maintaining optimal backpressure for consistent day-to-day nebulizer performance. The UniFit™ sample connector easily slides over the sample arm of the nebulizer, creating an excellent seal and a zero-dead-volume connection. The SeaSpray™ DC nebulizer also features a uniquely engineered self-washing tip with smooth surfaces to avoid build-up of salt crystals. In addition to providing outstanding nebulization efficiency, the SeaSpray™ DC nebulizer can also tolerate up to 20% TDS.

Figure 1. Details of SeaSpray DC nebulizer (PIN A31-07-J852)



## A Dedicated HF-Resistant, High Performance Sample Intro System (HP-SIS) for ICP-OES

Author: Ryan Brennan

### Abstract

The standard sample introduction system (SIS) of your ICP determines many factors, including detection limits, precision, different matrix tolerances and cost. ICP performance can often be improved by careful choice of torch, spray chamber and nebulizer components, taking into account the type of samples that will be analyzed. For samples that contain even trace amounts of hydrofluoric acid (HF), a glass or quartz sample introduction system is unsuitable.

In this article, we highlight the superior performance of an HF-resistant, high-performance sample introduction system (HP-SIS) from Glass Expansion, compared to a standard HF-Resistant SIS, using the Thermo Fisher Scientific® PRO Duo ICP-OES.

### Introduction

A major breakthrough in the performance of inert spray chambers came with the introduction of Glass Expansion's proprietary Stediflow surface treatment.<sup>1</sup> The Stediflow treatment improves the wettability of the PTFE surface, ensuring efficient drainage, and delivering sensitivity and precision comparable to those achieved with a glass spray chamber.

The common problem with polymers used to manufacture inert spray chambers is they do not wet completely, and large droplets collect on the inside walls. The formation of these droplets degrades ICP performance, leading to erratic drainage, poor precision and signal instability. The Stediflow treated PTFE Tracey™ spray chamber is nearly equivalent to a glass spray chamber.<sup>1</sup>

In addition to the Stediflow treatment, the PTFE Tracey spray chamber also features Glass Expansion's Helix™ CT interface.<sup>2</sup> The Helix CT locking screw and seal uses a Constant Torque ratchet mechanism to provide a zero dead-volume, gas-tight seal between the nebulizer and spray chamber for consistent performance. These design innovations (Figure 1) have provided the Tracey spray chamber sensitivity gains, reduced washout times and reduced matrix effects not possible with other spray chambers.

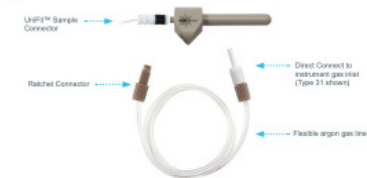
Figure 1. Details of PTFE Tracey (PIN 20-809-8108)



Choosing an inert nebulizer is just as important as the type of spray chamber selected. Key categories to review when choosing an inert nebulizer are: chemical resistance to HF, purity, tolerance to particulates and overall performance (sensitivity and precision). This way, the best nebulizer is chosen for the application and sample matrix.

All of Glass Expansion's Direct Connect (DC) nebulizer models feature a DC gas line and UniFit sample connector (Figure 2). The DC gas line provides an inert, metal-free, instrument-specific gas line. In addition to a reliable ratchet fitting to ensure a leak-free gas connection between the nebulizer and ICP, the DC fitting assists in maintaining optimal backpressure for consistent day-to-day nebulizer performance. The UniFit sample connector easily slides over the sample arm of the nebulizer, creating an excellent seal and a zero-dead-volume connection.

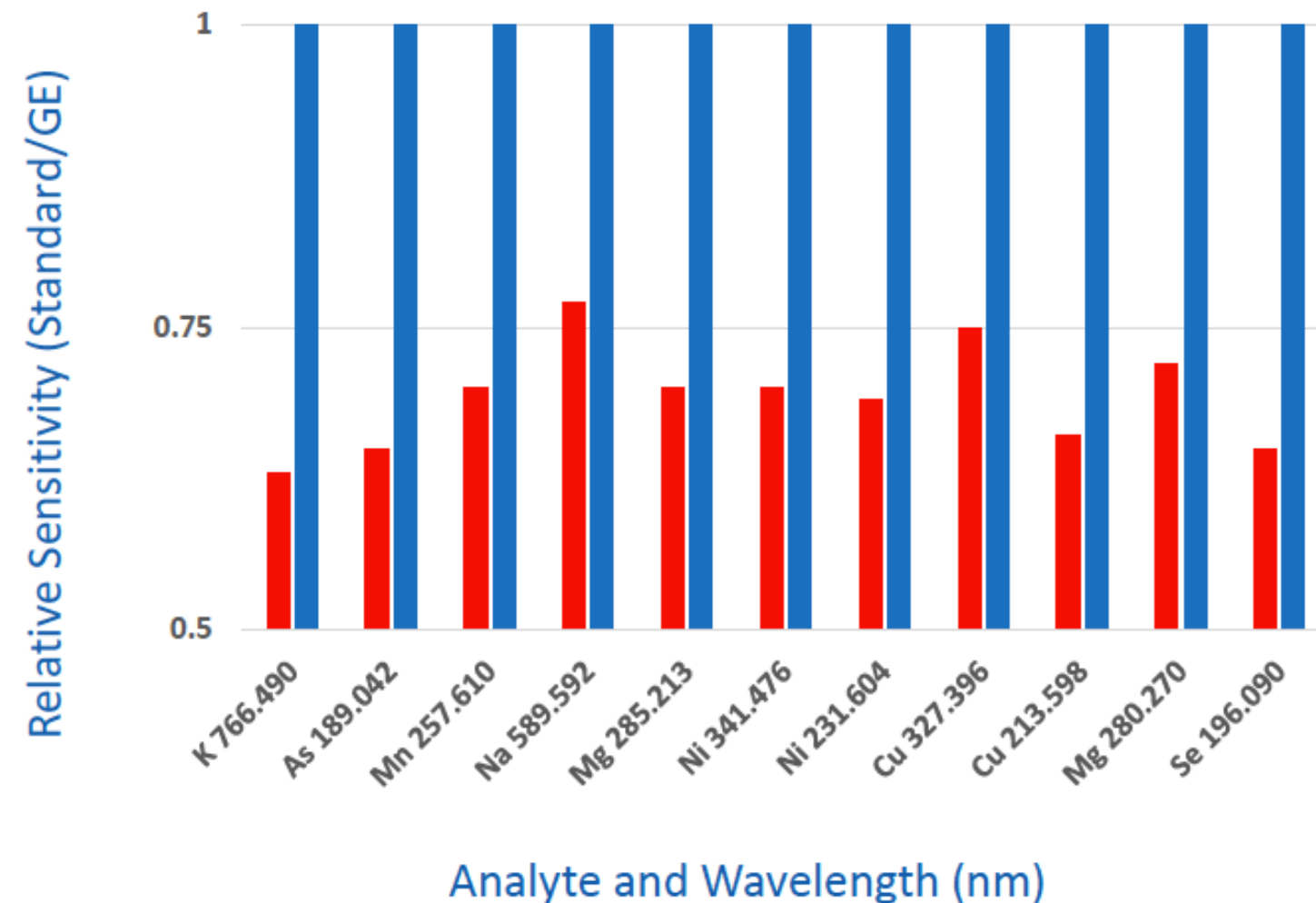
Figure 2. Details of DuraMist DC nebulizer (PIN A31-07-DM1)





# Aqueous HP-SIS - Sensitivity Comparison

Sensitivity of Standard Aqueous SIS relative to Glass Expansion Aqueous HP-SIS (relative sensitivity = 1)



- **Glass Expansion Aqueous HP-SIS**
  - Average improvement of 30%
- **Standard Aqueous SIS**

**The SeaSpray™ Nebulizer**

The SeaSpray™ nebulizer has re-written the rules for analysis with ICP-OES and ICP-MS – providing improved precision and sensitivity as well as freedom from clogging while nebulizing up to 20% salt solutions.

The SeaSpray combines a unique self-washing tip with the revolutionary Glass Expansion VitriCone construction. The SeaSpray nebulizer tip has been carefully designed with smooth surfaces to minimize adhesion of salt crystals. The design also uses the washing action of the dispersing droplets to further prevent crystal growth, allowing the SeaSpray to handle up to 20% salt solutions.

With some concentric glass nebulizer brands, the sample channel is constructed from fine drawn out capillary tubing. Glass Expansion nebulizers on the other hand, use the unique VitriCone construction. With the VitriCone design the sample channel is constructed from heavy glass capillary which is machined to very tight tolerances.

With the SeaSpray U-Series nebulizer, our proprietary UniFit connector slides easily over the sample arm and creates an excellent seal. As with all U-Series nebulizers, the sample channel is uniform from the entry point to the tip so there is nowhere for particulates to be trapped. And, since there is nowhere for sample to be trapped, you get the fastest possible washout and highest sample throughput. We supply SeaSpray U-Series nebulizers for all ICP-OES and ICP-MS spectrometers.

**Glass Expansion SeaSpray:**

Self-washing tip  
UniFit Sample Connector  
VitriCone Sample Channel  
Direct Connection Fitting

**Other brands:**

Thin drawn capillary

**Benefits of VitriCone™ Construction**

- The sample channel is uniform, so salt deposition is inhibited.
- The rugged precision-machined capillary resists vibration and delivers the best possible precision.
- The industry's tightest tolerances ensure that each nebulizer will perform to the same high standards as the

For more information visit: [www.geiso.com/intothenebulizer](http://www.geiso.com/intothenebulizer)

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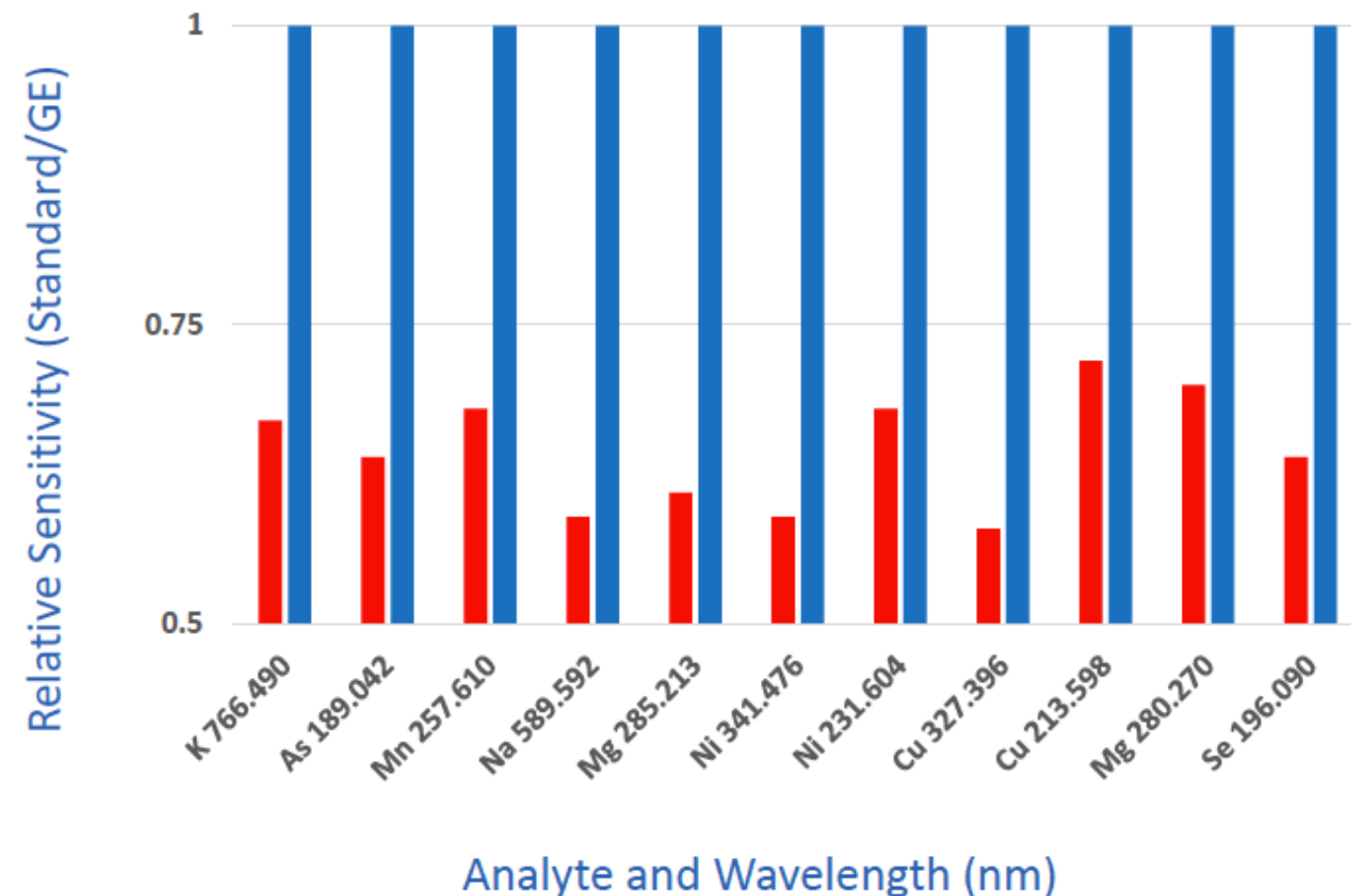
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# HF-Resistant HP-SIS – Sensitivity Comparison

Sensitivity of Standard HF-Resistant SIS relative to Glass Expansion HF-Resistant HP-SIS (relative sensitivity = 1)



- Glass Expansion HF-Resistant HP-SIS
  - Average improvement of 35%
- Standard HF-Resistant SIS

**DuraMist™ High Performance Inert Nebulizer**

**Inert material**  
Made from PEEK and it can tolerate a wide variety of acids including HF.\*

**High sensitivity and excellent precision**  
Due to concentric design and rigid construction.

**High tolerance to dissolved solids**  
(Typically up to 30%) due to smooth surface of capillary and nebulizer tip.

**High physical reproducibility**  
Minimal nebulizer to nebulizer variability so that changing nebulizers does not change your analytical performance.

