GLASS EXPANSION
Quality By Design

Handling Challenging Samples: Particulates and High TDS



Presenter:

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Glass Expansion GmbH
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www.geicp.com

Why Are Some Samples Challenging?

Real-world samples are rarely ideal for ICP analysis.

Common challenges:

Particulates

- Incomplete Sample Digestion
- Environmental Dust or Contamination
- Precipitation of certain elements during storage or dilution

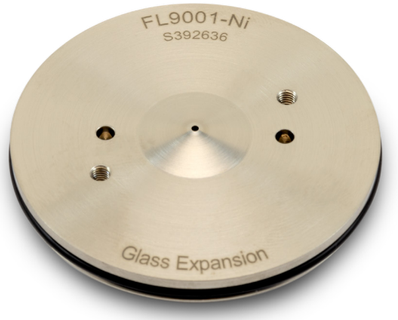
High Total Dissolved Solids (TDS)

- Seawater and Brines
- Geological digests and Mining samples
- Food and agricultural extracts
- Industrial process samples

Complex matrices

- Organics
- High acid concentrations
- Multiple interfering elements







➜ ***Most routine samples contain some level of matrix complexity that can impact stability, robustness, and maintenance.***

Typical Problems Caused by Particulates & High TDS

Particulates

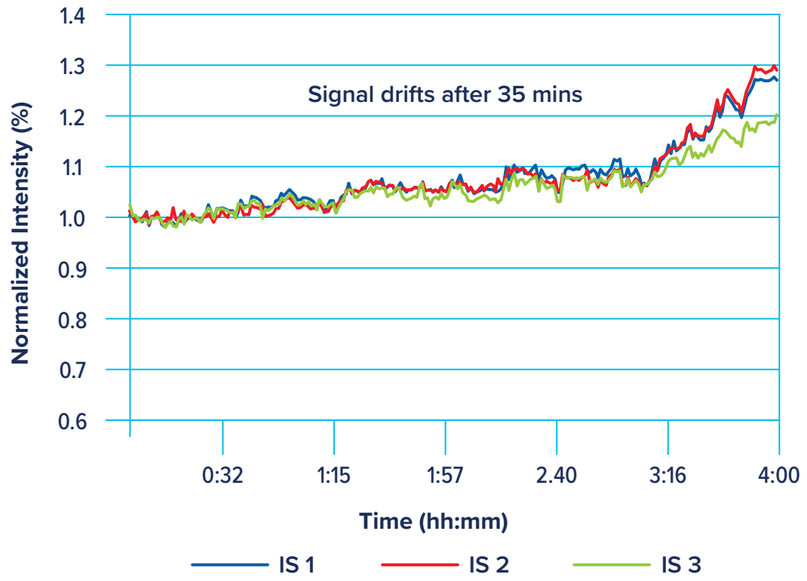
- Nebulizer clogging
- Injector blockage
- Unstable aerosol generation Signal instability
- Increased maintenance

High TDS may cause

- Salt deposition in the torch
- Plasma instability
- Drift and suppression effects
- Cone/injector fouling
- Reduced long-term robustness

➔ **Sample introduction is the most critical area to manage challenging matrices.**





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First Step: Selecting the Right Sample Introduction Setup

Practical advice:

- ✔ Match the **sample introduction system to the matrix**
- ✔ Avoid “one configuration fits all samples”

Sample Characteristics:

- Dissolved solids level
- Particulate load
- Acid composition

SIS Component Configuration:

- Nebulizer type
- Spray chamber choice
- Injector diameter
- Torch configuration

Website Tool:

View Recommended Product for Your Application

Thermo Scientific™: Q, RQ, TQ

View All Products for this Model

Instrument Applications

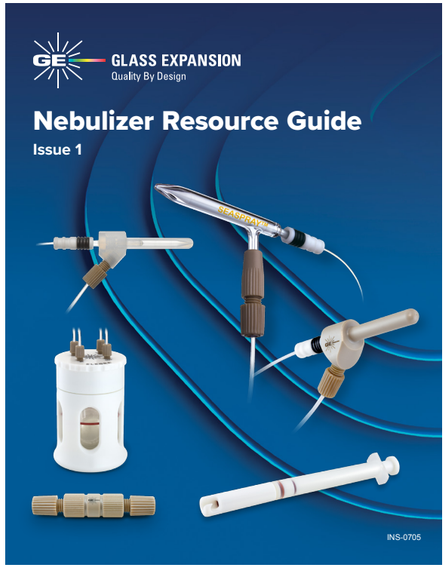
- Animal feed
- Brines and salts
- Chemicals and fertilizers
- Clinical and forensic materials
- Drinking, ground and surface water
- Food and drink
- Geological with HF
- Geological without HF
- Isotopic Analysis of Minerals
- Metals
- Petrochemicals
- Plants
- Semiconductors
- Soil and sediment with HF
- Soil and sediment without HF
- Waste water and sludge
- Wear Metals in oil



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Nebulizer Selection Guide

Nebulizer	Dead Volume V_0 (µL)	TDS (%)	Particulates (µm)	HF	Precision	Purity	Material
SeaSpray™	4	20	*200	No	High	Good	Glass
MicroMist™	1	15	*100	No	High	Good	Glass
Conikal™	5	5	210	No	High	Good	Glass
Slurry™	11	1	280	No	High	Good	Glass
Quartz SeaSpray™	5	20	210	No	High	Excellent	Quartz
OpalMist™	4	15	*200	Yes	High	Excellent	PFA
DuraMist™	4	30	*200	Yes	High	Good	PEEK
VeeSpray™	100	30	550	Yes	Moderate	Good	Ceramic



Nebulizer Resource Guide

***Particle Size Tolerance (µm):** **200** = USS1, USS2, DM2, PFA2; **140** = PFA1, DM1; **100** = USS04, PFA04, DM04; **90** = UM02, UM01, UM005; **70** = PFA005, PFA01, PFA02

Understanding Nebulizer Operating Conditions

When selecting a nebulizer model, choose one that matches your sample flow rate range.

