GLASS EXPANSION
Quality By Design

Selecting the Optimal Sample Introduction System for Your Application

Presenter:

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Introduction: About Glass Expansion

- GE have been specializing in sample introduction components for ICPs since 1985
- Global recognition for manufacturing precision and reliability
- OEM to every major ICP-OES and ICP-MS manufacturer
- Approximately 100 staff
- Sales Offices Worldwide: Australia, USA and **Germany**
- **Official Distributor for Sweden: Lab Supplies Nordic AB**

Glass Expansion - Europe
Weilburg, Germany

Glass Expansion - Americas
Cape Cod, Massachusetts

Glass Expansion – Asia-Pacific
Melbourne, Australia

Sample Introduction System

While often overlooked, the sample introduction system is a key factor in determining the overall analytical performance of your ICP system:

- Impacts precision, sensitivity, and detection limits
- Tailored solutions are essential: high matrix samples, HF-containing samples, low detection limits, organics, and more each require specific setups
- An optimized sample introduction system ensures accurate, repeatable results

Sample Delivery System

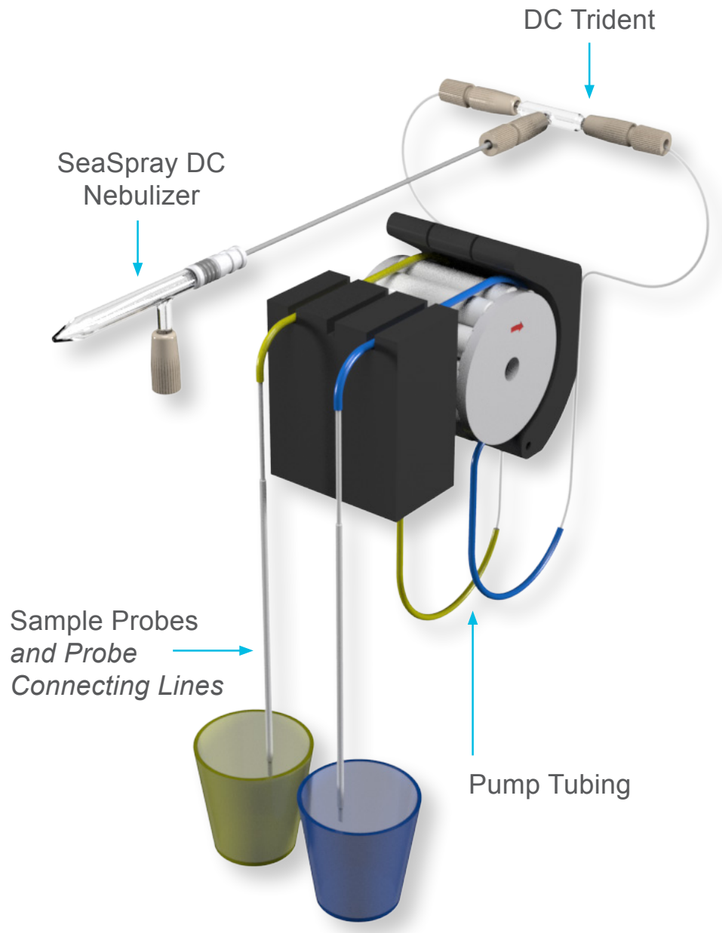
- **Sample Probe**
- **Peristaltic Pump Tubing**
- ***Teflon connecting tubing***
- ***Internal Standard Addition Kit***
- ***DC Trident***

Key Functions:

- Consistent and accurate transport of the sample from its container to the nebulizer
- Allows for precise control over sample volume for reproducible measurements

Common Challenges:

1. Ineffective Sample Digestion: Precipitates and undigested particles
2. Clogging and Blockages
3. Cross-Contamination
4. Sample Flow Issues: Variation in sample flow rate results in an unstable signal (poor RSDs)