The DuraMist™ is a HF-resistant nebulizer, providing excellent sensitivity and precision at an affordable price. The DuraMist is a concentric, self-aspirating nebulizer and is compatible with all ICP models. And its ability to run samples with up to 30% total dissolved solids without blockage make it effectively a universal nebulizer.

The strength and rigidity of the PEEK material allows the DuraMist to be manufactured to very tight tolerances, enabling it to closely match the Sealspray, the worldwide market-leading high performance glass nebulizer. A comparison of the DuraMist with the Sealspray showed that the DuraMist gave similar performance.

For more information visit: [www.geico.com/otoc/nebulizers](http://www.geico.com/otoc/nebulizers) or contact us at [ecoult@geico.com](mailto:ecoult@geico.com)

	Intensity	RSD
Sealspray	100	0.23%
DuraMist	87	0.28%

\* The DuraMist nebulizer is recommended for samples containing up to 5% HF. For samples with higher concentrations of HF, we recommend the OptaMist PFA nebulizer.

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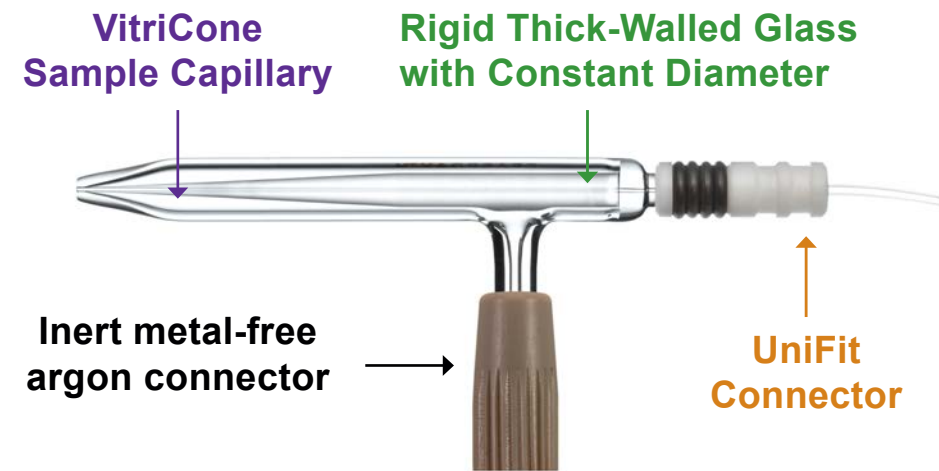
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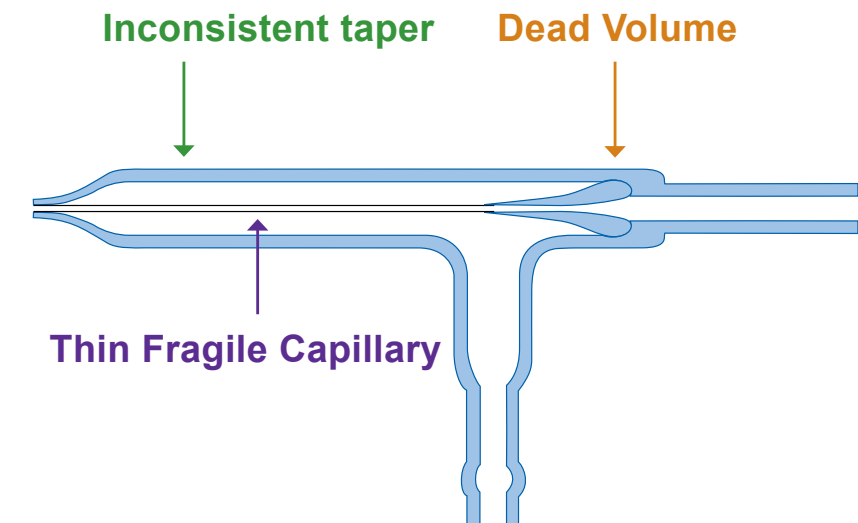
# Nebulizers

## GE Nebulizer Design



- **Machined from thick-walled tubing:** Highly reproducible geometry.

## Other Nebulizer Design

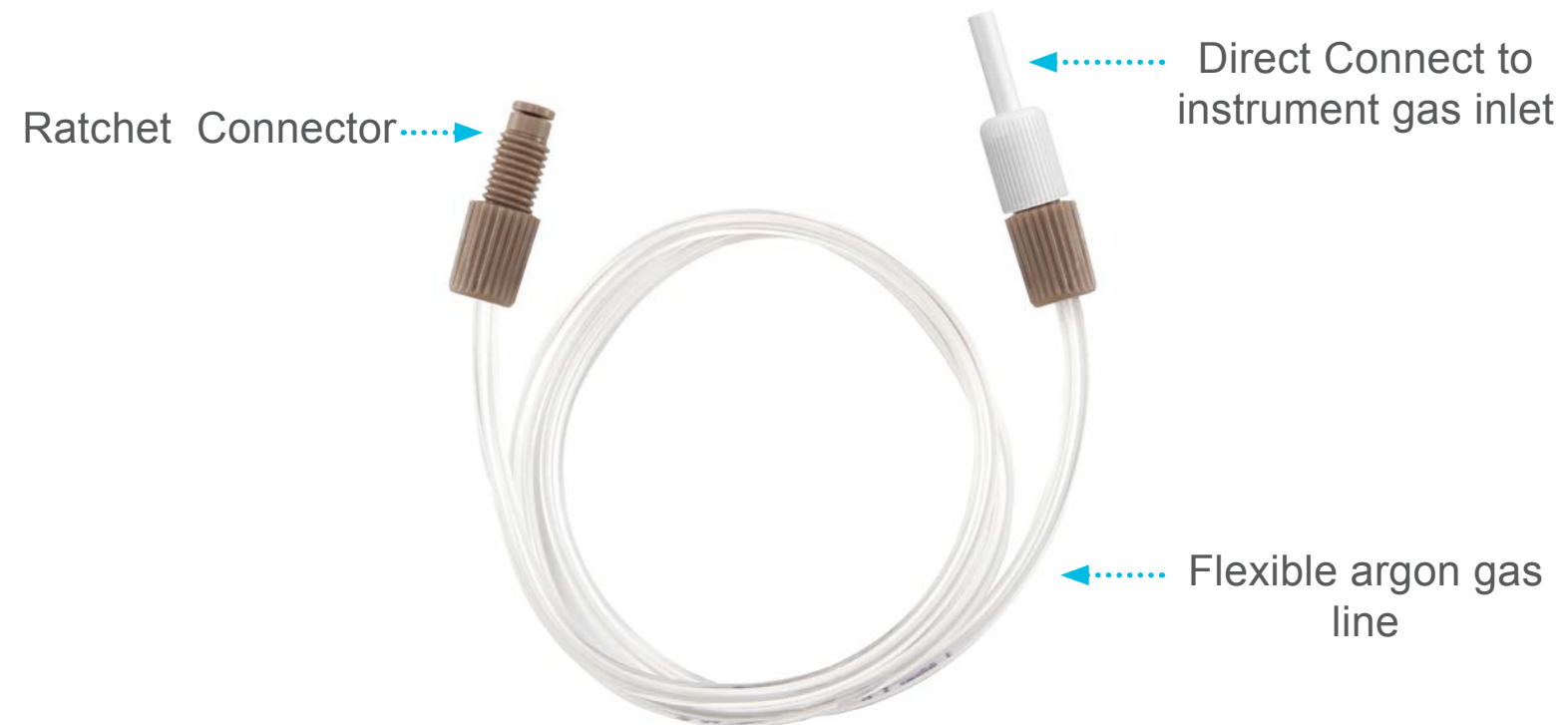


- **Constructed from drawn-out capillary tubing:** Challenging to replicate consistently.

# DC Nebulizer - Benefits



- Inert, metal-free argon connector
- Ratchet fitting ensures leak-free gas connection
- Direct plug-in gas line connection to instrument



# Glass Expansion DC Gas Lines

Manufacturer	Model	P/N Prefix	Gas Line Included
Agilent®	4100, 4200	MP11-	70-803-0969
Agilent®	Vista, 700-ES	A11-	70-803-0969
Agilent®	7700, 7800, 7900, 8800, 8900	A13-	70-803-1105
Agilent®	5100, 5110, 5800, 5900	A13-	70-803-1105
Analytik Jena®	ICP-OES	A13-	70-803-1105
Analytik Jena ®	ICP-MS	A61-	70-803-2002
Analytik Jena ®	ICP-OES	A13-	70-803-1105
Horiba ® Jobin Yvon	All Models	A13-	70-803-1105
Leeman	All Models	A11-	70-803-0969
Nu Instruments	ICP-MS	A51-	70-803-1858
Nu Instruments	TOF-ICP-MS	A52-	70-803-2044
PerkinElmer ®	Optima, PE Avio	A21-	70-803-1070
PerkinElmer®	Elan, NexION 300/350	A22-	70-803-1049
PerkinElmer®	NexION 1000, 1100, 2000, 2200, 5000	A23-	70-803-1449
Radom	MICAP® OES™ 1000	A70-	70-803-2054
Shimadzu®	All Models	A41-	70-803-1311
Spectro™	All Models	A21-	70-803-1070
Standard BioTools™ (Fluidigm)	Helios	A21-	70-803-1070
Thermo Scientific™	PRO, 6000/7000, MX Series, Q/RQ/TQ, X-Series & Neoma	A31-	70-803-1105
Thermo Scientific™	Neptune	A11-	70-803-0969



P/N 70-803-0969



P/N 70-803-2002



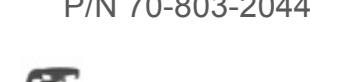
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P/N 70-803-1070



P/N 70-803-2054



P/N 70-803-1049



P/N 70-803-1449



P/N 70-803-1858



P/N 70-803-1311



**GLASS EXPANSION**  
Quality By Design

# How to Identify Nebulizer Issues

Verify the nebulizer back-pressure after instrument warm-up:

**1. Low nebulizer back-pressure** and a loss in sensitivity can indicate a leak on the supply line:

- Check the Ar nebulizer gas connection at the instrument and at the nebulizer gas arm.
- Inspect for any visible cracks.

**2. High nebulizer back-pressure** can indicate a partially blocked or clogged nebulizer:

- Clean nebulizer or replace if necessary.

**3. Record your normal sample uptake rate**

- A change in uptake rate can indicate a blockage, worn pump tubing, or incorrect tension on the pump.



Magnifier Inspection Tool  
P/N 70-803-1923



Conikal™  
SeaSpray™  
MicroMist™  
Slurry™



P/N 70-ELUO



DuraMist™

OpalMist™



P/N 70-ELUO-OPD



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# Nebulizer Cleaning Procedure

- To maintain your nebulizer, start and finish each run by nebulizing a mildly acidic blank solution, followed by DIW for 5-10 min.
- This prevents sample deposits from forming inside the nebulizer when the solvent dries out.