Approximate percentage reduction in water uptake measured using the TruFlo.

SeaSpray Nebulizer (P/N A13-07-USS2) operated at 0.7 L/min Argon (40 psi)		
Tubing ID (mm)	**Uptake Reading (µL/min - DI Water)**	**Decrease from Nominal**
0.75	2050	
0.50	1350	-34%
0.25	150	-93%
0.18	80	-96%

MicroMist Nebulizer (P/N A13-1-UM04) operated at 1.0 L/min Argon (40 psi)		
Tubing ID (mm)	**Uptake Reading (µL/min - DI Water)**	**Decrease from Nominal**
0.50	419	
0.25	123	-71%
0.18	84	-80%

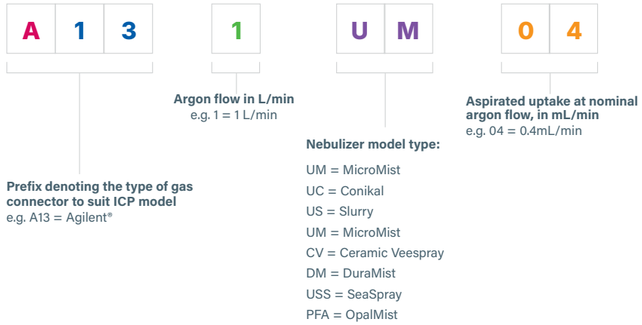
**The actual uptake depends on the viscosity of the sample, the length and ID of the nebulizer sample tubing, the sample height, and the nebulizer gas flow rate.*

*****Optimal nebulization occurs at the specified argon flow (~40 psi back pressure)**

Understanding Nebulizer Part Numbers:



Example: MicroMist DC Nebulizer 0.4mL/min



Nebulizer Model	Recommended Sample Flow Range
A13-07-USS2	0.4 to 3mL/min
A13-07-DM1	0.4 to 2mL/min
A13-1-UM04	0.05 to 1mL/min

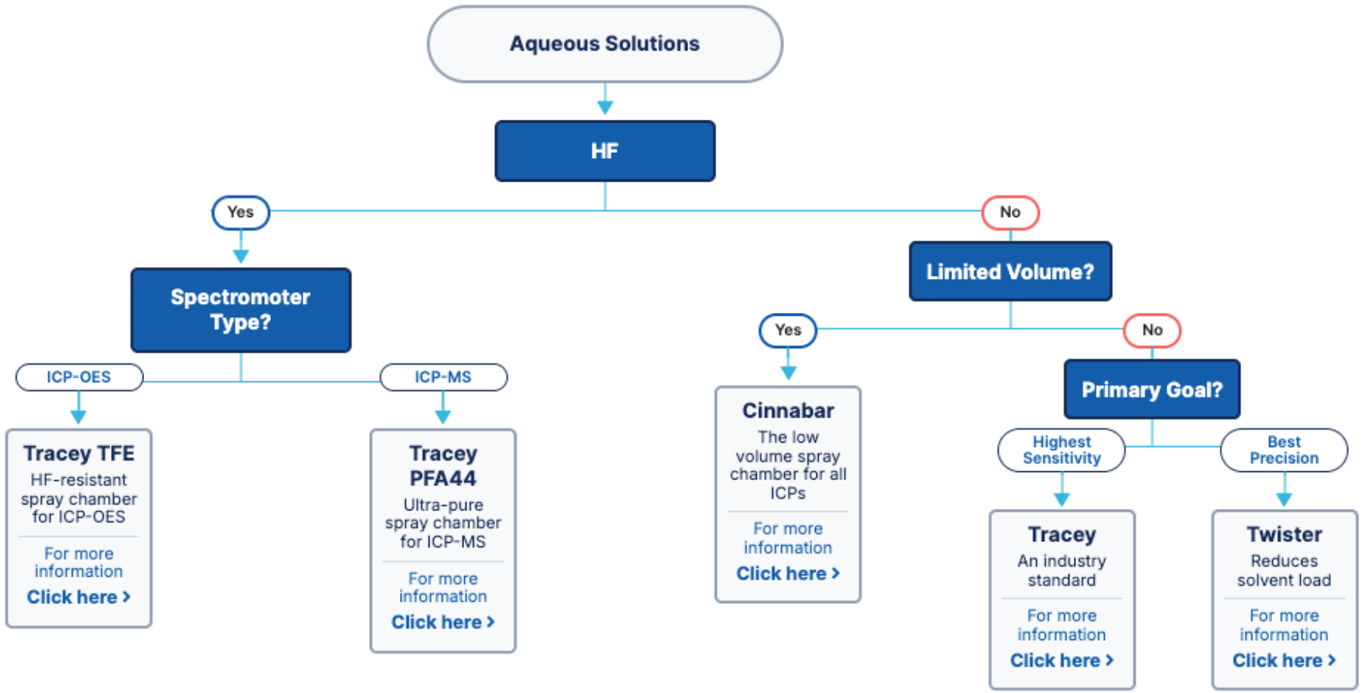
The recommended sample flow rate range for each nebulizer type.