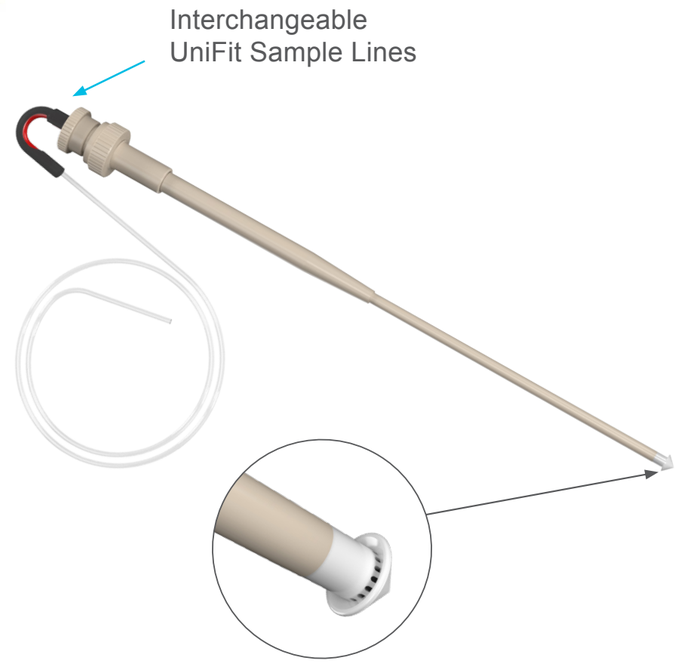
Sample Probe: Selection

1. 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. 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.



Peristaltic Pump Tubing: Selection

The pump speed together with diameter of the tubing, with cross-sectional area (mm2), determines the flow speed (mm/min), ultimately influencing the flow rate in mL/min.

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

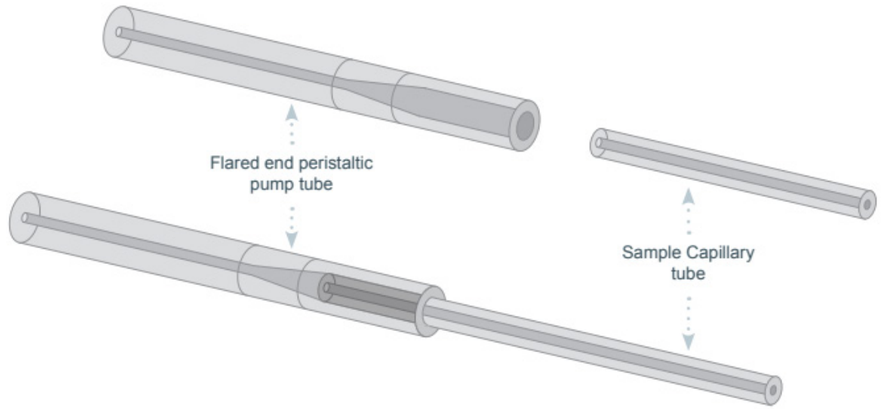
Flared vs. Non-Flared Options:

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

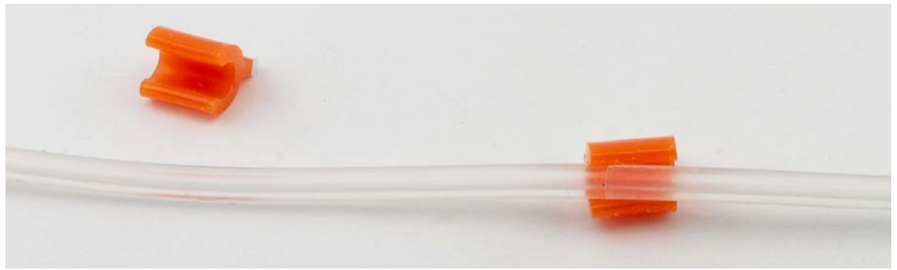
Customer Pain Points with traditional pump tubing:

1. Premature Tab Failure:

- **Description:** Tabs on the tubing can become loose or break off prematurely, especially if they are not properly bonded or are of poor quality.
- **Impact:** This can lead to detachment of the tubing from the connectors, causing interruptions in sample flow and requiring tubing replacement.

2. Tubing Slippage/Displacement:

- **Description:** Tubing can slip from the connectors or the pump rollers, particularly if the tubing is not properly fitted or if the connectors are worn.
- **Impact:** This can cause interruptions in the sample flow, inconsistent sample delivery and analysis interruptions.