## For Blockages:

1. Initially flush with water using the Eluo
2. Soak nebulizer tip in 25% Fluka for 24 hours.  
*An initial flush of 25% Fluka may be required.*
3. Flush 3x with water using the Eluo.
4. *Stubborn deposits may require an additional soaking for 2 hours with 5% HN03*
5. Flush 3x with water using the Eluo.
6. *For faster drying, flush with methanol.*





# Nebulizer Maintenance Practices to Avoid



- Do not insert anything through the orifice of the nebulizer, including wires and probes. This is most likely to damage the nebulizer beyond repair.
- Never touch the nebulizer tip. Any deposit of body oils can have a detrimental effect on the performance of the nebulizer.
- Do not use any concentration of HF to clean a glass or quartz nebulizer. Even dilute HF can alter the orifice of the internal capillary and deteriorate the performance of the nebulizer.
- Do not place a glass nebulizer in an ultrasonic bath as it may dislodge the internal capillary.
- Do not use hot liquid to flush the sample capillary of an inert nebulizer. The temperature can potentially deform the capillary and affect nebulizer

# Improved Stability in High TDS Matrices: Environmental and Mining

## Features:

- No heating or electric power required
- Membrane humidification technology
- Improved signal stability for samples with high TDS
- Inert metal free construction
- Dual-Channel version (ICP-MS)

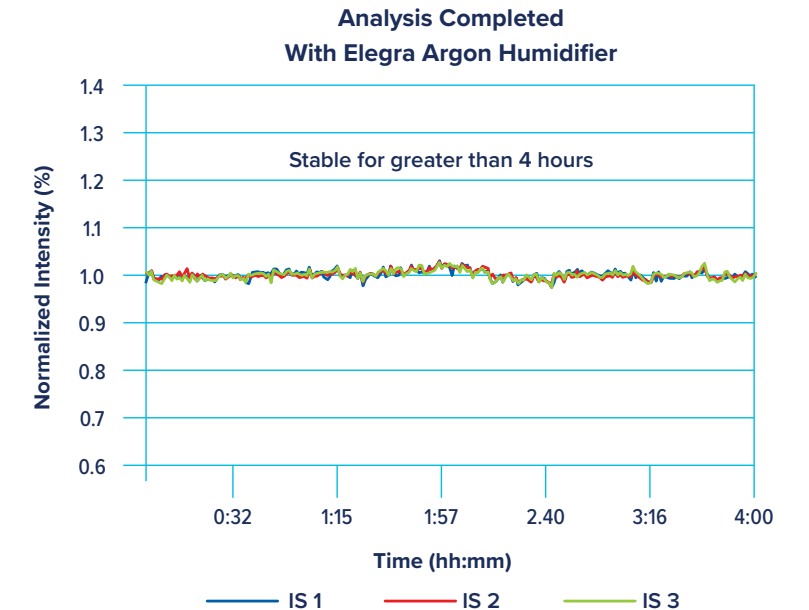
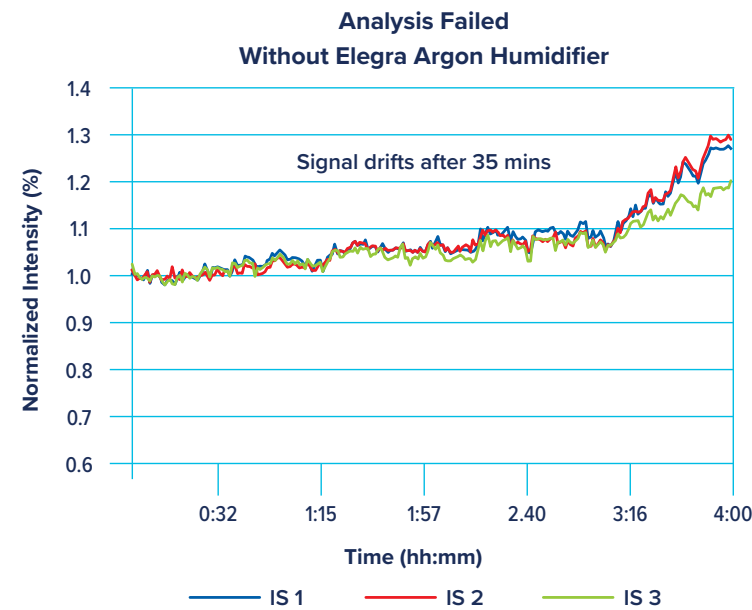
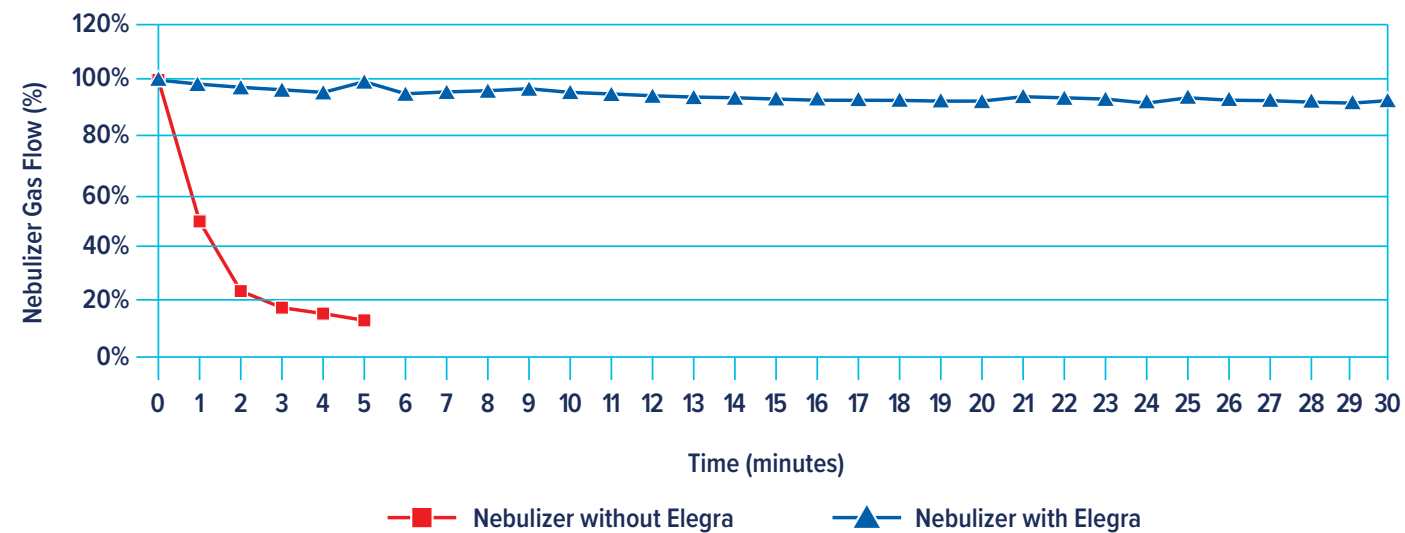
## Other tips for high TDS:

- Increasing the auxiliary argon flow will lift the plasma higher off the injector, slowing salt buildup at the injector tip.
- Extended rinses in between each sample.



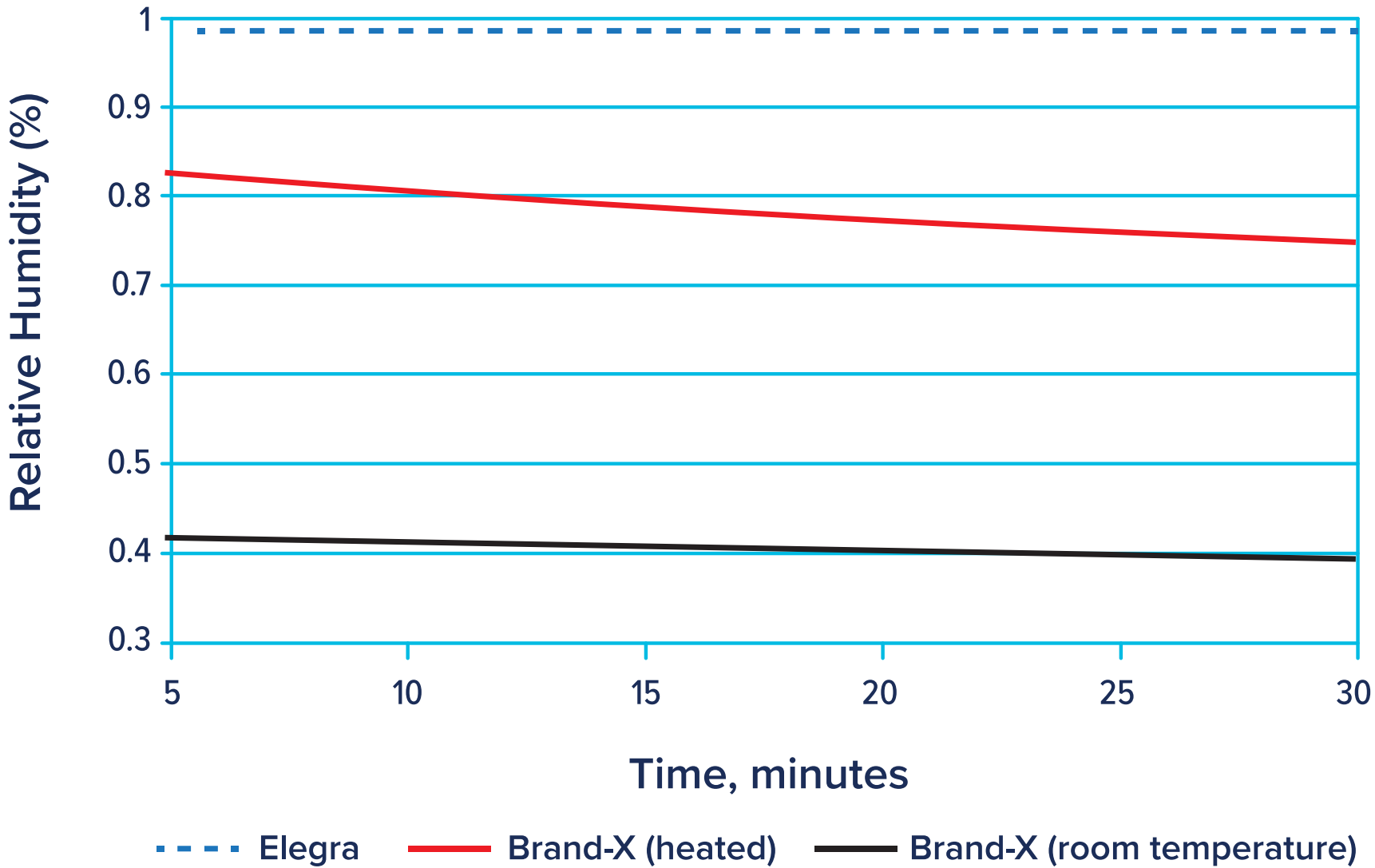
# Recommended Products: Elegra Argon Humidifier

Concentric Nebulizer with 25% TDS Tolerance



- Conikal nebulizer typically with up 5% TDS tolerance
- **Added moisture from Elegra prevented nebulizer clogging**
- High-throughput contact lab evaluation for Li metaborate
- **Without Elegra:** IS resulting in failed analysis (>10% drift)
- **With Elegra:** no variation in IS signal over-four-hour period

# Comparison of Humidifier Designs



Cinnabar™



Tracey™



Twister™



Twinnabar™



# Spray Chamber Optimal Selection and Maintenance

PTFE (Tracey™  
& Twister™)



IsoMist XR™



PCC



PFA Tracey™



**GLASS EXPANSION**  
Quality By Design



# Spray Chambers

What are the common challenges encountered when using spray chambers?

