Mastering Sample Introduction for Optimal ICP-OES and ICP-MS Performance

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President

Glass Expansion, Inc.

Pittcon®

Conference and Exposition

Elements Matter: Streamlining Trace Elemental Analysis in Oil and Soils

CEM

GE GLASS EXPANSION

Quality By Design

www.geicp.com

Common Challenges for Soil and Oil Analysis

Soil Analysis (6010D, 6020B):

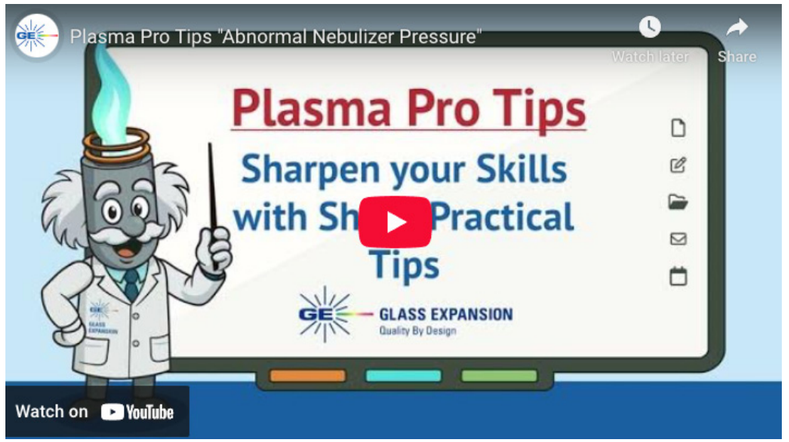
- Soils are high in total dissolved solids, which can result in signal drift, frequent maintenance, higher replacement intervals of consumables.
- Rigorous QC compliance for IS recoveries, ICV, and CCB; leads to frequent re-runs due to poor washout.
- ICP-MS requires higher dilution for complex samples.
- Typically a high-throughput, balancing of speed and precision.

Oil Analysis (D5185, D6751, and D7691):

- Carbon build-up leads to frequent maintenance and higher replacement intervals of consumables.
- Direct dilution with no digestion leads to presence of particulates and potential blockages.
- Lower surface tension of the diluted oils lead to dripping probes and cross-contamination.
- Typically a high-throughput, balancing of speed and precision.

Steps to Overcome SIS Challenges

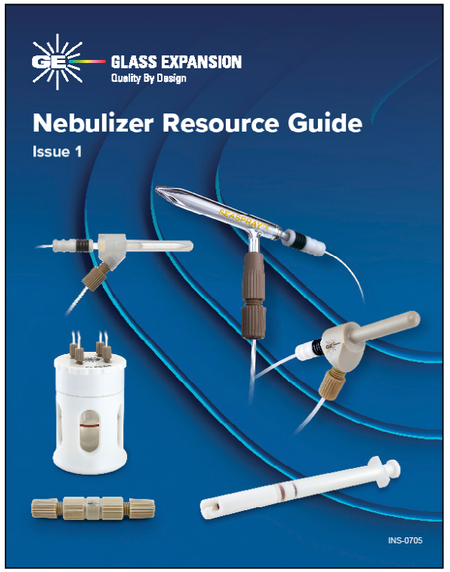
1. **Improve Data Quality:**
   - Select appropriate nebulizer, spray chamber, torch/injector, and cones
   - Tailor components to sample type for accuracy, precision & sensitivity
2. **Maximize Sample Throughput:**
   - Address carry-over and washout issues to improve efficiency
3. **Enhance Performance with Accessories**
   - Use tools like Elegra, Eluo, Guardian In-Line Filter, and Guardian Autosampler Probe improve stability
4. **Ensure Longevity & Consistency**
   - Implement proper care and cleaning routines
   - Reduce downtime through preventive maintenance



Nebulizer Selection

Selecting the right nebulizer requires careful consideration of various factors:

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



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

Glass Expansion Nebulizers - Industry leaders

- Glass Expansion is the only manufacturer that takes thick-walled precision-bore tubing and machines the outside to a uniform aerodynamic shape. This guarantees a uniform - lowest dead volume sample channel, assuring tolerance to nasty samples and excellent reproducibility.
- No other manufacturer can match the precision and reproducibility of the ‘VitriCone’ construction, making it the most robust and dimensionally reproducible concentric nebulizer available.
- The Global Standard in Nebulizer Innovation

Manufacturing Tolerance

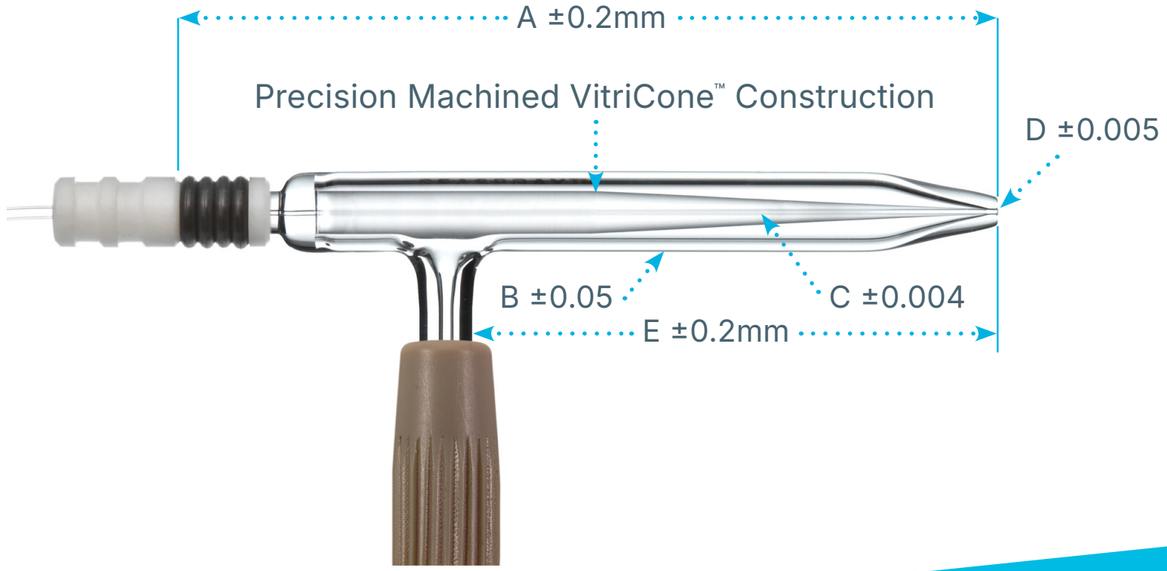
A. Controlled overall length precision

B. Shell Diameter

C. Full length precision bore capillary

D. Precision formed jet nozzle

E. Depth positioning stop



SeaSpray Nebulizer - Outstanding Efficiency and Tolerance to Dissolved Solids

- Material: Borosilicate glass
- A high physical reproducibility (1%) guarantees consistent performance of replacement nebulizers, backed by Glass Expansion's Value Proposition.
- TDS tolerance, typically up to 20%
- Tolerance to particulates, typically up to 200µm for USS1&2
- Low RSDs due to highly accurate construction
- Lowest dead volume for rapid washout
- Instrument Suitability: used with **both ICP-OES and ICP-MS**

The SeaSpray nebulizer has the highest sensitivity of any concentric glass nebulizer on the market. Perfect for high concentrations of dissolved solids up to 20%TDS.

Common samples include wastewater, seawater, groundwater, surface water, brines, high salt (including Li-ion batteries), **soils,** sludges and plating baths are just a few examples. A number of ICP-OES instrument manufacturers employ the SeaSpray as part of their standard instrument configuration.

Common standard testing methods include:

- **EPA 200.7**
- **EPA 6010D (SW-846)**
- **ASTM D1976**
- **EPA 200.8**
- **EPA 6020B (SW-846)**
- **ASTM D5673**

DuraMist Nebulizer - Versatile High-Performance for High Salt and HF Matrices

- Material: HF Resistant PEEK
- A high physical reproducibility (2%) guarantees consistent performance of replacement nebulizers.
- Tolerance to particulates, typically up to 200µm
- TDS tolerance, typically up to 30%
- Low RSD’s due to concentric geometry
- Lowest dead volume for rapid washout
- Instrument Suitability: ICP-OES and ICP-MS

The DuraMist™ is one of our most versatile and durable concentric nebulizer designs. The DuraMist can handle the toughest acid matrices, including up to 5% Hydrofluoric Acid (HF).