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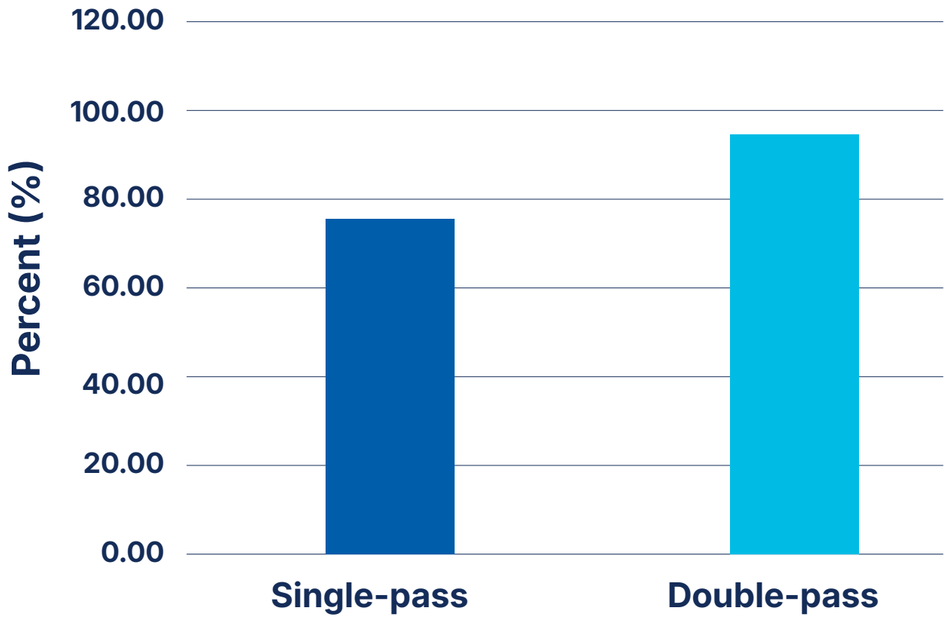
Spray Chamber Selection

Profound Effect on: Transport Efficiency, Precision and Washout

Aqueous Solutions



Percentage of Volume <10µm



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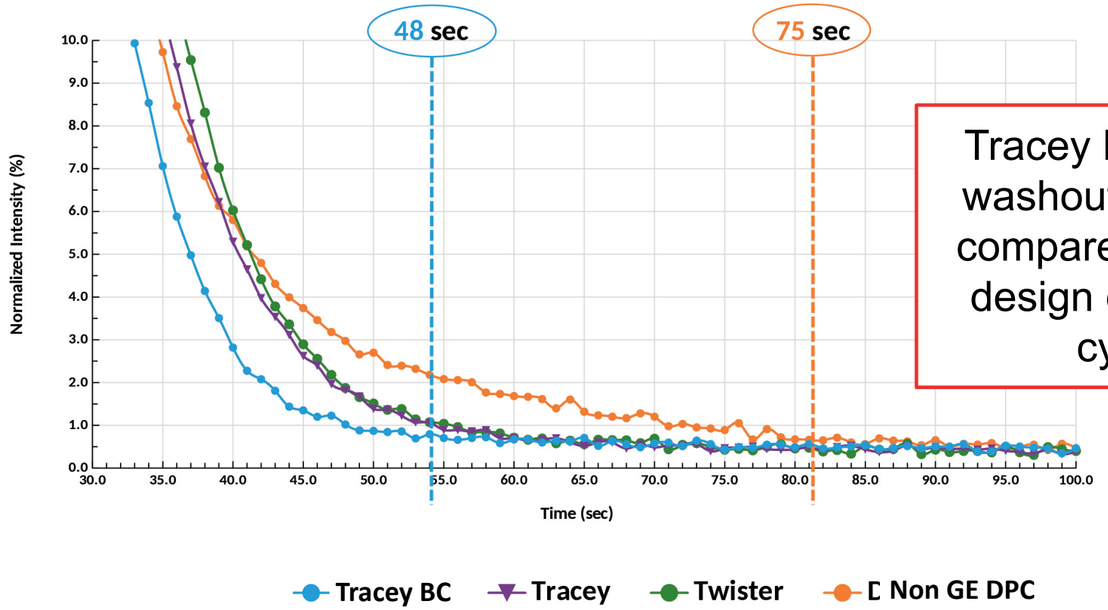
Tracey™ BC Spray Chamber: Design Considerations

Challenges in Routine ICP Work

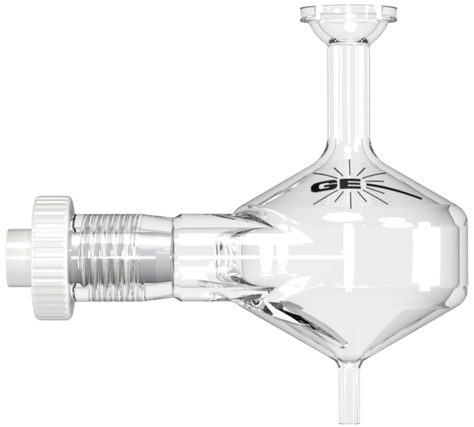
- Frequent O-ring wear and replacement
- Long washout times and memory effects
- Poor wetting or carryover with HF or harsh matrices

How the BC Design Helps

- **No O-rings** → Less maintenance, faster washout
- **Low-Volume 30mL Cyclonic** → Shorter stabilization, better throughput
- **Broad Compatibility** → Fits E-Torch, D-Torch, SDT/FDT
- **Cost-Effective** → Practical choice for routine analysis
- **Improved reproducibility** in maintaining tighter overall size specifications



Tracey BC achieves washout **64% faster** compared to non-GE design double pass cyclonic



Tracey™ Ball Joint Connection (BC) Spray Chambers

Exploring the Tracey™ BC PEEK Spray Chamber for Your Workflow

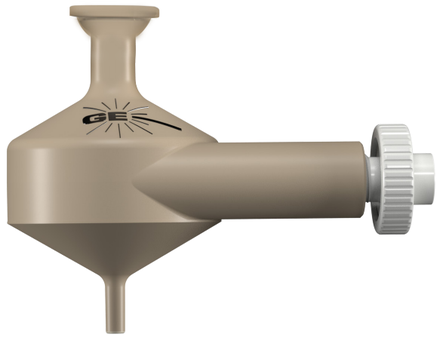
- **PEEK Construction** → Good chemical resistance (up to 5% HF)
- **Superior Wetting:** PEEK material maintains excellent wetting properties with routine laboratory cleaning.
- **No Internal Surface Treatment:** Unlike TFE or PFA, this spray chamber requires no internal surface treatment.