## Application Suitability



- HF
- Organics
- Limited volume samples

## Transport Efficiency



- Loss of Sensitivity
- Poor Precision and Accuracy
- Inconsistent Signal Stability

## Long washout Carryover



- Poor Precision
- Dead volume
- Compromised analytical results

Profound Effect on: **Transport Efficiency, Precision, and Washout**

# GE Spray Chambers Design Features: Helix CT

Sensitivity Gains + Reduced Washout Times + Reduced matrix effects

Vertical wall ensures maximum transport efficiency

Precisely placed groove guarantees smooth draining

Helix CT fixes nebulizer depth and provides the optimum interface for minimizing dead volume

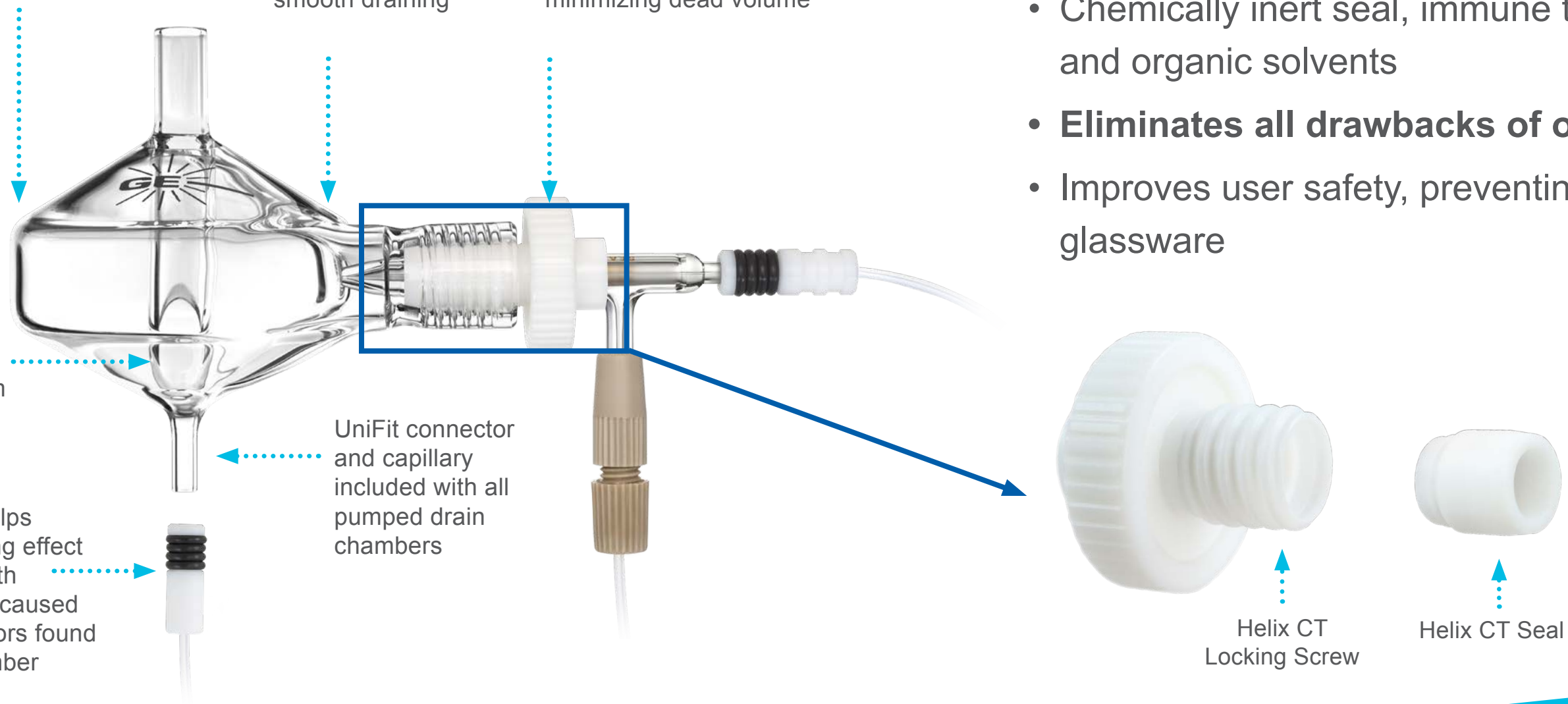
## Inert PTFE PressFit Seal:

- Chemically inert seal, immune to strong acids and organic solvents
- **Eliminates all drawbacks of o-ring seal**
- Improves user safety, preventing broken glassware

Baffle cut at angle and fused to bottom prevents droplet formation

UniFit connector helps prevent the pulsating effect often associated with ineffective draining caused by push-fit connectors found in other spray chamber designs.

UniFit connector and capillary included with all pumped drain chambers



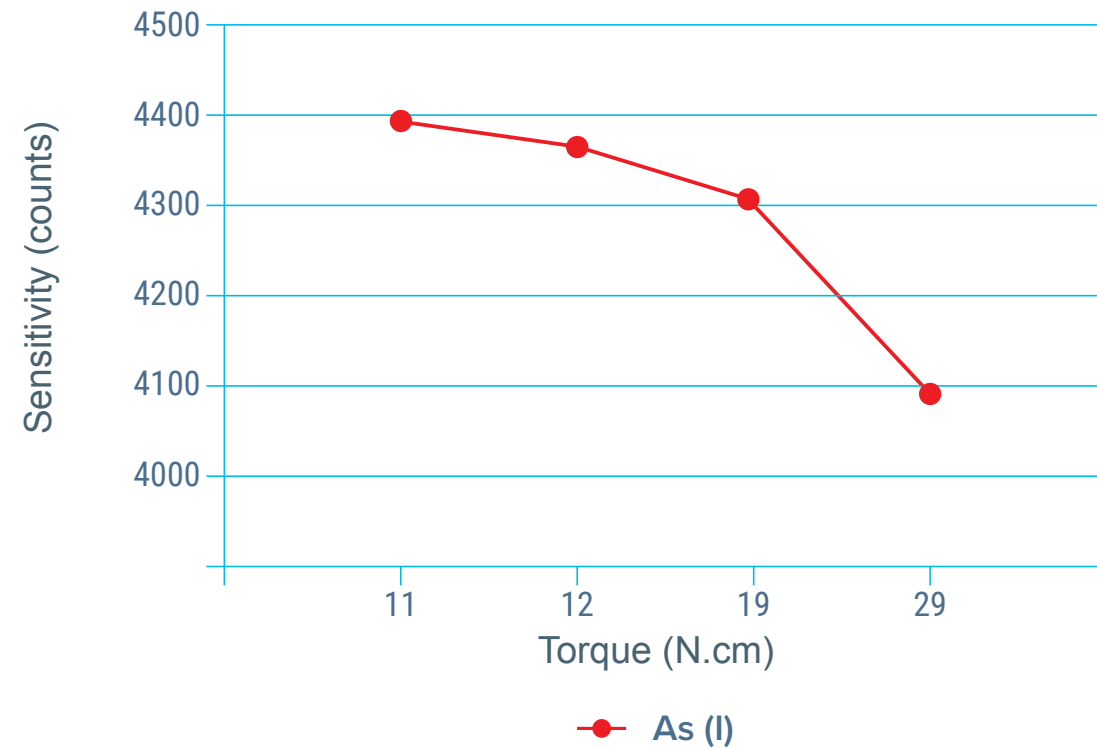
# Precision & Sensitivity: Design Considerations

## Helix CT: Constant Torque = Constant Performance

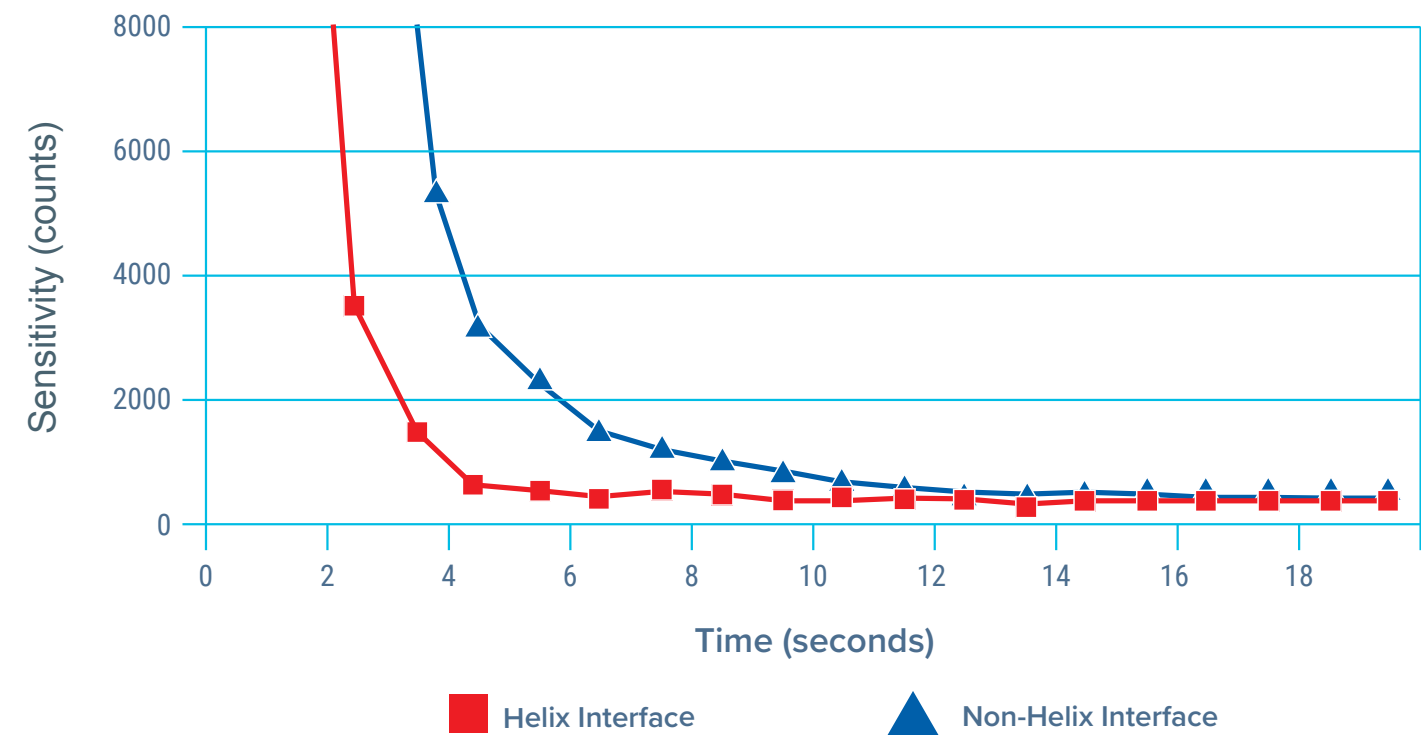
Reproducible day-to-day ICP performance

ICP sensitivity is affected by nebulizer depth within the spray chamber + torque applied to the nebulizer seal.