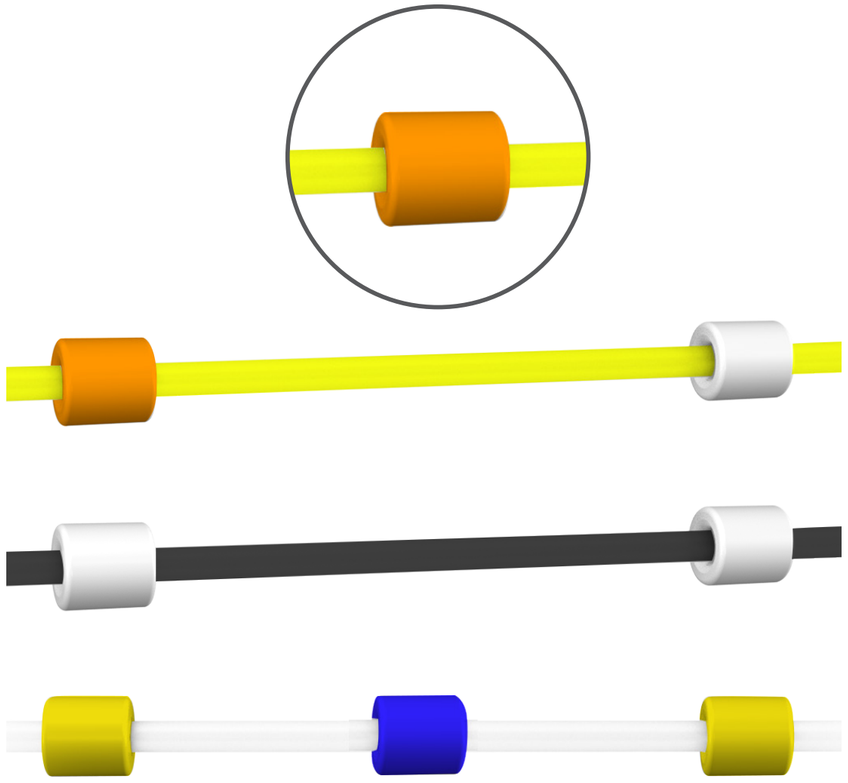


Traditional Pump Tubing

ProLok™ Peristaltic Pump Tubing

Features & Benefits:

1. **Enhanced Bonding Strength:** The color tab now features twice the surface area, ensuring a stronger and more secure attachment to the pump tubing.
2. **Durability:** Designed to prevent premature failure, the reinforced tabs eliminate issues with loose tubing connections.
3. **Superior Material Quality:** Crafted from high-quality Tygon® material, this product delivers premium performance and exceptional consistency.
4. **Consistent Compatibility:** Maintains the same GE part numbers for seamless integration.
5. **Precisely controlled tab spacing** designed to meet and exceed industry standards for ICP-OES and ICP-MS peristaltic pumps.



ProLok™ Peristaltic Pump Tubing

Sample Pump Tubing Selection

Tubing materials vary based on sample properties

Common materials include:

- **PVC Standard** (Tygon ST): Economical and suitable for most routine aqueous samples
- **Solva** (Tygon HC or Solvaflex): Special tubing for hydrocarbons, petroleum products and distillates
- **Tygon MH:** High-purity PVC; no additives or plasticizer; highly solvent-resistant (MIBK)
- **Viton** (Fluran): Fluropolymerelastomer; special tubing for concentrated acids and corrosive solvents

Sample Matrix	Material	Colour	Not recommended
Aqueous	PVC/Tygon	Transparent	DMF, DMSO, Xylene
Premisolve, Oil, Xylene	Solva	Yellow	DMSO
DMF, DMSO	Viton	Black	

Common Challenges Associated with ICP Sample Introduction

Nebulizers

- Application Suitability
- **Performance Issues:** Sensitivity loss, poor precision, extended washout times
- **Blockages & Contamination:** Cross-contamination, ICP backpressure, poor connections