Comparison of Tracey BC PEEK to the PTFE Tracey

Below are the average intensity and RSD results from 41 optimization checks using the PEEK and PTFE spray chambers.

The Optimization Solution contains 2 ppm Pb, As, and Mn in 1% HNO_3.

**Comparison conducted by Specialty Chemicals Manufacturer – USA*



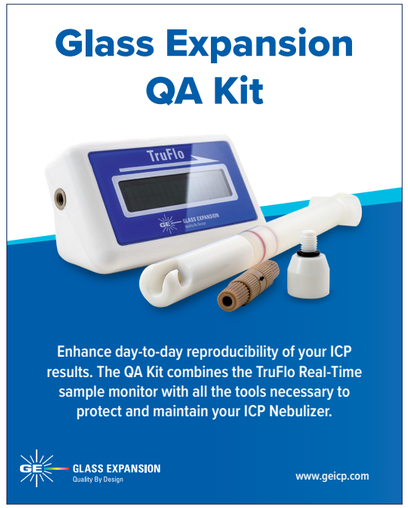
	% Increase in intensity	%RSD
Pb	74%	0.65
As	90%	0.69
Mn	68%	0.68



Practical Tips for Handling Particulates

To improve robustness:

- Ensure complete digestion when possible
- Filter or centrifuge samples if appropriate
- Avoid precipitation during dilution
- Regularly inspect nebulizer and injector
- **Use larger bore sample introduction components**
- **Minimize narrow flow paths**



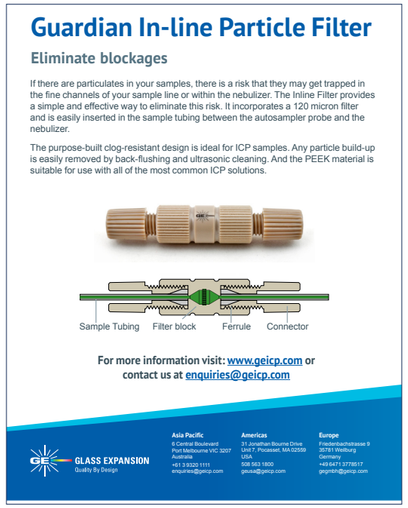
Helpful accessories when particulates are unavoidable:

Guardian In-line Filter:

A simple and effective way to eliminate blockages and safeguard your ICP from large particles.

Guardian Autosampler Probe:

Robust tip and built-in filter to prevent blockages in nebulizer and capillary tubing.



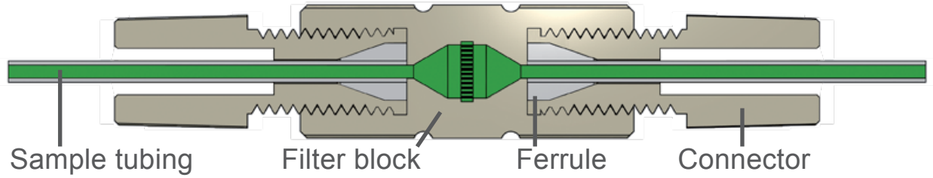


Guardian In-Line Particle Filter

Protection of the sample introduction system from particulates

- Installed in sample line between autosampler probe and nebulizer
- **120 µm filter** with seals for both 1.6 mm and 1.3 mm OD tubing
- Easy maintenance via back-flushing or ultrasonic cleaning
- **PEEK Clog-resistant honeycomb design** reduces blockage compared with frit filters





Typical applications:

- Incomplete digestions (soil, food, biological samples)
- Environmental samples (waters, sediments, wastewater)
- Geological and mining samples
- Samples prone to precipitation/ contamination

Eluo Nebulizer Cleaning Tool P/N 70-ELUO

P/N 70-803-1160

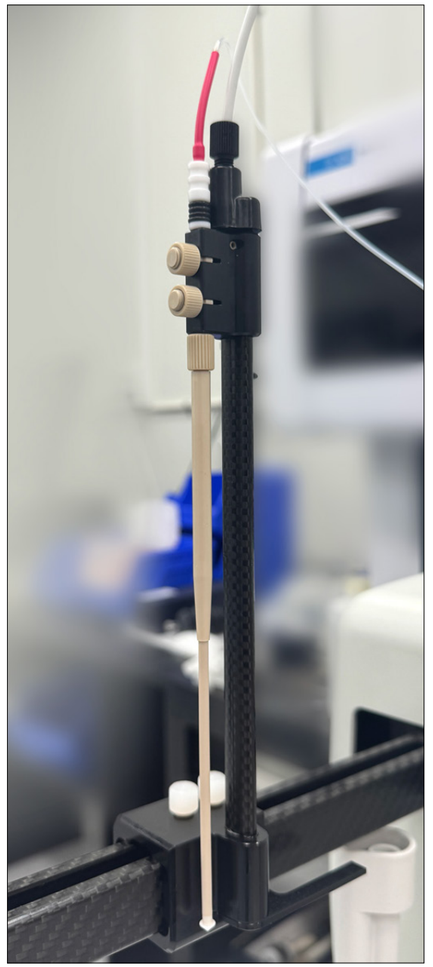


We have tried the inline filter.....and we are pretty happy with its performance. It is able to capture the AgCl ppt.... and prevent it from entering the Niagara valve and SeaSpray Neb.... The inline filter has reduced the frequency of ICP troubleshooting. Currently, we rinse the filter every two weeks.