### Optimum Sensitivity



### Improved Washout

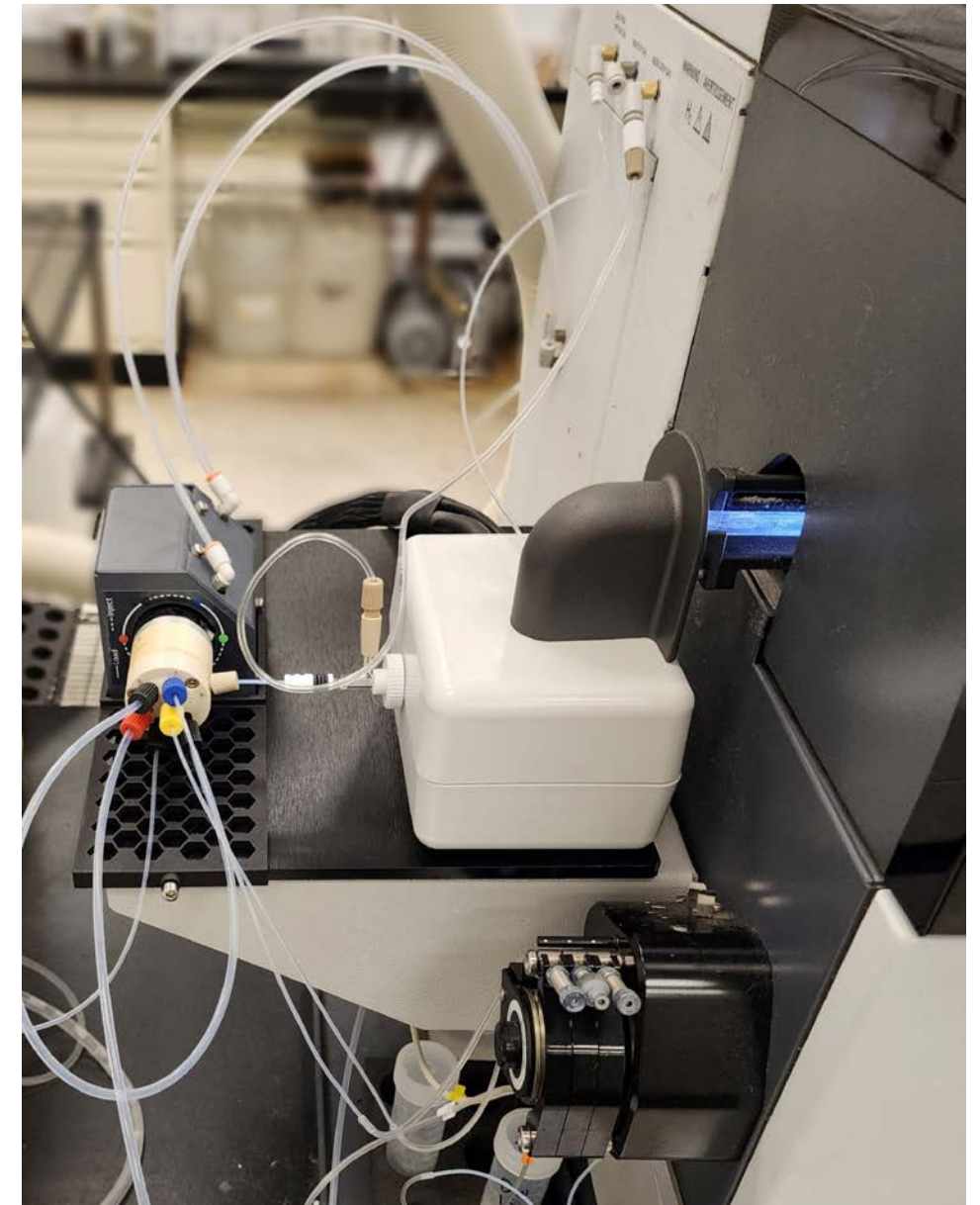


# New PCC™ Kit

- Compatible with Agilent® 7850/7900/8900.
- Compatible with Agilent® HM and UHMI conditions.
- Compatible with Agilent® AVS/ADS2/ISIS-3.
- Interfaces direct to the existing electronics and water cooling system of the Agilent® ICP-MS.
- A convenient mounting bracket allows for fast and simple installation.
- Minimizes washout time with highly concentrated samples and troublesome elements, such as B, Hg, Pb and Sb; compared to the standard Scott-style spray chamber.

## Customer Comments

- For our particular application this PCC kit was a great improvement. On specific cases that required four (or more) blank runs to bring the boron level to baseline now we can do it two or one blank run. This allowed us to **increase sample throughput by about 50%**. — Specialty Chemical Manufacturer - USA



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Quality By Design

# PCC™ Kit



Scott style Spray Chamber



Tracey Spray Chamber



# Analytical Performance

Spray Chamber	Tuned Nebulizer gas flow (L/min)	Sensitivity (CPS)		
		7 Li	89 Y	205 Ti
Scott Style	1.03	5,534	32,852	24,521
PCC Kit	1.05	5,882	32,540	22,801

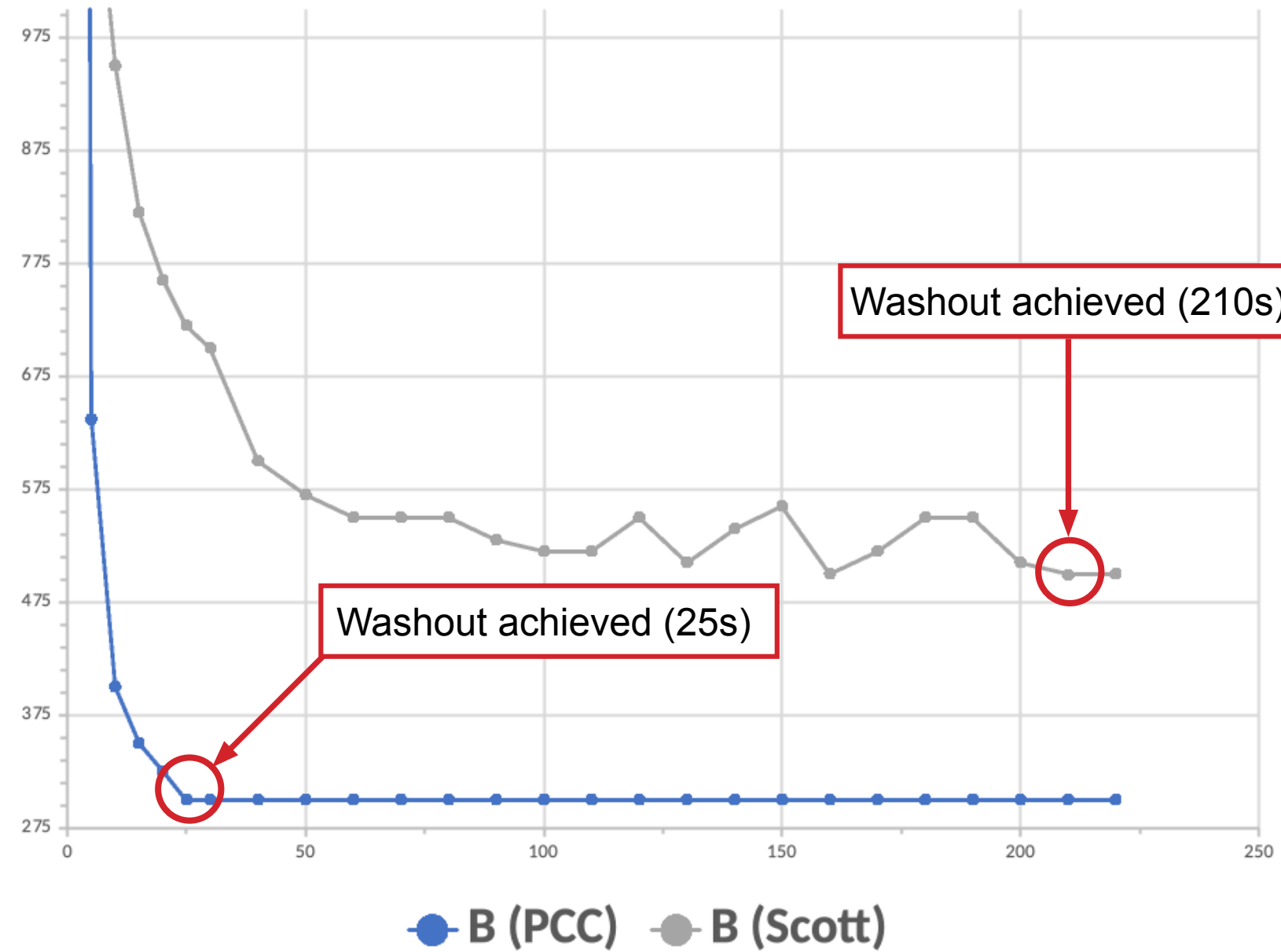
Spray Chamber	Tuned Nebulizer gas flow (L/min)	Short-term Precision (%RSD)		
		7 Li	89 Y	205 Ti
Scott Style	1.03	2.1	1.5	1.8
PCC Kit	1.05	2.6	2.2	2.4

Spray Chamber	Tuned Nebulizer gas flow (L/min)	Oxide Ratio (%)	Charged Ratio (%)
		CeO <sup>+</sup> /Ce <sup>+</sup>	Ce <sup>2+</sup> /Ce <sup>+</sup>
Scott Style	1.03	0.996	0.896
PCC Kit	1.05	0.905	0.954