A uniquely designed smooth tip provides an outstanding tolerance to total dissolved solids (TDS), up to 30%.

It is a great “all-rounder” and the choice for the analysis of diverse sample types. Serviceability is high, as the capillary insert assembly can be replaced if needed.

Common standard testing methods include:

- **EPA 200.7**
- **EPA 6010D (SW-846)**
- **ASTM D1976**
- **EPA 200.8**
- **EPA 6020B (SW-846)**
- **ASTM D5673**

Slurry Nebulizer - Ideal for Wear Metals in Engine Oils

- Material: Borosilicate glass
- A high physical reproducibility (1%) guarantees consistent performance of replacement nebulizers, backed by Glass Expansion's Value Proposition.
- TDS tolerance, typically ~ 1%
- **High tolerance to particulates, typically up to 280µm**
- Low RSD's due to highly accurate construction
- Slurry nebulizers have a natural liquid uptake of 4mL/min but **operate best between 1.5 and 2.5mL/min**
- Instrument Suitability: ICP-OES

The Slurry nebulizer excels at exactly what it sounds like, the analysis of slurries or samples with undissolved particulates. The common sample types include slurries, suspensions, oils (including used engine oil, edible oils, and other oil-based lubricants), and organics such as engine coolants and antifreeze. A number of ICP-OES instrument manufacturers recommend the Slurry for used oils.

Common standard testing methods include:

- **ASTM D5185**
- **ASTM D6751**
- **ASTM D7691**

Common Nebulizer Models for Used Oil Analysis

Nebulizer Model	Cost
Slurry™	
V-Groove (Glass)	
Enhanced V-Groove (Glass)	
Enhanced V-Groove (ULTEM)	
Enhanced V-Groove (PEEK)	

Slurry™ 36% More Cost Effective than the average cost while still providing the best overall analytical performance

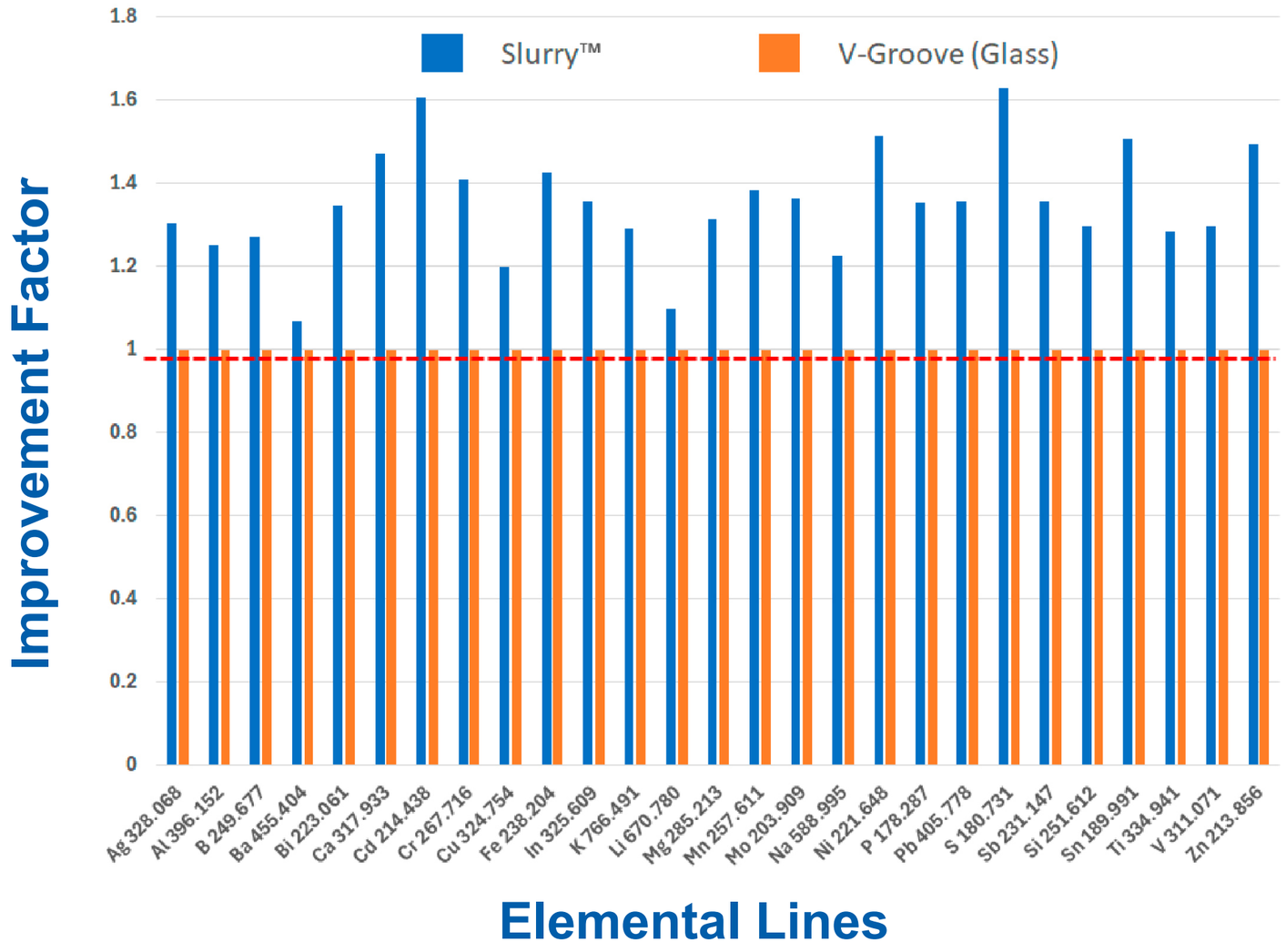
A Comparison of Nebulizers Using New Organic Solvent

- Inorganic Ventures compared the analytical performance of the Slurry™ and V-Groove nebulizer using their new bio-based organic solvent (IV-77742).
- Twister™ spray chamber was used with both nebulizers.
- Used a 5 ug/g (ppm) calibration standard to compare sensitivity and precision.
- Final sample matrix was 1:10 w/w dilution with 10% Organometallic hydrocarbon oil standard (90% IV-77742).
- Analysis was performed with Spectro ARCOS III ICP-OES in Radial (SOP) mode.