Contract laboratory - Canada

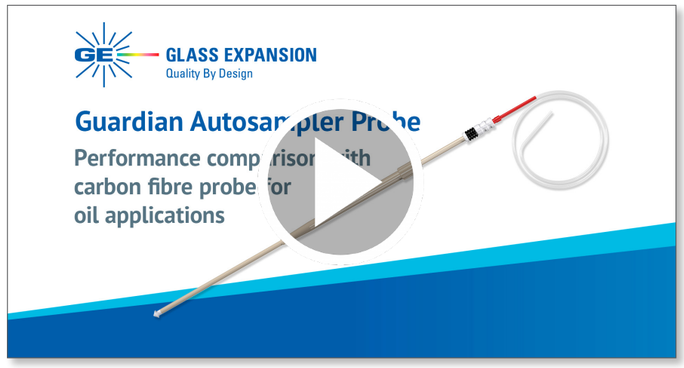
Guardian Autosampler Probe

- **Robust tip design** prevents crushed or damaged tips from misalignment.
- **Drip-resistant** to minimize cross-contamination, especially with oils.
- **Built-in particle filtering** holds back particulates from blocking the line.
- **Optimized ceramic filter tip** to minimize dripping and particulate blockages.
- **Completely inert construction** (Ceramic, PEEK, and PTFE) for strong acid/solvent resistance.
- **Interchangeable UniFit sample lines** (3000mm in length) to accommodate various IDs (e.g. 0.3, 0.50, 0.75 & 1.0mm)
- Designed to suit Teledyne Cetac®, Agilent®, PerkinElmer®, Shimadzu®, Aim Lab and Thermo Fisher Scientific™ Autosamplers
- *Click here to view the Guardian Probe Flyer*





Guardian Autosampler Probe for Cetac-ASX200/500/800 Series



Practical Tips for Handling High TDS Samples

Salt deposits form when high-TDS or acidic solutions evaporate at the nebulizer or injector tip. Leads to analytical drift or even plasma extinguishing.





DuraMist™



SeaSpray™

(In reference to the Elegra: *"Talking with my operators that are here today neither of them has changed a nebulizer since we put it on… We had been replacing nebulizers after about a week and a half… I will be ordering 2 more."* - **Contract Laboratory - USA**

When analyzing high dissolved solids:

- Use robust plasma conditions
- Monitor salt buildup in torch, injector, and nebulizer
- Rinse thoroughly between samples
- Increasing the auxiliary argon flow will lift the plasma higher off the injector, slowing salt buildup at the injector tip

Elegra™ Argon Humidifier:

- Adds moisture to argon gas → prevents salt build-up and reduces maintenance
- Operates without heating or electricity using efficient membrane humidification technology
- Flexible configurations: single- or dual-channel versions with custom gas fittings

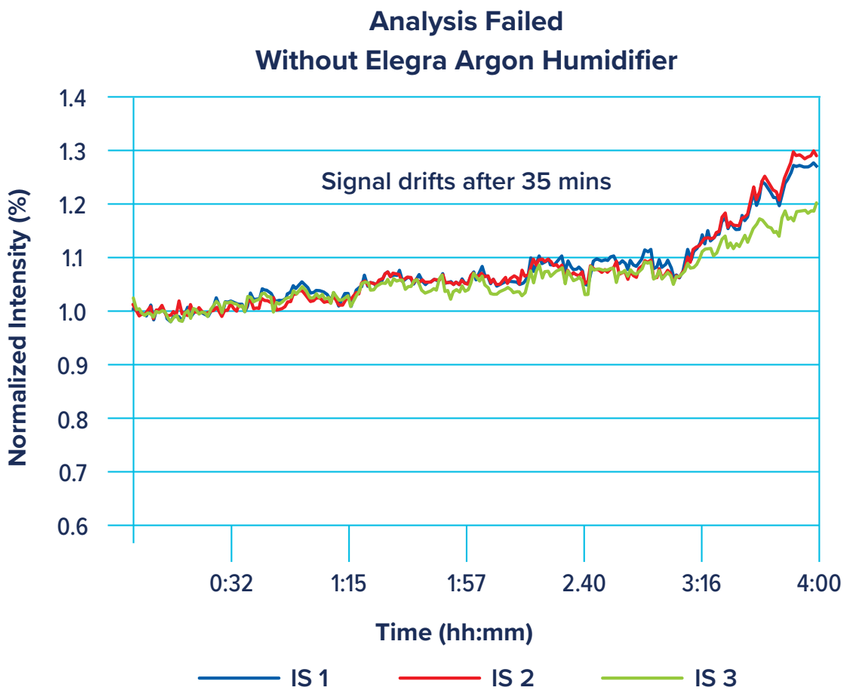
Complements a high-TDS sample intro setup:

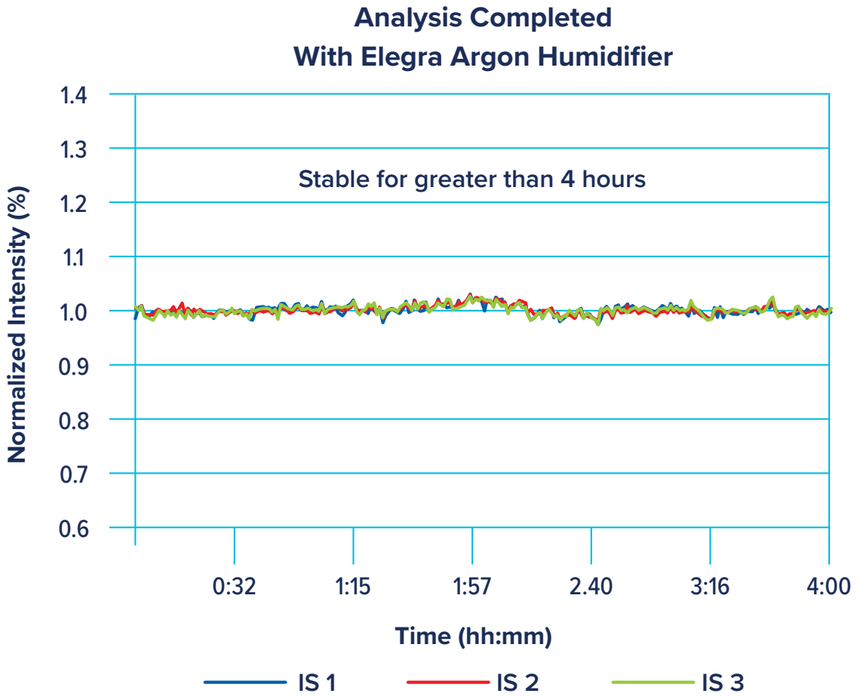
- SeaSpray™ /DuraMist™ nebulizer, Twister™ spray chamber, and wide-bore injector