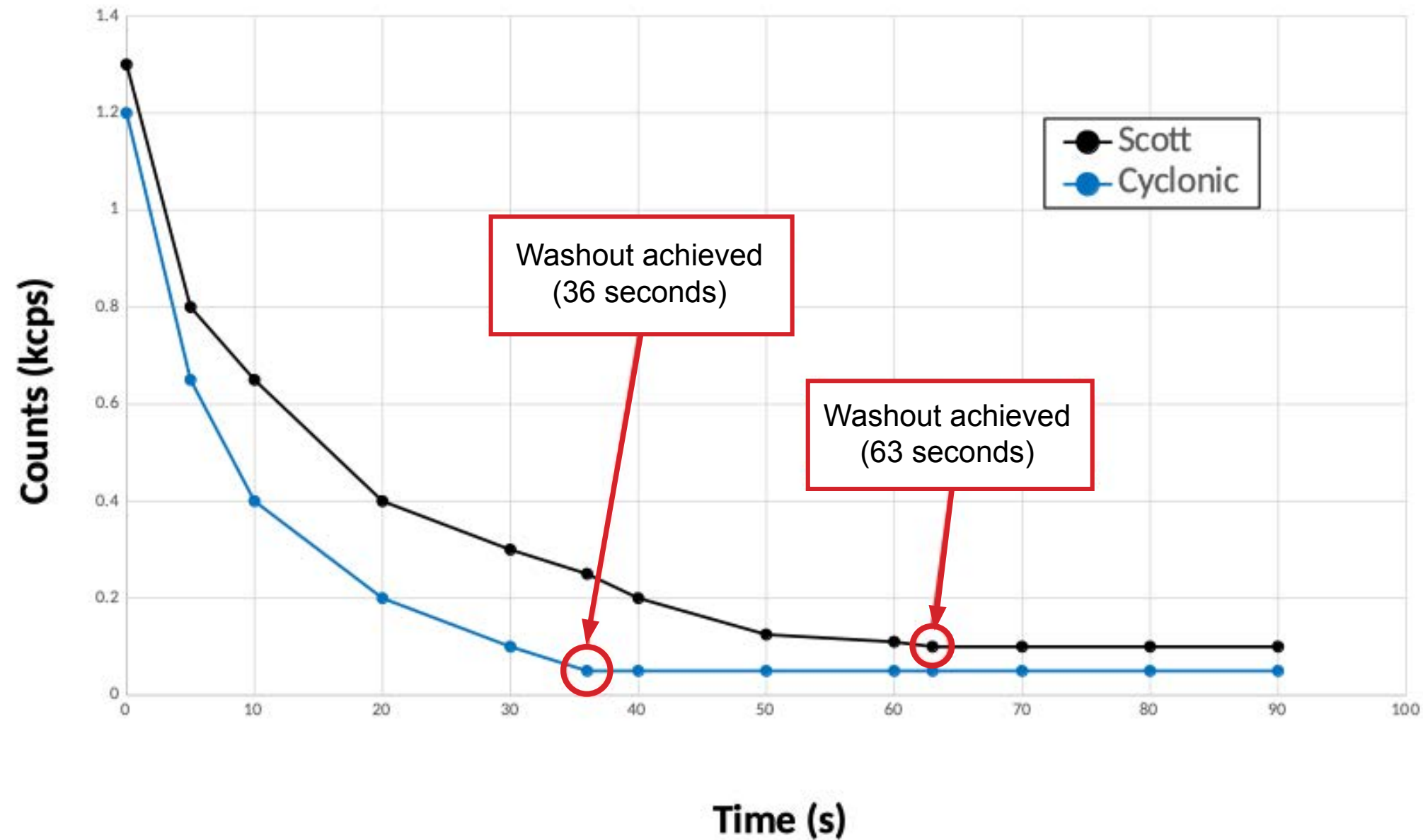


**GLASS EXPANSION**  
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# Washout Comparison (200 ppb Boron)



# Washout Comparison (100 ppb Mercury)



# Direct Connect (DC) Spray Chambers

## Features & Benefits:

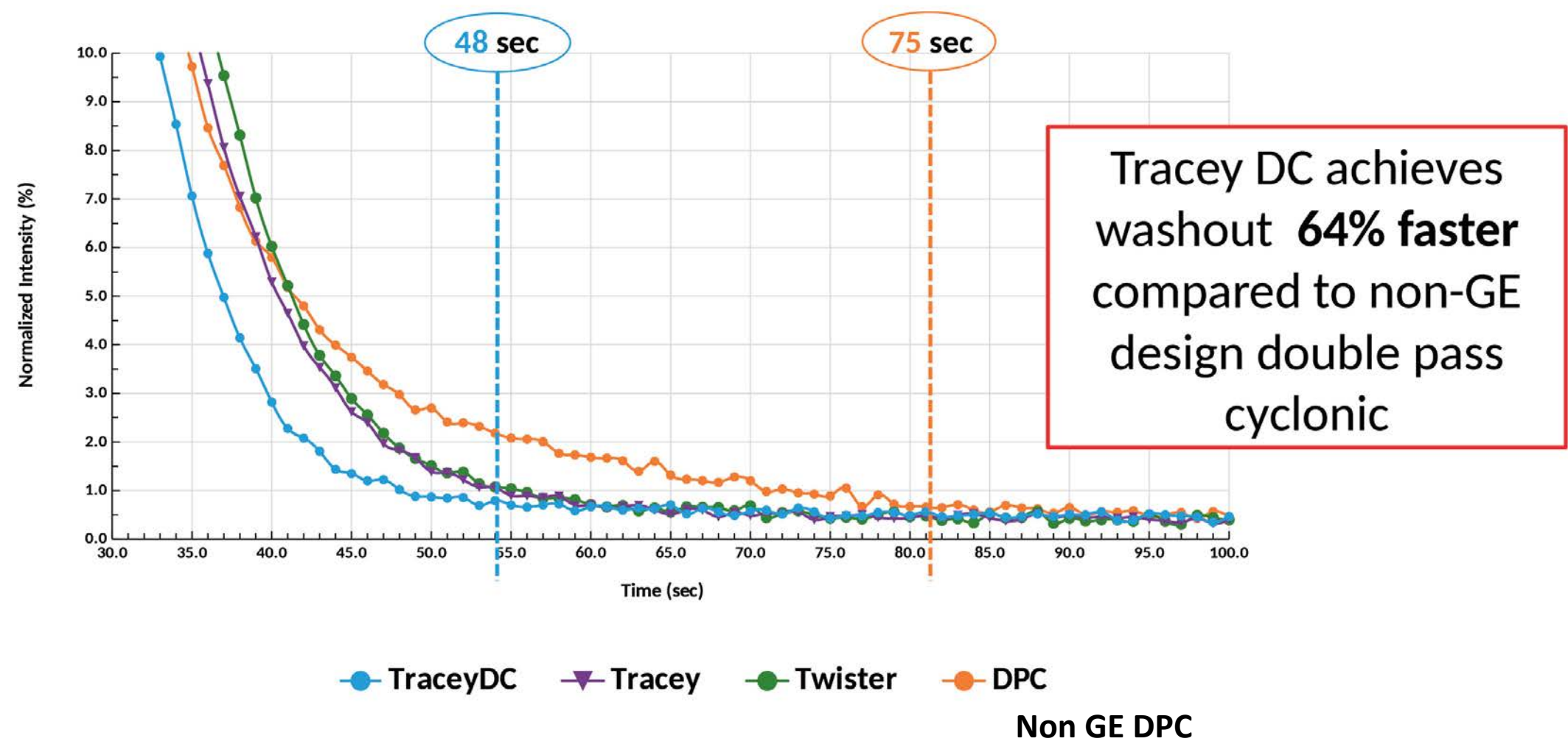
- 1. No O-Rings:** Reduces washout times and eliminates frequent replacements due to wear.
- 2. Inert DC Connection:** PEEK Construction ensures durability and chemical resistance. No ball joint clamps that corrode over time.
- 3. Consistent Alignment:** Provides precise alignment for enhanced accuracy and efficiency.
- 4. Efficient Washout:** 30mL low-volume cyclonic chamber with Helix CT technology.
- 5. Cost-Effective:** More affordable than traditional glass spray chambers.
- 6. Wide Compatibility:** Fits most common ICP-OES models with E-Torch, D-Torch, and SDT/ FDT. Tracey DC spray chamber design is available in Glass and PEEK.



**GLASS EXPANSION**  
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# Direct Connect (DC) Spray Chambers

Washout Profiles for 1 ppm Hg:





# Tracey™ DC PEEK Spray Chamber

## Features & Benefits:

1. **HF Resistance:** With resistance up to 5%
2. **Contamination-Free:** DC fitting removes the need for metal clamps, reducing contamination risk.
3. **Superior Wetting:** PEEK material maintains excellent wetting properties with routine laboratory cleaning.
4. **Compact Design:** Lightweight and compact, eliminating the need for additional spray chamber brackets.
5. **No Internal Surface Treatment:** Unlike TFE or PFA, this spray chamber requires no internal surface treatment.
6. **IsoMist Compatibility:** Fully compatible with IsoMist MS temperature-controlled spray chambers.
7. **Cost-Effective:** More affordable compared to other HF spray chamber designs.



P/N 20-809-4801  
Tracey DC PEEK  
Spray Chamber



**GLASS EXPANSION**  
Quality By Design

# Spray Chamber Maintenance: Glass

## Suggestions:

- **Do not:** use HF, sonicate, nor use metal or ceramic brushes
- **Daily cleaning:** Start and end analysis by nebulizing mildly acidic blank followed by DI water
- **Initial cleaning:** Nebulize 2.5% Fluka RBS-25 for 15 mins followed by DI water
- **Thorough cleaning:** Overnight soak in 25% Fluka followed by DI water rinse
- Check Helix CT seal and UniFit drain line, replace as needed.

**Important note:** Our glassware nebulizers, spray chambers, and torches are supplied clean and ready to use.



Soak in 25% Fluka RBS-25



Replace Helix CT seal,  
e.g. P/N [70-803-1456](#)



Replace UniFit drain line,  
e.g. P/N [UFT-16-75](#)

# Torch Optimal Selection & Maintenance



**GLASS EXPANSION**  
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# Torch (& Injector)

What are the common challenges encountered when using ICP Torch?



## Application Suitability

- HF
- Organics
- High TDS

## Poor analytical Performance

- **Loss of Sensitivity:** Blocked injector in torch
- Poor Plasma Stability
- **RF coil alignment:** to reduce devitrification

## Care & Maintenance

- **Effects of Harsh Matrices:** High TDS; Organics
- Worn or deformed torch
- Devitrification



# Torch (& Injector)



## ICP Torch Designs:

### 1. Single piece quartz torch:

General use torch: Lower initial cost structure with no removable parts

### 2. Semi-demountable torch:

Enables injector interchangeability without torch replacement

### 3. D-Torch:

Removable: injector, outer tube

### 4. Fully demountable torch (FDT):

Removable: injector, intermediate tube, outer tube

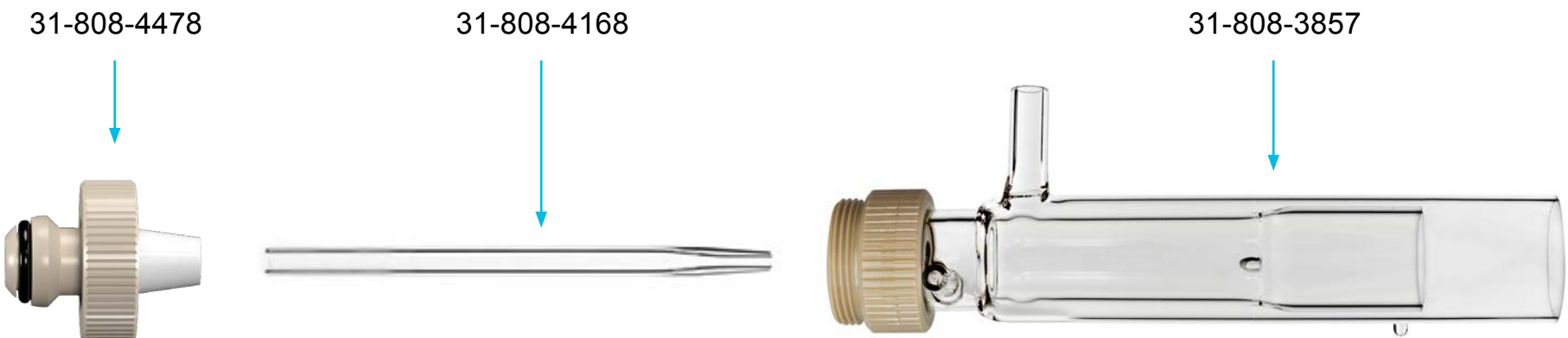
# NEW Semi-Demountable Torch

- New semi-demountable torch compatible with Agilent® ICP-MS, P/N 30-808-3853.
- High purity quartz torch body.
- Compatible with interchangeable quartz, alumina or sapphire injectors.



## Injector Options:

Part Number	Description
31-808-4172	Tapered Quartz Injector 1.0mm ID
31-808-4173	Tapered Quartz Injector 1.5mm ID
31-808-4168	Tapered Quartz Injector 2.4mm ID
31-808-4169	Tapered Alumina Injector 1.0mm ID
31-808-4170	Tapered Alumina Injector 1.5mm ID
31-808-3855	Tapered Alumina Injector 2.4mm ID
31-808-4159	Sapphire Capillary Injector 2.4mm ID



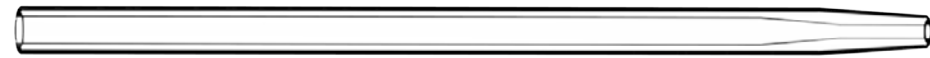
**GLASS EXPANSION**  
Quality By Design



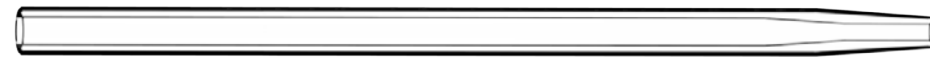
# Multiple Applications with a Single Torch



- Narrow bore quartz, **1.0mm** or less for volatile organics



- **1.5 to 2.0mm** quartz for standard aqueous matrices



- Large bore quartz, **2.0mm** or greater for high TDS



- High grade **alumina for HF** containing samples



- Sapphire for ultra high purity and HF

- *Pt tipped and Sialon injectors are also available for some D-Torch models and by request.*



**GLASS EXPANSION**  
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# GE D-Torch – Demountable Torch

The D-Torch is a cost-effective alternative for any laboratory with a moderate workload.

## Benefits

- Replace just outer tube (fastest to degrade)
- **Alumina intermediate tube**, which resists wear and is tolerant to high temperatures, high TDS and acid attack
- **Optional ceramic outer tube** which does not devitrify like quartz

\* The D-Torch is covered by US Patents 7,847,210 B2 and 8,232,500 B2



Agilent® 5000 Series D-Torch™



**GLASS EXPANSION**  
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# D-Torch with Ceramic Outer Tube

## Ceramic D-Torch:

- High Li conc. can degrade the torch's outer tube over time.
- The demountable option allows for replacing only the outer tube, avoiding the need to replace the entire torch.
- **Injector: Alumina (~1.8 mm)**
- Ceramic outer tubes outlast quartz, reducing maintenance, cleaning, and downtime, especially for high-TDS samples.
- Provides a higher average signal intensity



Analyte	Ceramic Outer Tube	Quartz Outer Tube	% Increase
As	173	148	17
Cd	4259	3367	26
Co	1050	855	23
Cr	5490	4435	24
Cu	5258	4558	15
Fe	3408	2767	23
Mn	49529	40237	23
Mo	954	778	23
Ni	721	584	24
Pb	285	226	26
Sb	326	278	17
Se	102	90	13
Ti	185	146	27
V	4677	3815	23