Slurry™

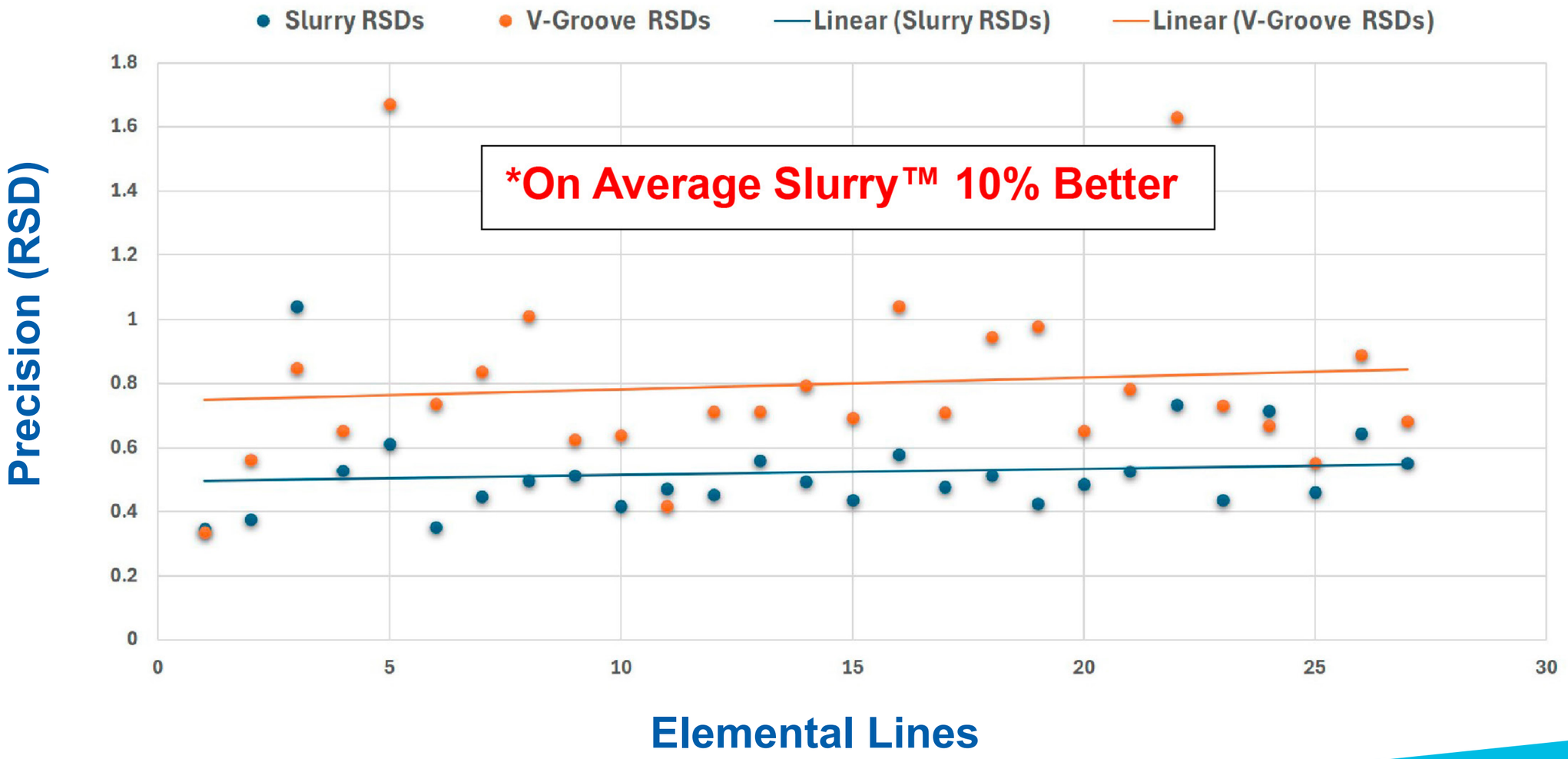
V-Groove Glass

Nebulizer Intensity Comparison



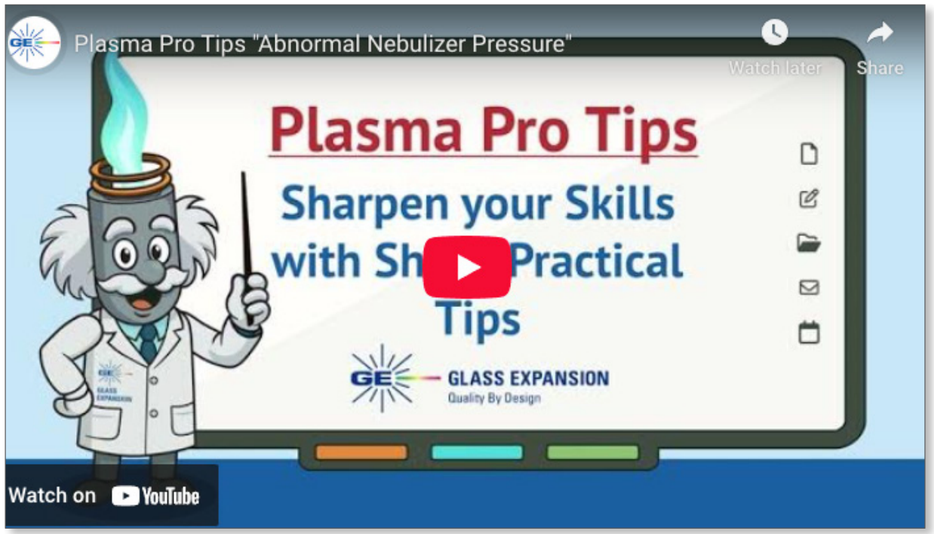
***On Average Slurry™ 35% Better**

Nebulizer Precision Comparison



Recommendation for frequent Nebulizer Blockages

- Identify the root cause of blockages: salts, particulates, or other contaminants
- Take preventive actions:
  - **Use “Plasma Pro Tips” guidelines**
  - **Regular Maintenance**
  - **Helpful Accessories:** (1) Particulates; (2) High TDS; (3) Eluo Nebulizer Cleaner; Magnifier Inspection Tool



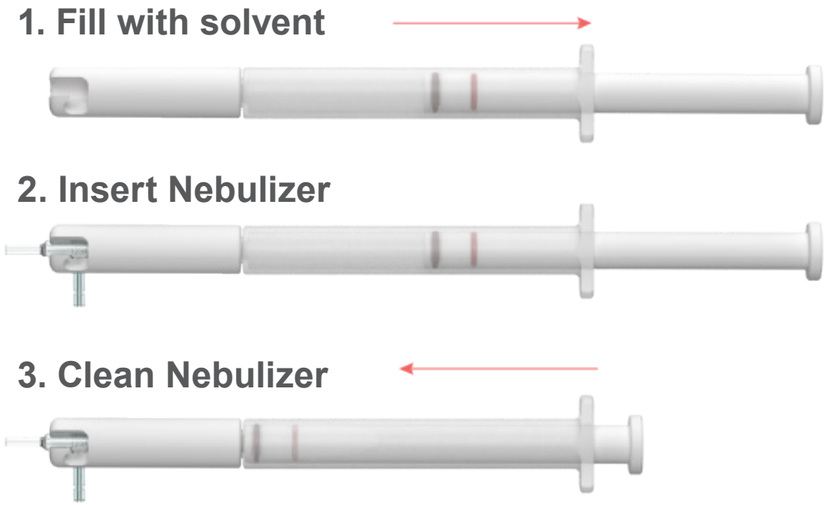
Helpful Accessories to reduce Nebulizer Blockages:

Maintenance Tools:

1. Eluo Nebulizer Cleaning Tool

Why use it?

- Manual cleaning risks damage to delicate nebulizer channels
- **How it helps:** Safe, controlled cleaning using a soft stream of liquid
- Extends nebulizer life and maintains consistent performance



2. Glass Expansion Magnifier Inspection Tool

Why use it?

- Nebulizer tips and sample introduction components are tiny and hard to inspect
- Salt deposits or physical damage may go unnoticed until performance drops
- **How it helps:** Provides a clear, close-up view of nebulizer or injector tips
- Quickly identify wear, blockages, or salt build-up before issues escalate

Samples That Contain Particulates:

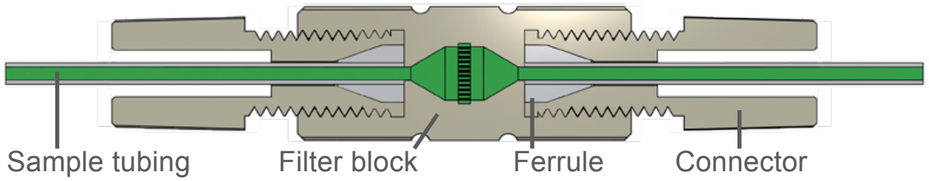
Why address particulates issue?

- Particulates can **clog fine sample lines or nebulizer channels,** disrupting analysis
- Preventing blockages reduces downtime and maintains performance

How to solve it?