Samples with High TDS: Argon Humidifier

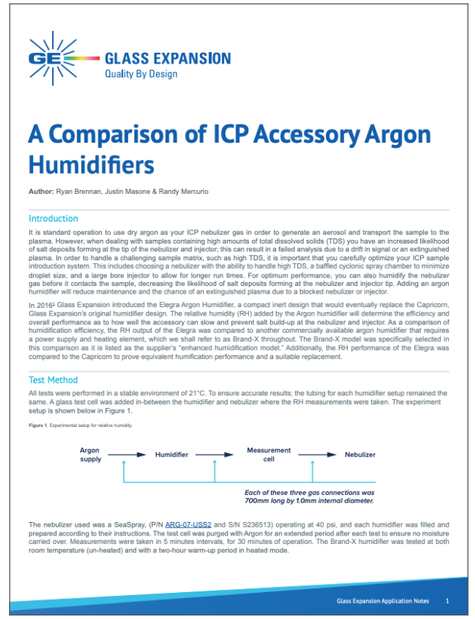
Performance

- Includes easy-use bypass switch to disable humidification without disconnecting lines
- Tested to deliver over **4 hours of stable internal standard signal with high-salt** samples, outperforming other humidifiers
- Superior performance: up to 60% more effective relative humidity than competing models





Elegra Application Note


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A Comparison of ICP Accessory Argon Humidifiers

Author: Ryan Brennan, Justin Masone & Randy Mercurio

Introduction

It is standard operation to use dry argon as your ICP nebulizer gas in order to generate an aerosol and transport the sample to the plasma. However, when dealing with samples containing high amounts of total dissolved solids (TDS) you have an increased likelihood of salt deposits forming at the tip of the nebulizer and injector; this can result in a failed analysis due to a drift in signal or an extinguished plasma. In order to handle a challenging sample matrix, such as high TDS, it is important that you carefully optimize your ICP sample introduction system. This includes choosing a nebulizer with the ability to handle high TDS, a baffled cyclonic spray chamber to minimize droplet size, and a large bore injector to allow for longer run times. For optimum performance, you can also humidify the nebulizer gas before it contacts the sample, decreasing the likelihood of salt deposits forming at the nebulizer and injector tip. Adding an argon humidifier will reduce maintenance and the chance of an extinguished plasma due to a blocked nebulizer or injector.

In 2016[1] Glass Expansion introduced the Elegra Argon Humidifier, a compact inert design that would eventually replace the Capricorn, Glass Expansion's original humidifier design. The relative humidity (RH) added by the Argon humidifier will determine the efficiency and overall performance as to how well the accessory can slow and prevent salt build-up at the nebulizer and injector. As a comparison of humidification efficiency, the RH output of the Elegra was compared to another commercially available argon humidifier that requires a power supply and heating element, which we shall refer to as Brand-X throughout. The Brand-X model was specifically selected in this comparison as it is listed as the supplier's "enhanced humidification model." Additionally, the RH performance of the Elegra was compared to the Capricorn to prove equivalent humification performance and a suitable replacement.

Test Method

All tests were performed in a stable environment of 21°C. To ensure accurate results; the tubing for each humidifier setup remained the same. A glass test cell was added in-between the humidifier and nebulizer where the RH measurements were taken. The experiment setup is shown below in Figure 1.

Figure 1. Experimental setup for relative humidity.

Argon supply → Humidifier → Measurement cell → Nebulizer

Each of these three gas connections was 700mm long by 1.0mm internal diameter.

The nebulizer used was a SeaSpray, (P/N ARG-07-USS2 and S/N S236513) operating at 40 psi, and each humidifier was filled and prepared according to their instructions. The test cell was purged with Argon for an extended period after each test to ensure no moisture carried over. Measurements were taken in 5 minutes intervals, for 30 minutes of operation. The Brand-X humidifier was tested at both room temperature (un-heated) and with a two-hour warm-up period in heated mode.

Glass Expansion Application Notes 1

Demountable Torch

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
- In contrast, other demountable torch designs typically feature quartz intermediate tubes, which add to consumable costs



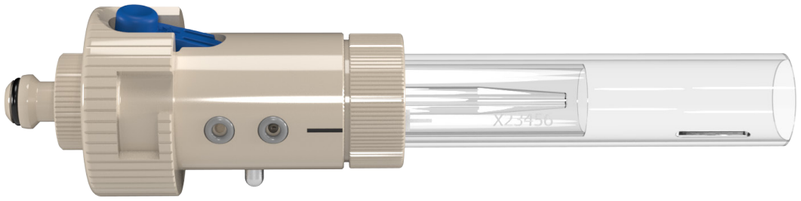
D-Torch Installation Video for
Agilent® 5100/5110/5800/5900



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Aggressive Sample Matrices: Torch Contamination

High salt deposits and plasma temperatures shorten quartz torch life
O-ring failures or gas leaks can destabilize plasma or prevent ignition