Six hours of running 10 % NaCl



Standard quartz torch body

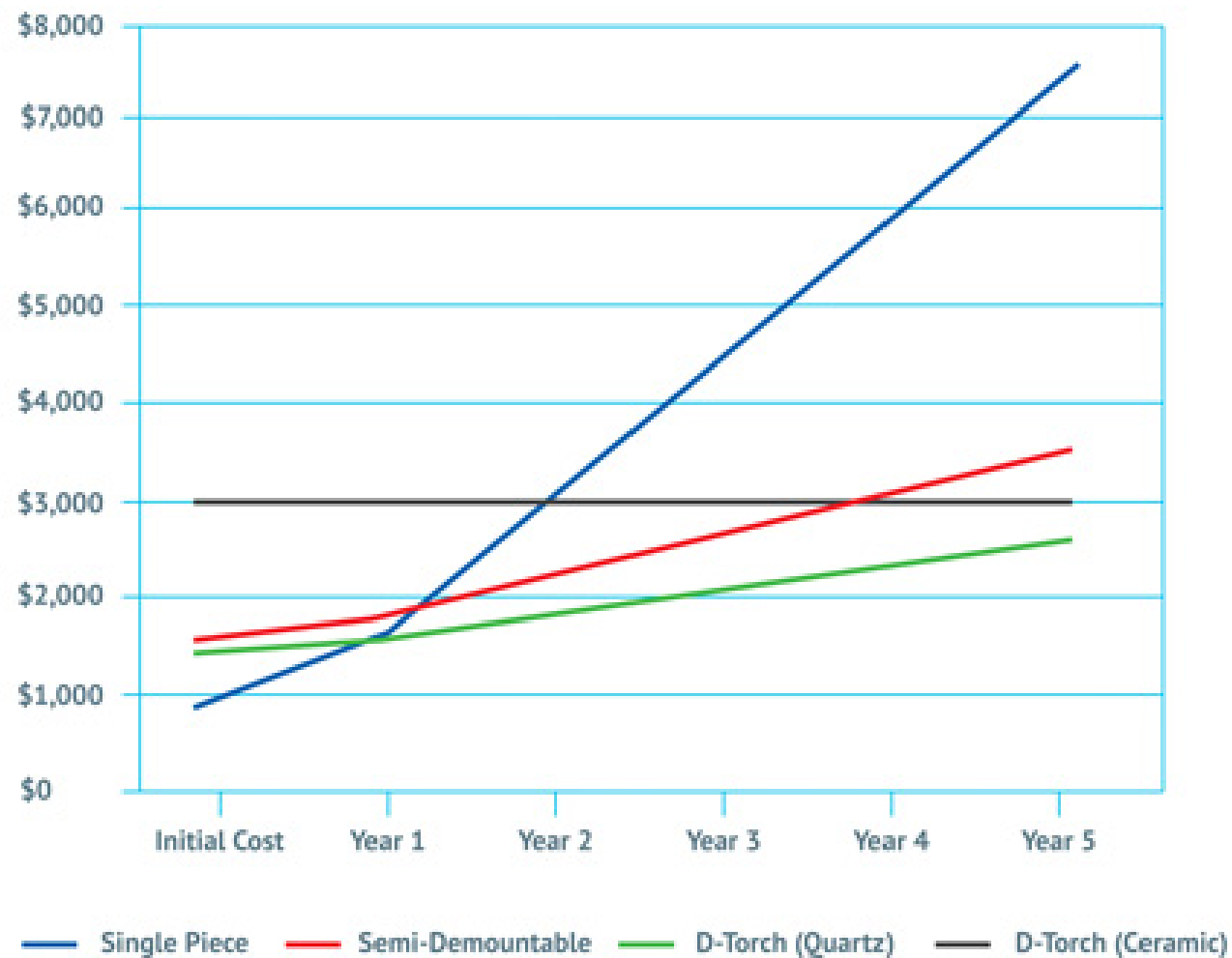


Ceramic outer tube



**GLASS EXPANSION**  
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# Comparitive Torch Ownership Costs



# D-Torch Application Notes

Atomic

THE APPLICATION NOTEBOOK




GLASS EXPANSION  
Quality By Design

### A Robust, High Performance, Revolutionary Demountable ICP Torch

Ryan Brennan, Justin Masone, Terrance Hettipathirana and Glyn Russell, Glass Expansion, Inc.

Glass Expansion designed and patented the D-Torch, a revolutionary, demountable torch. The D-Torch uses high-precision engineering to provide the benefits of a demountable torch, such as lower running costs, chemical inertness, and configurable injector geometry, without compromising usability, performance, or durability. In this report, we discuss the effects of harsh matrices on torches, as well as the features, benefits, and improvements in analysis achieved with the D-Torch.



**Figure 1:** Glass Expansion D-Torch for Agilent 5100/5110 and 5800/5900 ICP-OES instrument.

Figure 1 shows a photograph of the Glass Expansion D-Torch assembly. It consists of a central torch body with a quartz outer tube and a ceramic intermediate tube. The torch is shown in its demountable configuration, with the outer tube and intermediate tube separated from the main torch body.

A single-piece inductively coupled plasma (ICP) torch can be a costly consumable item requiring regular maintenance and replacement, particularly with aggressive sample matrices, such as hydrofluoric acid (HF), organic solvents, and high total dissolved solids (TDS). Dealing with such samples is a common challenge with ICP spectrometry, and, generally, most "real samples" analyzed by ICP laboratories contain considerable concentrations of TDS, including soils, sludges, wastewater, brines, high acid digests, and fusions. Analyzing these types of samples can pose a number of challenges for the ICP analyst, including increased frequency of torch replacement due to shortened torch life.

The combination of high temperature from the plasma and salt deposits on the torch causes a quartz torch outer tube to devitrify. The disadvantage of a single-piece torch is that it is a relatively high-cost consumable item, and the entire torch must be replaced, when, in most cases, it is just the outer tube that suffers from devitrification. For this reason, many ICP manufacturers have moved away from the single-piece torch, and most now use a semi-demountable torch design.

The D-Torch (Figure 1) is a robust and higher-performing alternative to both a single-piece and a semi-demountable quartz torch. Compared to other demountable torches, the D-Torch is the only torch design that comes standard with a ceramic intermediate tube for greater robustness and a lower cost of ownership. With the D-Torch design, the analyst most often replaces only the outer tube, rather than replacing the entire torch or a quartz torch body. With demountable torch designs offered by other manufacturers, the intermediate tube is made of quartz and fused to the quartz outer tube, which is an additional consumable whose cost can quickly add up and negate the economic benefits of the torch itself. The D-Torch also features fully interchangeable injectors, allowing the analyst to install a specific injector (i.e., material and inner diameter) for each application, whether it be for aqueous, organics, high TDS, or HF.

Another exclusivity of the Glass Expansion D-Torch is an optional ceramic outer tube, which is of particular benefit for the analysis of high-TDS sample matrices, as the SiAlon material does not devitrify. In addition to providing durability, the ceramic outer tube on an ICP torch produces a hotter, more robust plasma, which reduces matrix effects and improves sensitivities and detection limits. Compared to a quartz outer tube, the ceramic outer tube has a much longer lifetime, greatly reducing maintenance, cleaning, and downtime due to torch failure. In some sample matrices, quartz outer tubes can degrade in hours, while the ceramic outer tube will last years under the same conditions.

The ceramic outer tube is ideal for:

- monitoring of wear metals in engine oils, as quartz outer tubes often suffer cracking and shortened lifetimes due to thermal shock;
- analysis of fusion samples where the lithium salts rapidly attack quartz;
- measuring high-TDS samples that will quickly devitrify the quartz outer tube.

Each Glass Expansion D-Torch design is a direct replacement for the standard torch, including ICP models that incorporate an easy-to-use, self-aligning torch installation. Each D-Torch model is designed with a base that provides the same self-aligning, turn-key installation for ICP models such as the Agilent 5800 and 5900, PerkinElmer Avio, Thermo iCAP, and Spectro Arcos MV. Compared to other demountable torches, the D-Torch also offers easier cleaning and maintenance with the ability to remove the injector and outer tube, with no O-rings to degrade and go brittle.

70 Spectroscopy 35(2) February 2020

www.spectroscopyonline.com

Spectroscopy 35 (2) February 2020

Technical Note: 43053

### Radial Demountable Ceramic Torch for the Thermo Scientific iCAP 6000 Series ICP spectrometer

Key Words

- iCAP 6000 Series
- Radial Ceramic D-Torch
- High Matrix
- Organics



**Key Benefits**

- Fully demountable torch design for cost effective replacement of parts
- Durable long lasting ceramic material to handle the most demanding sample matrices and analysis regimes.

**Introduction**

Since the introduction of Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES), the main weakness of the technique has been the sample introduction system. The sample introduction system has a large influence on the analytical performance of a spectrometer and is the main area of the hardware that users interface with. One key component of this system is the ICP torch. The ICP torch is a relatively high cost consumable item which can require regular maintenance and replacement when performing more demanding applications.

Currently the majority of ICP torches are made from quartz which is a crystalline form of silicon dioxide (silica, SiO<sub>2</sub>). When a quartz ICP torch is heated (by the plasma) it can undergo a process known as devitrification (which means becoming less glass like). This is commonly observed in ICP torches when the region of the ICP torch that contains the plasma becomes translucent and then opaque, flaking of the internal surface of the torch can also occur (Figure 1a). This process occurs when the transition temperature (T<sub>g</sub>) of the quartz (573°C) is reached and the covalent bonds of the quartz are broken and reformed incorporating impurities. These impurities are introduced to the quartz from the plasma and are typically elements with a valency of less than 4 such as sodium, potassium, calcium and lithium.

The process of devitrification can decrease the expected lifetime of the ICP torch and is commonly seen when samples are analyzed that contain the above mentioned elements at high concentrations (greater than 1000 mg/L). Typical sample types may include those prepared as a lithium metaborate fusions, sea waters and brines.

Quartz has a low thermal expansion coefficient which is important as the temperature gradient along the axis of the torch is large. The lowest temperature is at the base of the ICP torch where the gas is introduced, it increases rapidly just below the load coil, reaches a maximum within the load coil and then decrease slightly in the region above the load coil. Quartz is also relatively resistant to sudden temperature changes (such as when plasma ignition takes place). These two properties make quartz an ideal material for ICP torches which are designed for analyzing aqueous samples and this has been demonstrated over many years of practical use. However, it is when organic solvents are introduced into the plasma that the temperature gradient along the axis of the ICP torch increases more significantly. The main reasons for this increase in temperature gradient are as follows:

- Higher RF powers are typically used when analyzing organic solvents.
- Carbon based molecules will emit large amounts of infrared (IR) light which is absorbed by the quartz increasing the temperature.

This increase in the temperature gradient can lead to premature failures of the quartz ICP torch (Figure 1b). Whilst ICP technology has undergone considerable developments, little effort has been directed specifically at ICP torch design and the use of alternative materials to improve torch durability. This is despite the fact that both devitrification and premature failures of quartz ICP torches are common problems.



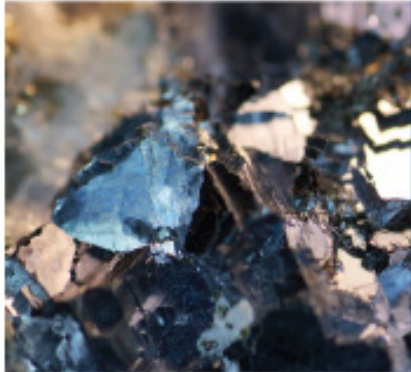
**Figure 1:** Examples of devitrification (1a) and premature failure (1b) of quartz ICP torches.

Thermo Scientific

Thermo® Application Note 43053

APPLICATION NOTE

ICP-Optical Emission Spectroscopy



**Stable Analysis of Lithium Metaborate Fusion Samples with the Avio 500 ICP-OES**

**Introduction**

The analysis of geological materials poses a challenge due to their matrix composition and the sample preparation process required to convert the samples into solution. Sample preparations vary depending on the sample type and elements of interest, but a commonly used sample preparation technique for geological samples is lithium fusion. The fusion process involves mixing the sample with excess lithium borate and heating until the lithium borate melts and dissolves the sample to form a homogeneous mass. The resulting solid is dissolved in acid for analysis.

Fusion samples are some of the most punishing samples for an ICP-OES sample introduction system, as they contain high concentrations of Group I elements, such as lithium (Li), sodium (Na), and potassium (K). The high salt concentrations from the fusion preparation process can result in deposits on the nebulizer and injector, resulting in signal drift. In addition, the high concentrations of Group I elements may cause rapid redistribution of the quartz torch. Obtaining accurate results with good precision over longer time intervals is very challenging. However, with the proper choice of sample introduction components, these challenges can be overcome.

This note describes the analysis of fusion samples leveraging the PerkinElmer Avio 500 ICP-OES, with a focus on long-term stability.