Guardian In-Line Particle Filter (P/N 70-803-1108) between probe and nebulizer

- **120µm filter** with seals for both 1.6mm and 1.3mm OD tubing
- **Clog-resistant PEEK** design — easily cleaned by back-flushing or ultrasonics



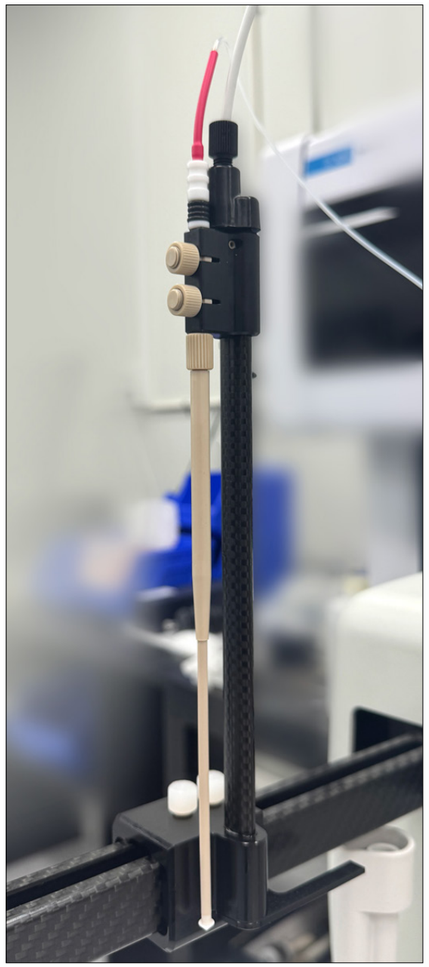
In-Line particle filter: *"By the way, the particle filters that we have purchased are working out very well with our soil sample analyses on our ICP-OES units, have saved a lot of headaches with blocked nebulisers!"*

Soil & Plant Laboratory - Australia

Samples That Contain Particulates:

Guardian Sample Probe:

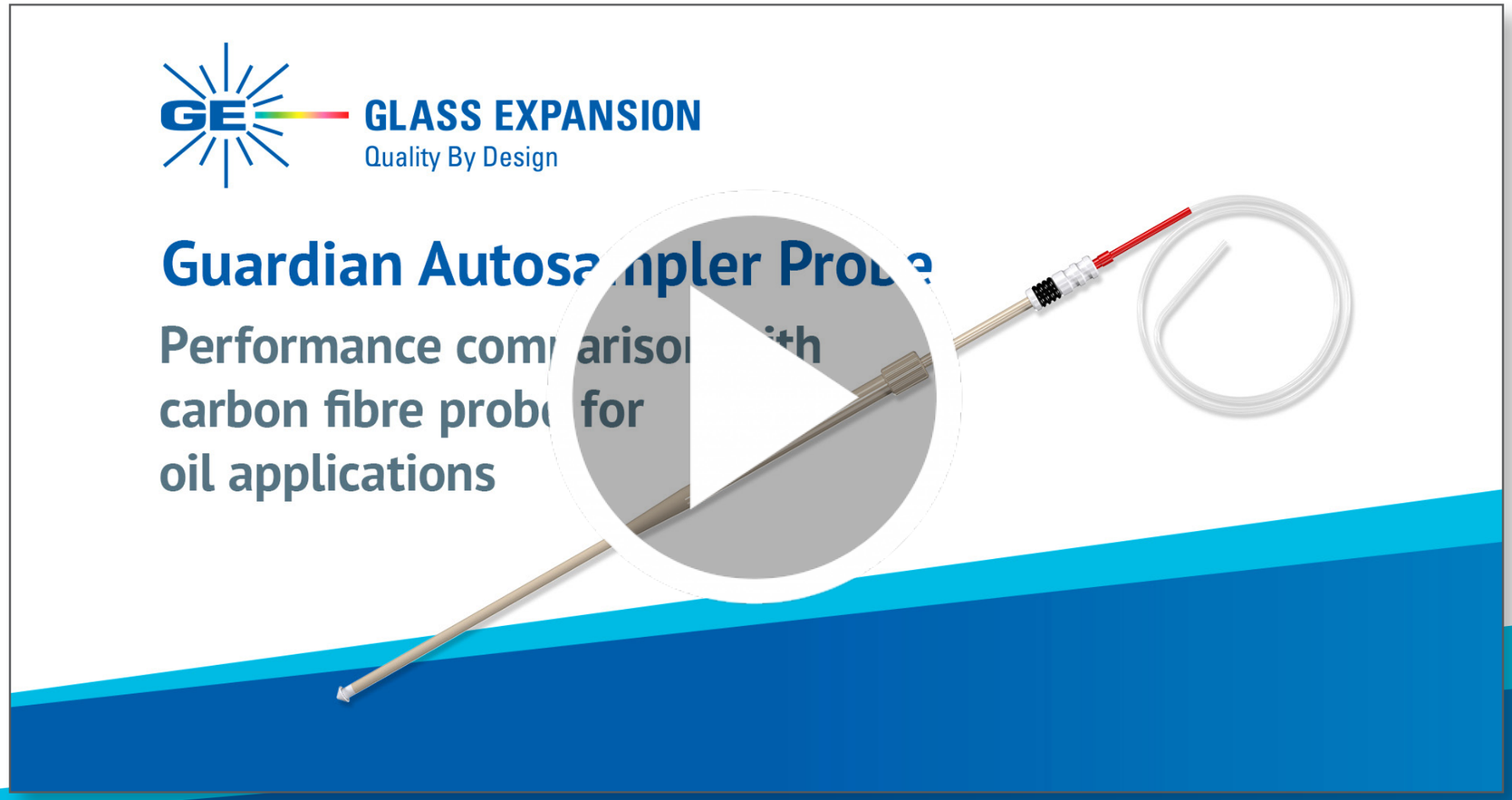
- **Enhanced surface finish** reduces residual carryover between samples
- **Robust tip design** prevents crushed or damaged tips from misalignment.
- **Drip-resistant** to minimize cross-contamination, especially with oils.
- **Unique inbuilt particle filtering** prevents blockages in your nebulizer and capillary tubing.
- **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)



Guardian Probe Assembly for ASX-200, 500, 800 Series P/N 70-803-1787

Guardian™ Probe Performance Comparison Video

Below is a performance comparison of the Guardian Autosampler Probe against a regular carbon fibre probe for oil applications.