NEW! **E-Torch for Thermo® PRO DUO**
P/N 30-808-4388

Mitigation:

- Clean torch regularly using appropriate methods for organics, salts, and metals
- **Use a Demountable Torch →** replace only the outer tube, lowering cost of ownership
  - Large bore quartz: 2.0mm or greater: High TDS
  - Ceramic (alumina): HF-containing samples
  - Platinum/Sapphire Injectors: Inert applications



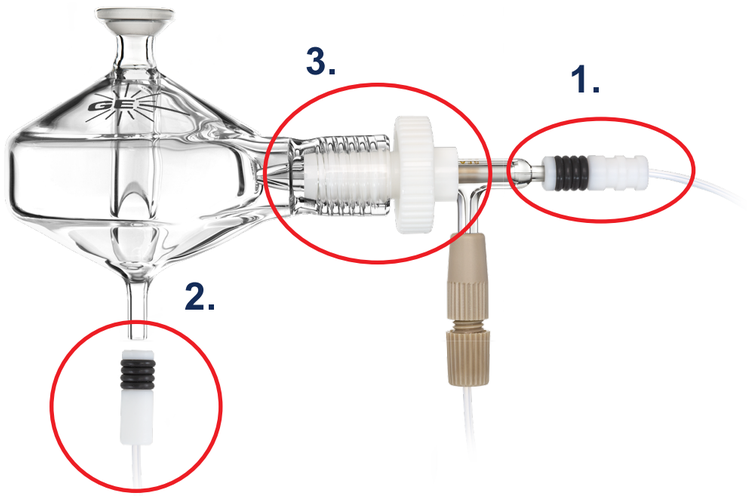
- **Ferrule-based design:** Secure injector seating, fewer leak points
- **Ceramic outer tube →** resists devitrification, lasts longer
  - Ideal for high-TDS, salty, or organic samples
  - Hotter, more robust plasma improves sensitivity and stability
- **RF Coil Condition:** Properly aligned, clean, and well-plated RF coil improves energy transfer to the plasma

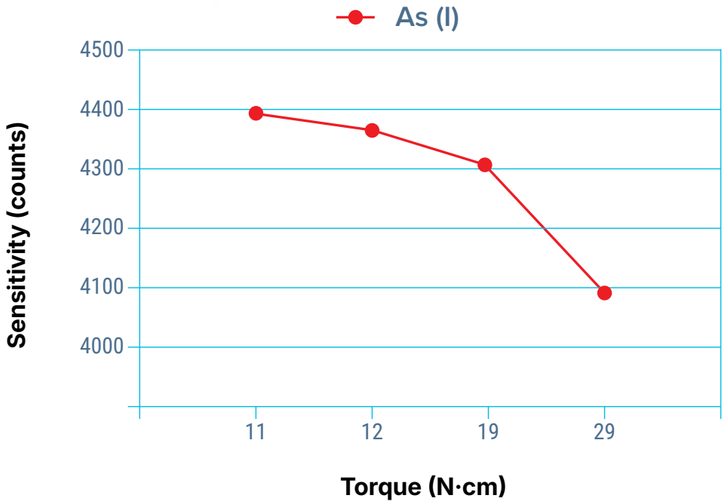
Comparison of Quartz tube set to Ceramic Outer tube set		
Element	**% Increase in Sensitivity**	**%RSD**
Zn (213) λ	17%	0.36
Ni (231) λ	19%	0.57
Mn (257) λ	14%	0.52



NEW! **Ceramic Outer Tube Set DUO**
P/N 31-808-4502

Hidden Causes of Instability in ICP Systems





Optimum Depth and Torque = Optimum Sensitivity

Connection Issues

- Leaks or **loose fittings**
- Improper waste drain seating → **unstable flow**
- Worn pump tubing → **air ingress**
- Blocked or kinked lines → **restricted flow**

Zero Dead Volume Connections

1. Between Sample line and nebulizer: **UniFit connector**
2. Between Waste tubing and spray chamber: **UniFit connector**
3. Between nebulizer and spray chamber: **Helix CT**

Quick Diagnostic Checks

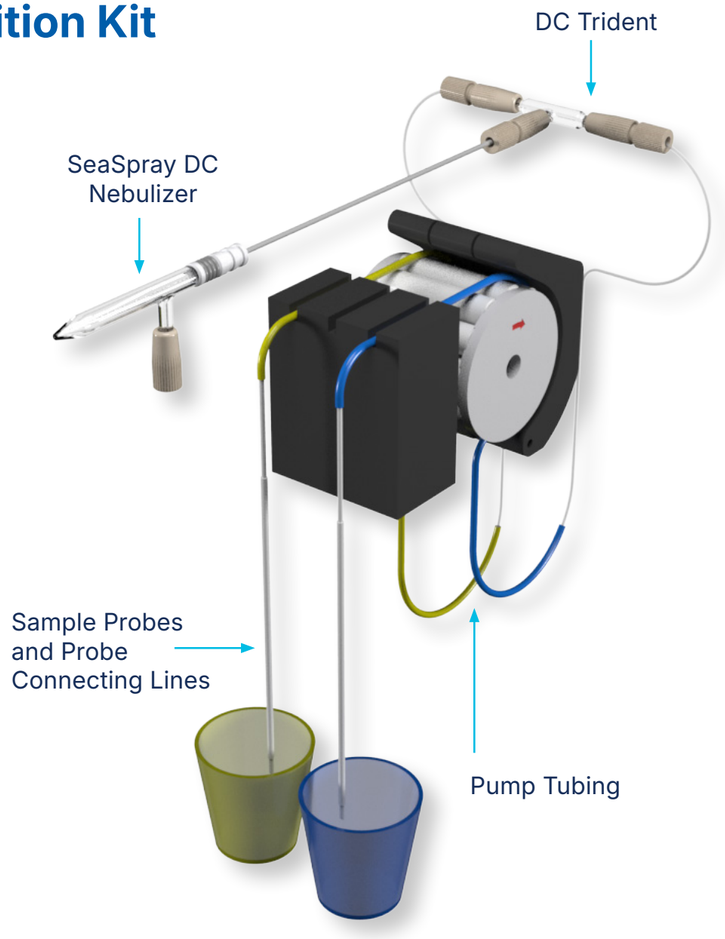
- **Free-flow test:** steady, fine mist from nebulizer
- **Drain check:** smooth, continuous drainage
- **Visual inspection:** bubbles, wet fittings, leaks