PerkinElmer

PerkinElmer

PerkinElmer® Application Note 35847



# D-Torch Availability

Manufacturer	Model	Ceramic Outer Tube Available
Agilent Technologies ®	5100, 5110, 5800, 5900	✓
Horiba ®	24, 38 & 138 Series, Ultima, Activa	
Nu Instruments™	Nu Plasma	
PerkinElmer ®	AVIO 200, 500	✓
PerkinElmer ®	Optima 8x00 Series	✓
PerkinElmer ®	Optima 4300V, 5300V, 7300V	✓
PerkinElmer ®	NexION 1000, 11000, 2000	
PerkinElmer ®	NexION 300, 350	✓
Spectro™ (Ametek ®)	SpectroBlue™ EOP	
Spectro™ (Ametek ®)	SpectroBlue™ SOP	✓
Spectro™ (Ametek ®)	EOP (Modula, CIROS, Genesis, ARCOS)	✓
Spectro™ (Ametek ®)	SOP (Modula, CIROS, Genesis, ARCOS)	✓
Thermo Scientific™	PRO Duo	✓
Thermo Scientific™	PRO Radial	✓
Thermo Scientific™	6000, 7000 Duo	✓
Thermo Scientific™	6000, 7000 Radial	✓

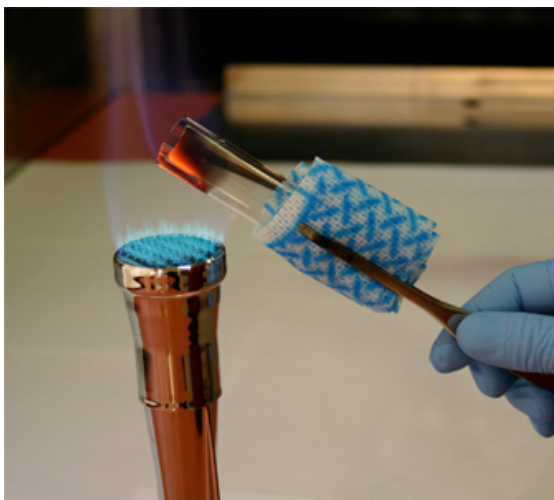
# Torch Maintenance

## Suggestions:

- Carbon deposits from organic samples can be removed with a portable propane torch.
- **D-Torch outer tube cannot be heated in a muffle furnace since it has a polymer ferrule attached to it.**
- **Salt deposits are best removed by soaking the torch in a 25% Fluka or in dilute acid.**
- Stand the tube upright in a beaker and use sufficient cleaning solution to cover the salt deposits.
- Metallic films are best removed by soaking the tube in acid (usually the one from sample prep).



High TDS



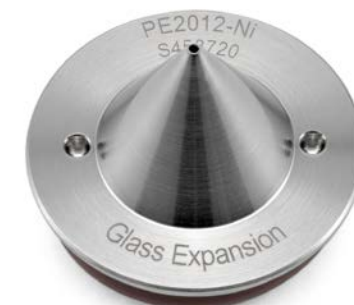
We recommend that the polymer ferrule is not soaked in acid.



Organics

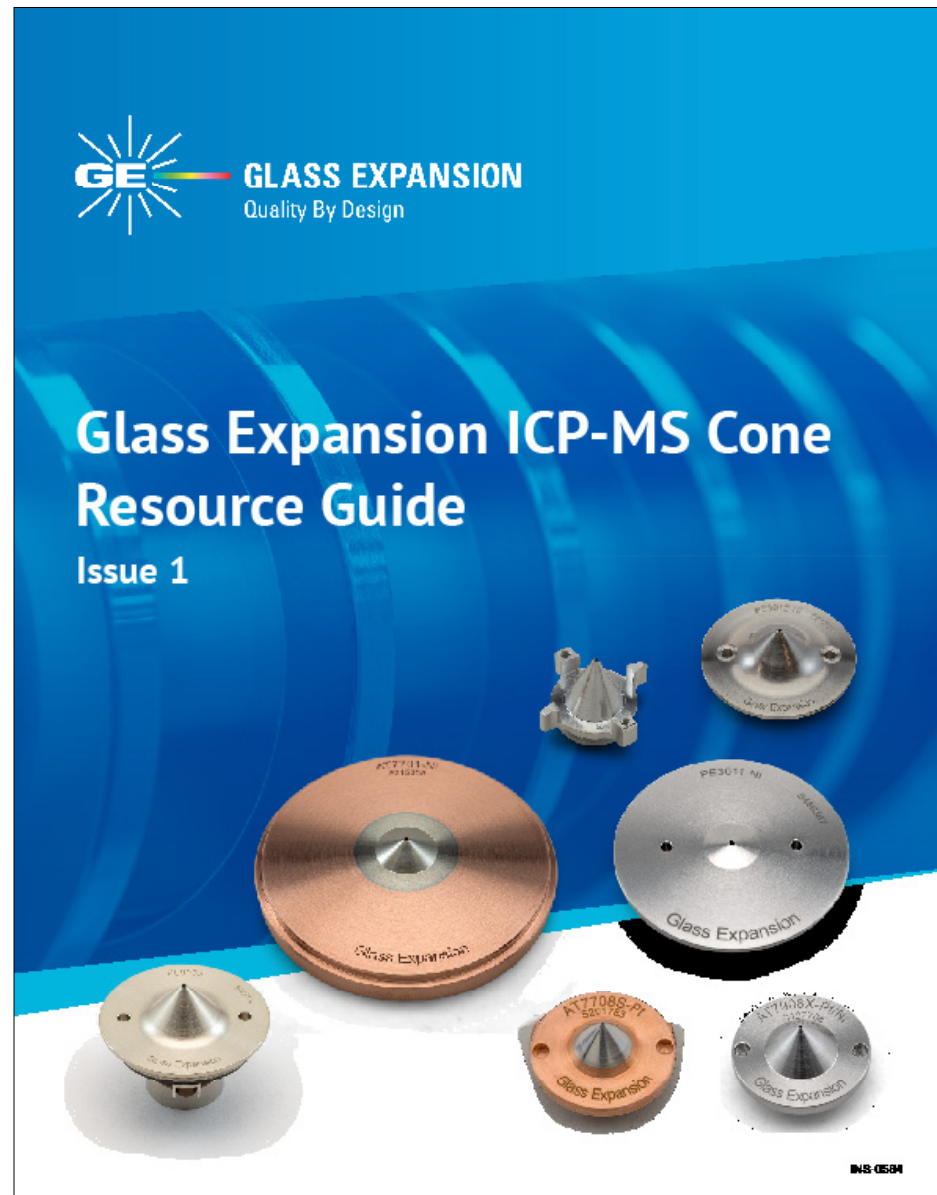


# Cones Optimal Selection and Maintenance



**GLASS EXPANSION**  
Quality By Design

# Cone Resource Guide



- **Guidance on cone selection**
  - Advantages of different cone raw materials
  - Selection based on matrix and performance
- **Tips on Care and Maintenance**
- **Organized by ICP-MS Model**
  - Cross-reference OEM product numbers
  - [\*\*\*Click here to view the Cone Resource Guide\*\*\*](#)



# General Guidelines on Cone Material

## Copper:

- Often the **lowest-cost option**
- Most-susceptible to matrix effects, corrosion, and sample deposition
- Most-efficient heat transfer – this means it “**runs colder**”
- Often need more **frequent cleaning**



## Nickel:

- Often the “**standard**” option
- Good thermal and chemical resistance—more than Cu but less than Pt
- Moderate heat transfer: runs “hotter” than Cu but “colder” than Pt.



## Platinum:

- Typically the most durable and longest-lasting option
- Excellent chemical resistance: **Suitable for aggressive acids or high-matrix samples**
- Least-efficient heat transfer— this means it “runs hotter” than both Cu and Ni
- **Can be refurbished**





# When to Clean Cones

## Suggestions:

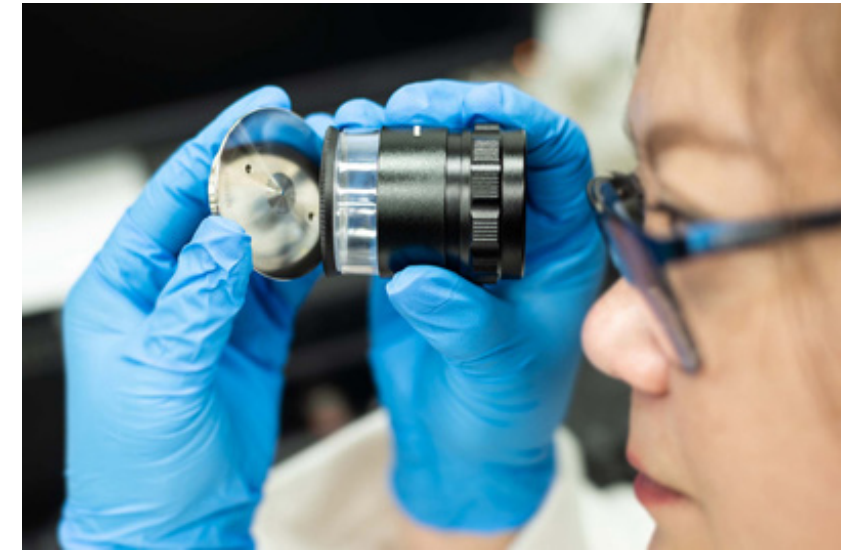
- Physical observation of cone condition using **Magnifier Inspection Tool** (P/N [70-803-1923](#)) or indicated by the data and results
- Sampler cone is more exposed to the plasma: more frequent cleaning
- *Always end the day by aspirating an acidified rinse solutions followed by UPW*

## Experimental indicators of cone cleaning:

- Increased background
- Memory effects
- Decreased sensitivity
- Change in vacuum

## Observational indicators for cone cleaning:

- Visible deposits near or in the orifice
- Distorted Orifice



**Magnifier  
Inspection Tool**  
P/N [70-803-1923](#)



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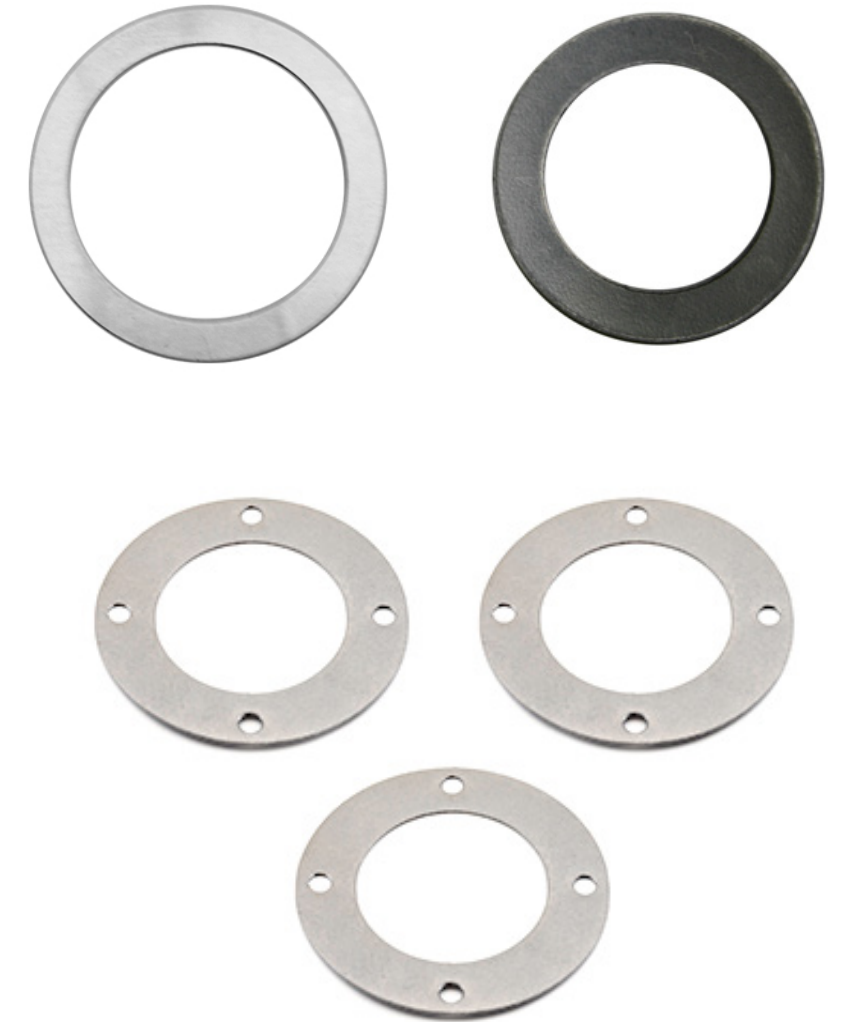
# Cones Re-Installation

## Suggestions:

Always check gaskets or O-rings before installing cones

## Cone Conditioning:

- To ensure the lowest background levels of Cu and Ni, conditioning before use is recommended for **uniform coating that leads to improved long-term stability.**
- To condition your cones, prepare the following conditioning solutions:
  - 1% nitric acid blank
  - 50ppm calcium in 1% nitric acid
- Install the new cones or cleaned cones into the instrument. Turn on the plasma.
  - **Aspirate the 50ppm calcium solution for 10 minutes**
  - **Change to 1% Nitric acid blank solution and aspirate for a further 10 minutes**



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# Thank You

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