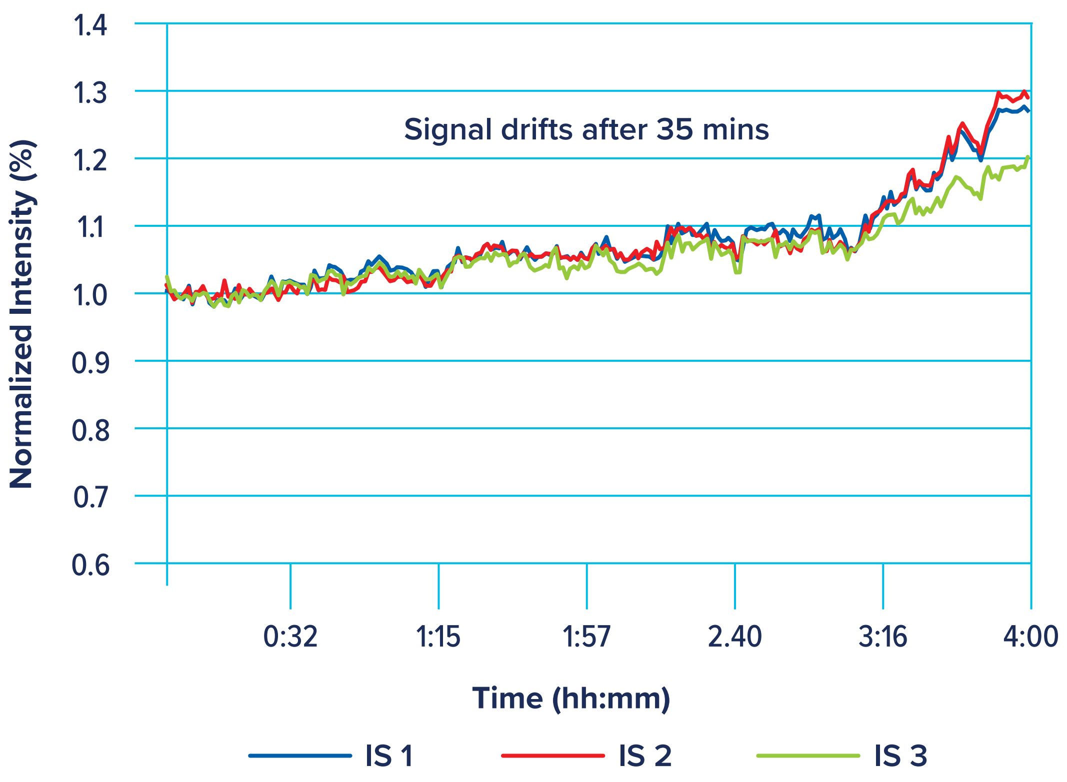


Samples With High TDS: Argon Humidifier

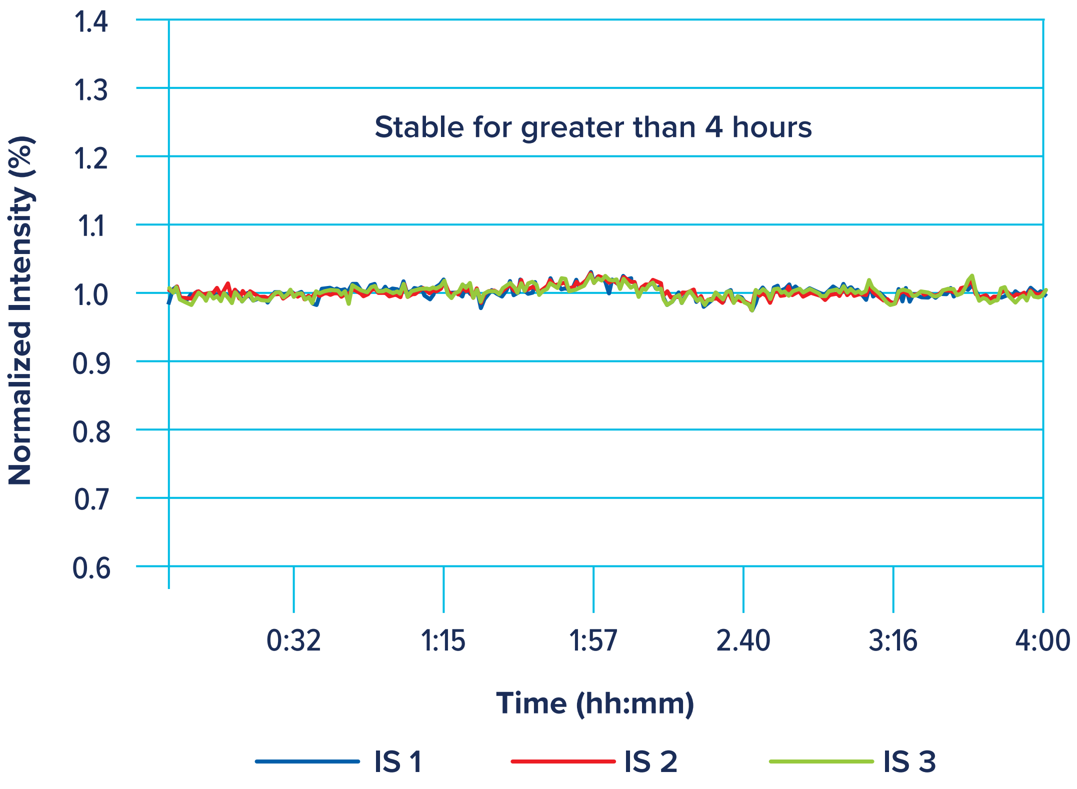
Performance

- 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

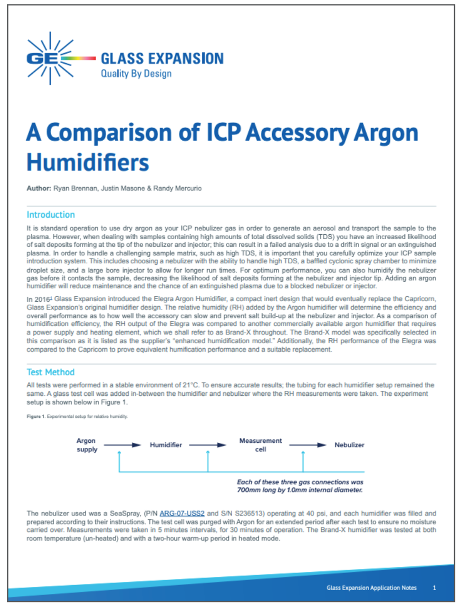
Analysis Failed
Without Elegra Argon Humidifier



Analysis Completed
With Elegra Argon Humidifier



Elegra Application Note



Spray Chambers: Transport Efficiency, Precision, and Washout

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

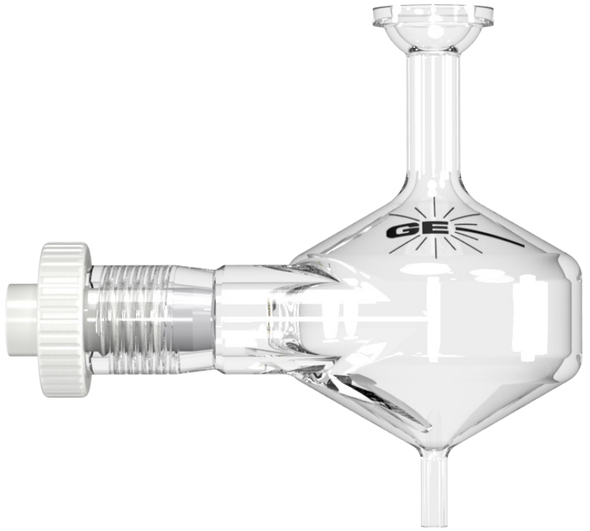
Long washout Carryover

- Poor Precision
- Dead volume
- Compromised analytical results

Tracey™ Ball Joint Connection (BC) Spray Chambers

Features & Benefits:

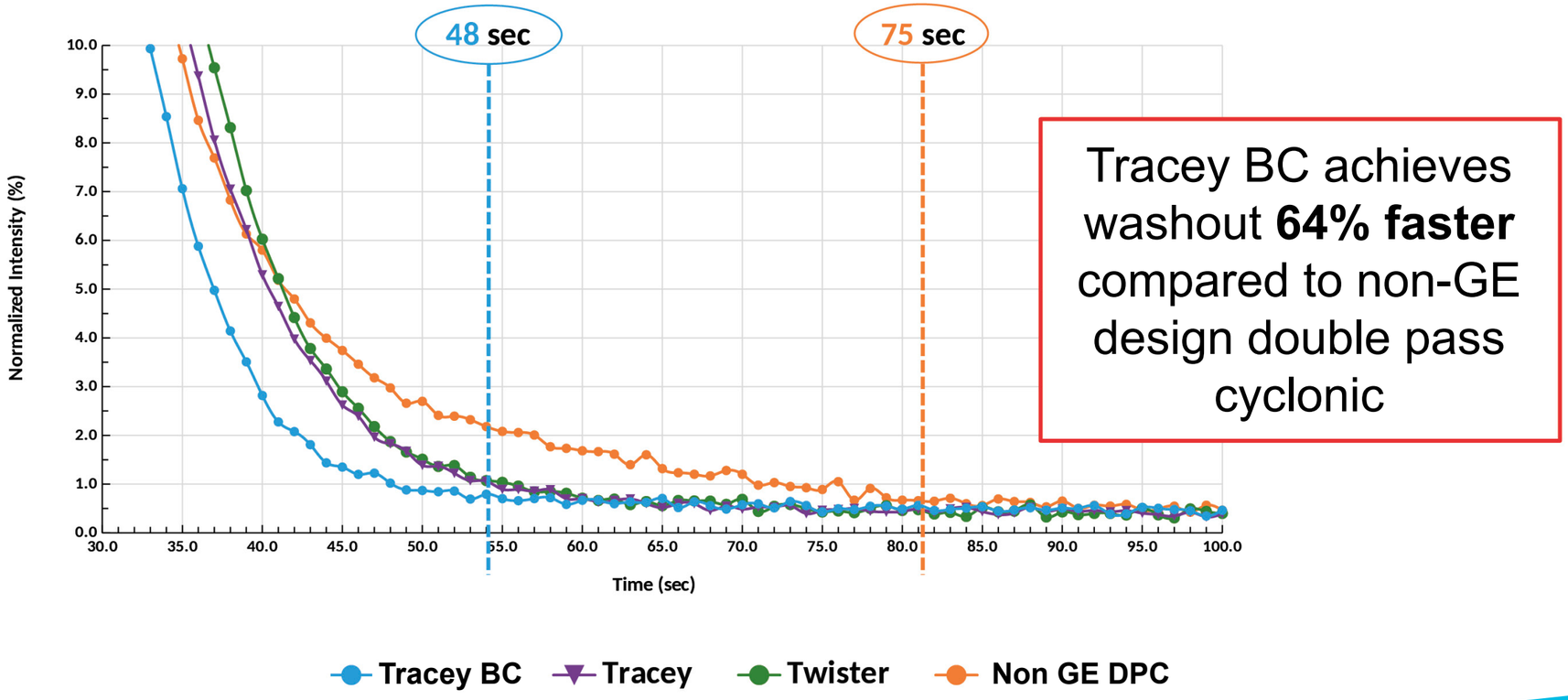
1. **Helix CT:** Reduces washout times and eliminates frequent replacements due to wear.
2. **Excellent Precision:** Short-term noise on average 0.5% or better providing excellent repeatability and stability.
3. **Cost-Effective:** More affordable than traditional glass spray chambers.
4. **Efficient Washout:** 30mL low-volume cyclonic chamber.
5. **Wide Compatibility:** Fits most common ICP-OES models.