Enhancing ISTD Recovery by Minimizing Leaks and Contamination

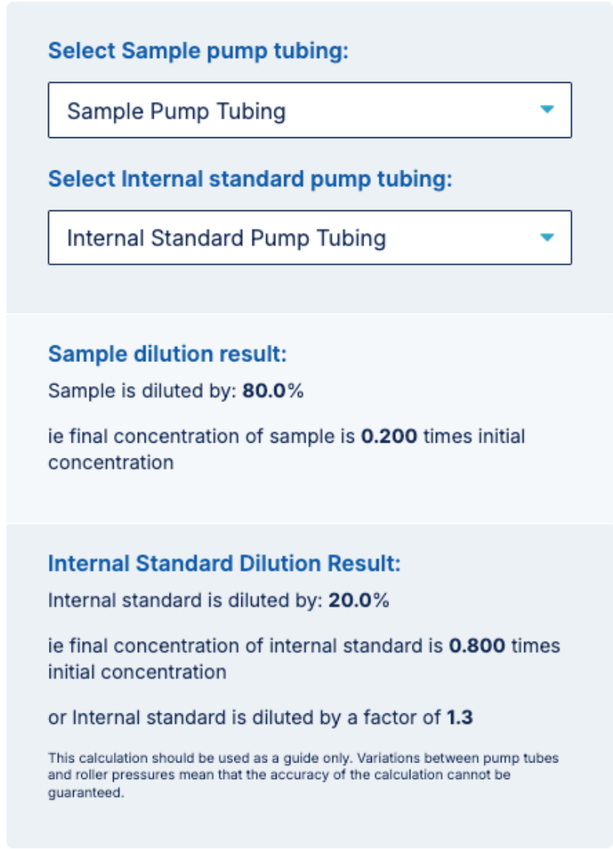
1. Trident CT™ Internal Standard Addition Kit

- Compact, efficient mixing chamber ensures complete mixing of the sample and reagent.
- **ConstantTorque™ (CT) ratchet fittings** for a durable, leak-free seal on all connections.
- Consistency in torque application helps maintain the reliability and performance of the mixing chamber.





Trident CT™ Internal Standard Kit
P/N 60-703-1179



Trident Dilution Factor Calculator

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ICP-MS Cone Material Selection

Nickel Cones:

- Balanced cost & performance →standard for many applications
- Good thermal & chemical resistance →less prone to corrosion and deposition
- Runs hotter than copper →stays cleaner longer, more stable signals
- **Suitable for routine aqueous samples (<5% acid, non-HF, non-organic)**

Nickel-Plated Cones:

- Nickel plating boosts chemical resistance while retaining copper's efficient heat transfer →Helps prevent rapid orifice degradation, and preserving stability
- **Ideal for samples with >5% acid concentration**

Platinum Cones:

- **Excellent chemical resistance** →Most durable, but highest cost
- Least efficient heat transfer → runs hotter, but stays cleaner longer
- Can be refurbished 2-3 times and recycled for reclaim value
- **Ideal for high-matrix, high acid, or organics**





Cone Resource Guide

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Summary: Steps to Overcome SIS Challenges

1. Improve Data Quality

- Select appropriate nebulizer, spray chamber, torch/injector, and cones
- Tailor components to sample type for accuracy, precision & sensitivity

2. Maximize Sample Throughput:

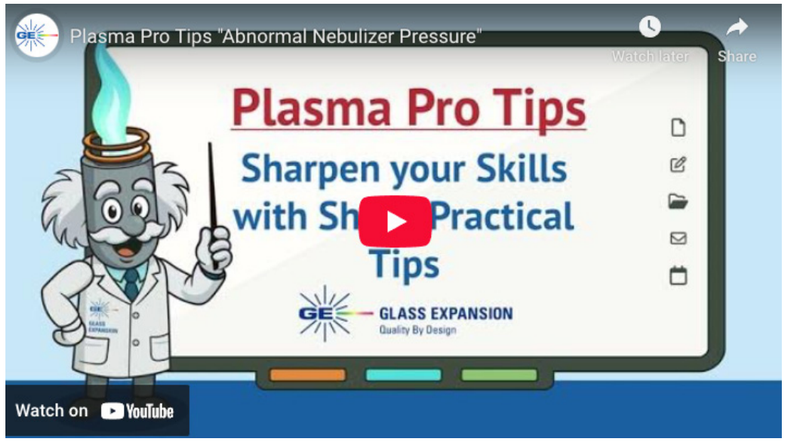
- Address carry-over and washout issues to improve efficiency

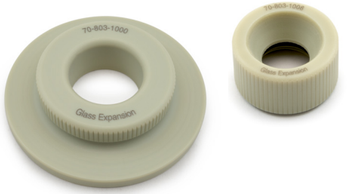
3. Enhance Performance with Accessories

- Use tools like Elegra, Eluo, Guardian In-Line Filter, and Guardian Autosampler Probe improve stability

Ensure Longevity & Consistency

- Implement proper care and cleaning routines
- Reduce downtime through preventive maintenance







Click here to view our Product Care Page



Thank You



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Weilburg, Germany

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Email: gegmbh@geicp.com
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