Tracey™ BC Spray Chamber

Tracey™ Ball Joint Connection (BC) Spray Chambers

Washout Profiles for 1 ppm Hg:

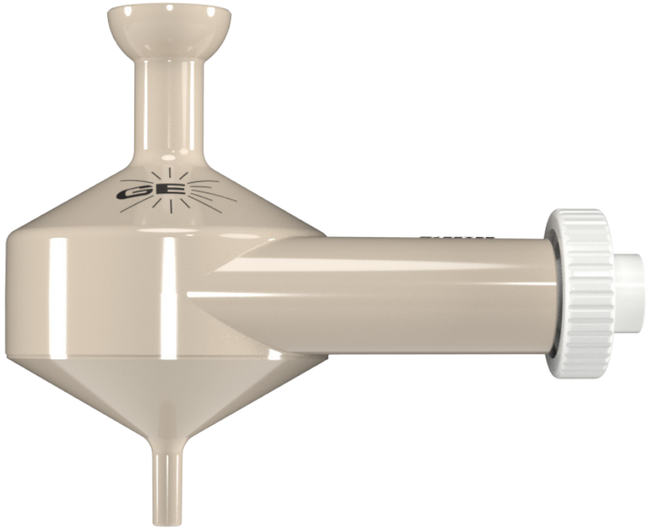


Tracey BC achieves washout **64% faster** compared to non-GE design double pass cyclonic

Suggestion for upgrading ICP Inert Spray Chambers:

Tracey BC PEEK Spray Chambers:

- **HF Resistance:** With resistance up to 5%
- **Superior Wetting:** PEEK material maintains excellent wetting properties with routine laboratory cleaning.
- **Compact Design:** Lightweight and compact, eliminating the need for additional spray chamber brackets.
- **No Internal Surface Treatment:** Unlike TFE or PFA, this spray chamber requires no internal surface treatment while maintaining excellent precision.



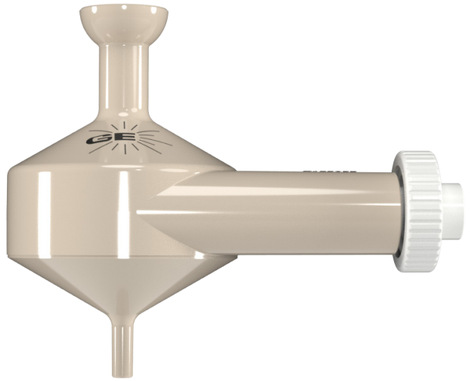
Tracey™ BC PEEK Spray Chamber

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.

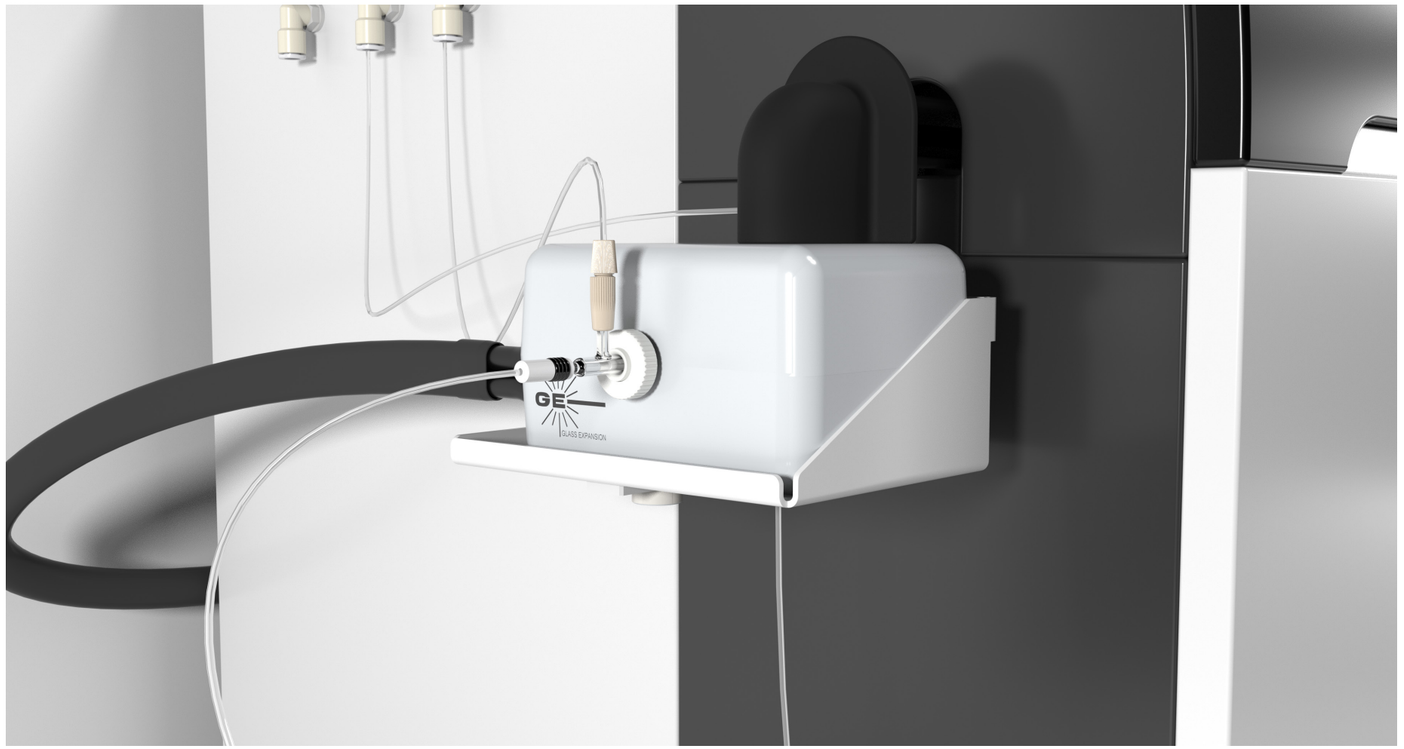
*Comparison conducted by Specialty Chemicals Manufacturer – USA



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

Introducing the Revolutionary PCC™ Kit

Enables the switch from a standard Scott style… to Glass Expansion's Tracey™ Cyclonic Spray Chamber



Scott Style
Spray Chamber

Tracey™
Spray Chamber

Key Advantages of the PCC™ Kit Spray Chamber

1. Improved Washout Efficiency:

- Distinctive design of the cyclonic spray chamber minimizes washout time.

2. Helix CT™ Interface:

- All Glass Expansion cyclonic spray chambers feature the Helix CT™ locking screw and seal.

3. Interchangeable Materials:

- **The PCC Kit allows easy interchangeability between different spray chamber materials:**
  - **Borosilicate Glass:** Cost-effective option for routine analyses not requiring low-level boron measurements.
  - **Quartz:** Required for precise low-level boron detection.
  - **PFA:** Ideal for applications with a hydrofluoric acid matrix and **ultra-trace ICP-MS analyses** (paired optimally with Glass Expansion's DuraMist™ DC or OpalMist™ DC Nebulizer).
  - The Tracey PFA spray chamber interior features the proprietary Stediflow surface treatment, improving wettability and efficient drainage.

4. Fast and Simple Installation:

- The PCC Kit connects directly to the existing electronics and water-cooling system.
- A convenient mounting bracket ensures swift installation on the Agilent® ICP-MS systems.

5. Jet Vortex Interface (JVI™) – Aerosol Filtration:

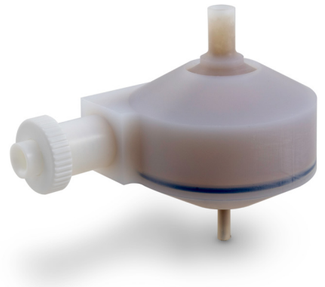
- Compatible with your existing method settings for HMI or UHMI (7850/7900/8900).

Glass Tracey™ Spray Chamber with Helix CT

P/N 21-809-4368

Quartz Tracey™ Spray Chamber with Helix CT

P/N 21-809-4448

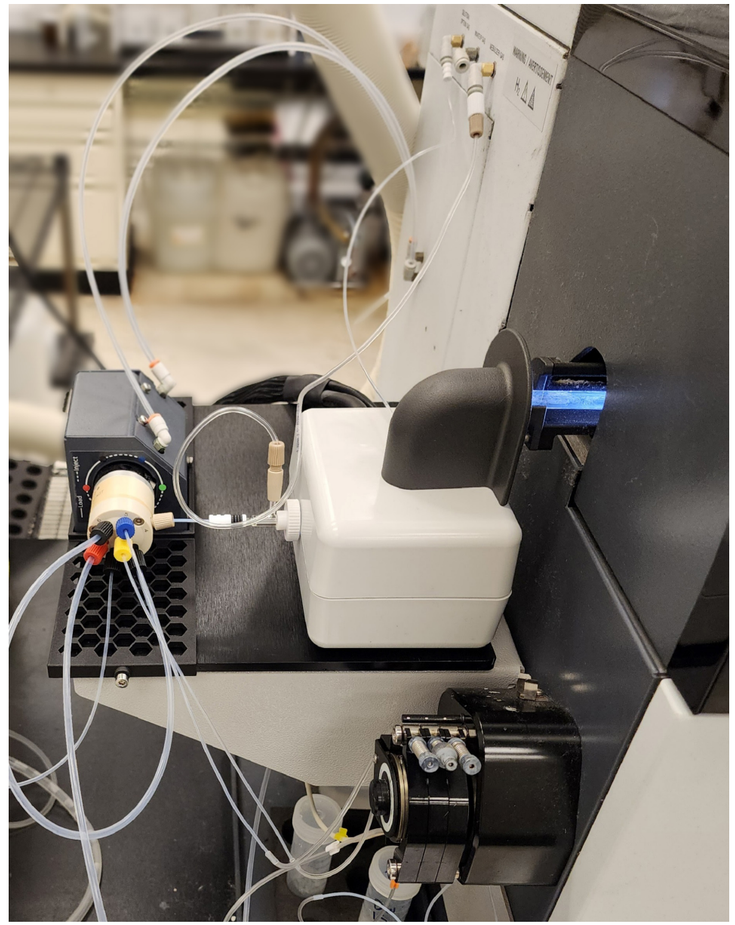


PFA Tracey™ Spray Chamber with Helix CT

P/N 21-809-2985

New PCC™ Kit (P/N KT-1212Q)

- Compatible with Agilent® 7850/7900/8900
- Compatible with Agilent® HMI or 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 while reducing the nebulizer path length.
- 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

Jet Vortex Interface (JVI™) – Aerosol Filtration

A patent pending, novel design, providing highly efficient Aerosol Filtration. Simple and straightforward installation, the JVI works in conjunction with the existing “Make-Up” or “Dilution/Auxiliary” gas option of your ICP-MS.

Benefits

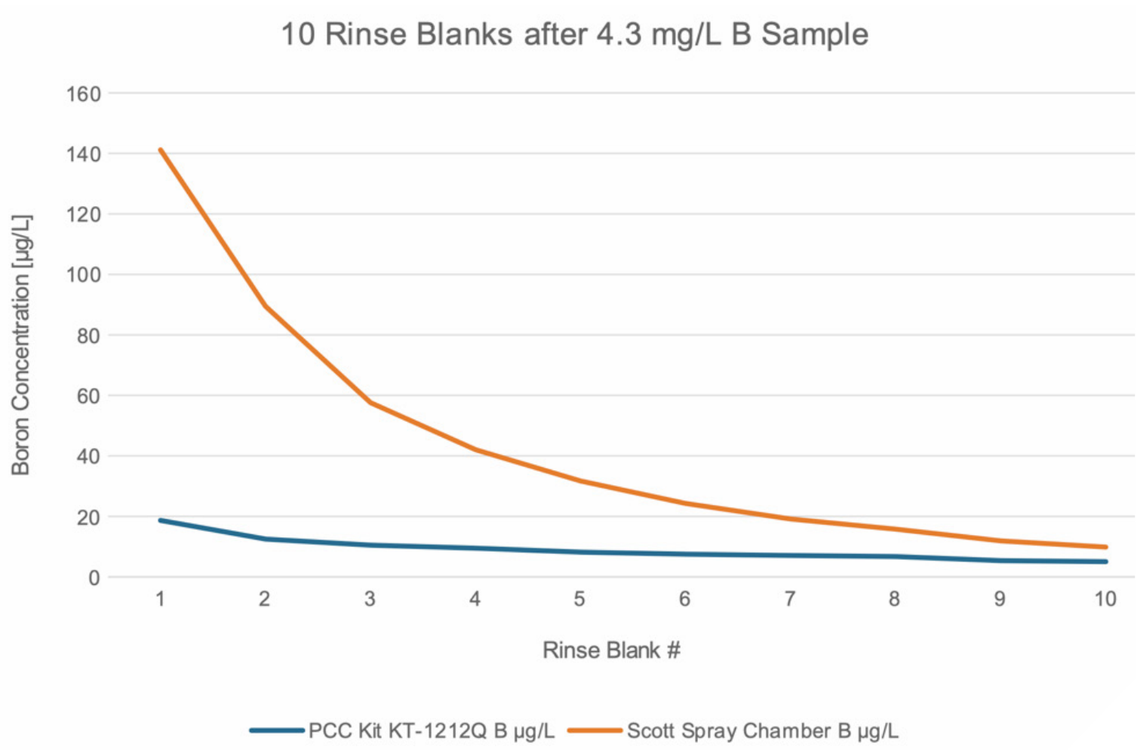
- Compatible with your existing method settings for HMI and UHMI (7850/7900/8900).
- Chemically inert, made from Teflon® (PTFE).
- Secure connection to gas supply, spray chamber and transfer tube.
- Improved life of torch & interface cones.
- Reduce build-up on injector & interface cones.
- More robust plasma conditions.

JVI™

B Washout after 4.3 mg/L Sample

	PCC Kit (KT-1212Q)		Scott Style Spray Chamber	
	11 B [H2]		**11 B [H2]**	
Time Stamp	**Conc. [ppb]**	Type	**Conc. [ppb]**	Time Stamp
7:35 PM	4294.897	Sample	4376.533	2:49 PM
7:38 PM	18.655	Blank 1	141.146	2:52 PM
7:41 PM	12.491	Blank 2	89.449	2:55 PM
7:44 PM	10.483	Blank 3	57.566	2:58 PM
7:47 PM	**9.49**	Blank 4	42.028	3:01 PM
7:50 PM	8.183	Blank 5	31.679	3:04 PM
7:53 PM	7.505	Blank 6	24.263	3:08 PM
7:57 PM	7.083	Blank 7	19.126	3:11 PM
8:00 PM	6.706	Blank 8	15.771	3:14 PM
8:03 PM	5.366	Blank 9	11.902	3:17 PM
8:06 PM	5.026	Blank 10	**9.851**	3:20 PM

✓ In this example, a **61% improvement** in B washout time, resulted in a much higher throughput and much lower potential for any carryover.



Summary of Key PCC™ Kit Benefits

- **Faster Washout Times:** Compared to traditional Scott-style spray chambers, the PCC™ significantly reduces washout times for “sticky” elements such as boron and mercury.
- **More Efficient Workflow:** Less reruns from unanticipated carryover or poor RSDs.
- **Improved Signal Stability:** Reduced memory effects lead to more consistent and accurate boron measurements, and longer analysis times with less analytical drift.
- **Higher Quality Data:** Less data flags on instrument blanks, method blanks, duplicates, dilutions, and other QA/QC samples.
- **Increased Sample Throughput:** Faster uptake and washout times enable shorter total sample acquisition times, thereby increasing sample throughput.

Agressive Sample Matrices: Torch Selection

Examples: Soils, wastewater, brines, high-acid digests, organics, lithium fusions

Challenges:

- High salt deposits and plasma temperatures shorten quartz torch life
- Frequent toch replacement increases cost of ownership
- O-ring failures or gas leaks can destabilize plasma or prevent ignition

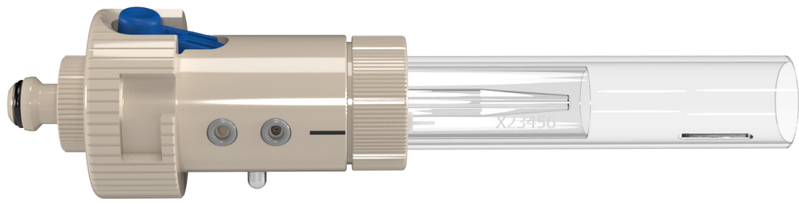
Mitigation:

- Use a Demountable Torch → replace only the outer tube, lowering cost of ownership
  - *Narrow bore quartz: 1.0mm or less: volatile organics*
  - *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

Upgrade: Optional ceramic outer tube → resists devitrification, lasts longer, and maintains plasma stability

Benefits: Ideal for high-TDS, salty, or organic samples; hotter, more robust plasma improves sensitivity



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

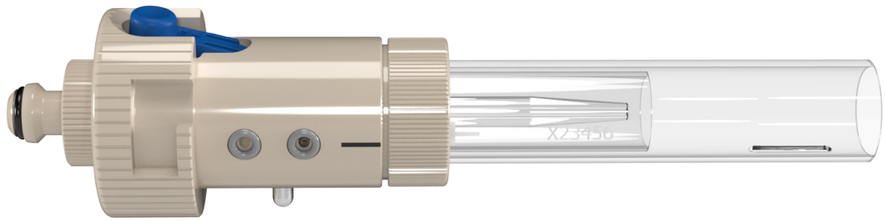
Comparison of Quartz tube set to Ceramic Outer tube set		
Element	**% Increase in Sensitivity**	**%RSD**
Zn (213) λ	17%	0.36
Ni (231) λ	19%	0.57
Mn (257) λ	14%	0.52

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

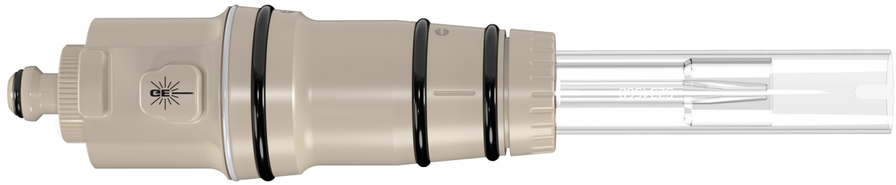
NEW E-Torch™ for ICP-OES

Benefits

- Made from PEEK, PTFE & Quartz
- Interchangeable injectors (Quartz, Ceramic, Sapphire)
- Compatible with any ball joint spray chamber
- Performance equivalent to the D-Torch
- Ceramic tube set available on request for HF and high TDS applications
- **User-friendly tube set and injector assembly simplifies deposit removal during maintenance and allows oven cleaning of carbon deposits.**



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



NEW! **P/N 30-808-4466**
E-Torch Agilent 5000 Series

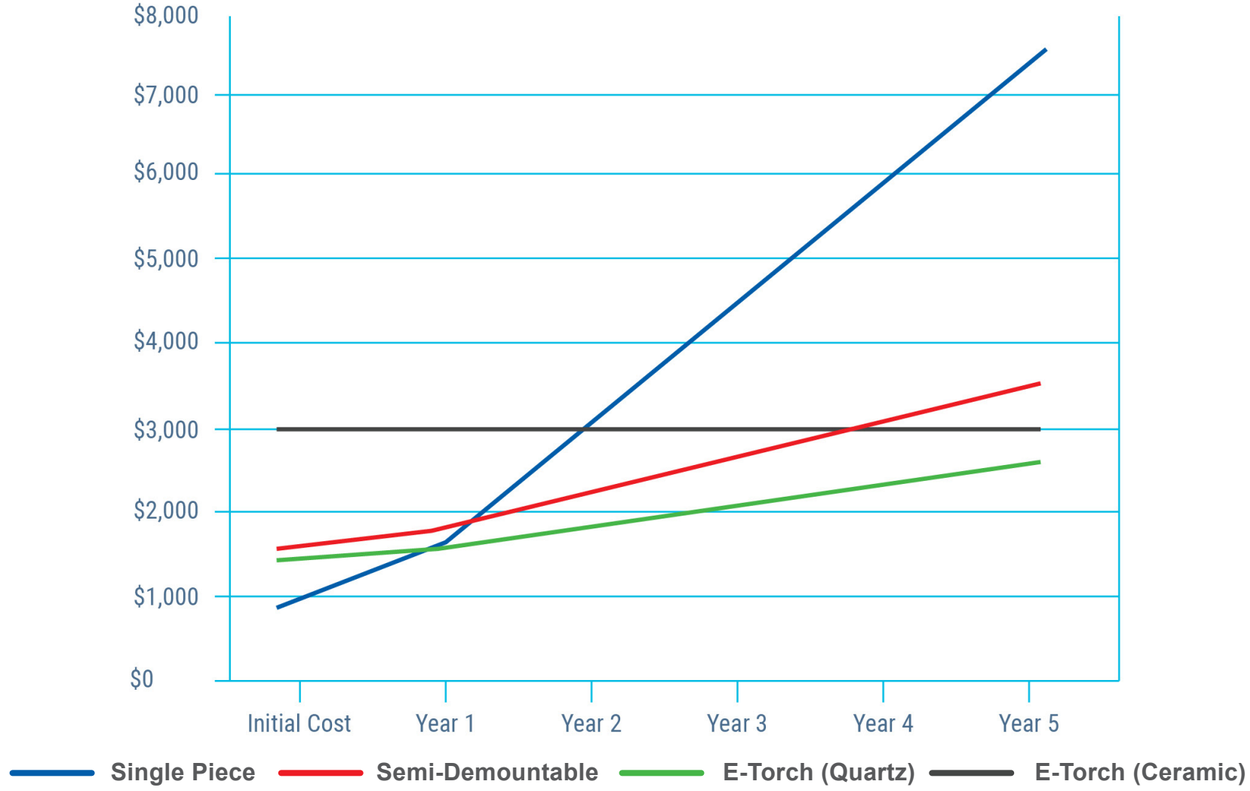
Comparitive Torch Ownership Costs

NEW! Agilent® 5000 Series E-Torch

Quartz tube set

Ceramic tube set

Comparative torch ownership costs versus the E-Torch



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:

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

Platinum Cones:

- Most durable, longest-lasting, but highest cost
- Excellent chemical resistance - ideal for **high-matrix, high acid,** or organic **solvent samples**
- Least efficient heat transfer → runs **hotter**, but stays **cleaner longer**
- Can be **refurbished 2-3 times** and **recycled** for reclaim value towards future purchases

ICP-MS Cone Resource Guide

Support and Customer Service

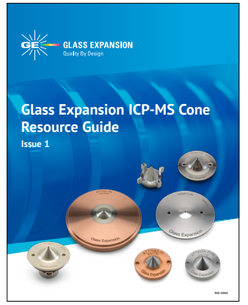
- Application notes
- Newsletters
- Catalogs
- Product Flyers
- Website
- Product care advice
- Operating Instructions
- Videos

Flyers

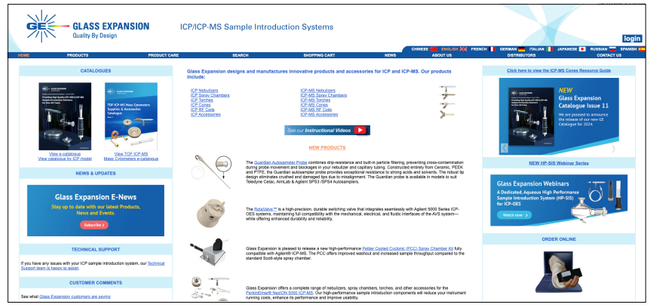
Newsletters

Instructions

Application Notes



Catalogs



Website

Want a FREE review of your Sample Introduction System?

Visit US AT BOOTH #2655

✓ Optimize your sample introduction system components.

✓ Identify other performance enhancing accessories available for your ICP.

✓ Discuss any sample introduction challenges.

✓ Explore ways to reduce operating costs.

✓ Obtain quotes.

Contact by email: geusa@geicp.com

Thank You

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