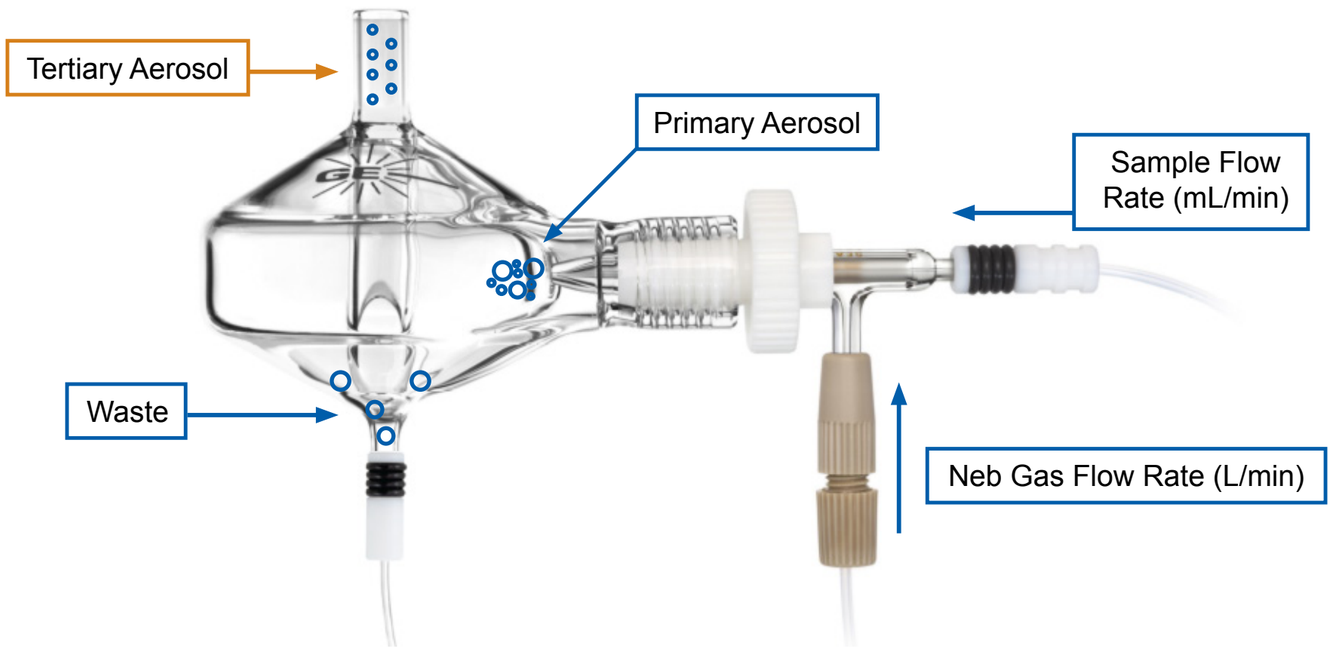
Spray Chambers

- Application Suitability
- **Profound Effect on:** Transport Efficiency, Precision, and Washout

Torch & Injector

- Application Suitability
- **Performance Issues:** Sensitivity loss, poor plasma stability, blocked injector
- **Maintenance:** RF coil alignment to reduce devitrification, worn or deformed torch
- **Harsh Matrix Effects:** Devitrification from high TDS and organics

Aerosol Generation



Primary aerosol is produced by the nebulizer

Droplet size decreases as argon gas velocity increases and sample liquid flow rate decreases

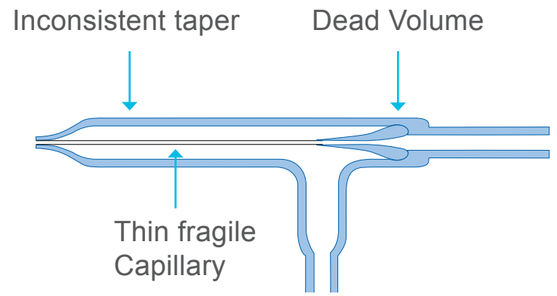
Tertiary Aerosol "filtered" by Spray Chamber, <10 µm

Only the smallest droplets (<10 µm) are transmitted to the plasma & 95- 98% of nebulized sample is drained as waste

Quality of Aerosol ∝ Quality of Results

Concentric Nebulizers: Design Considerations

Other Nebulizer Design:



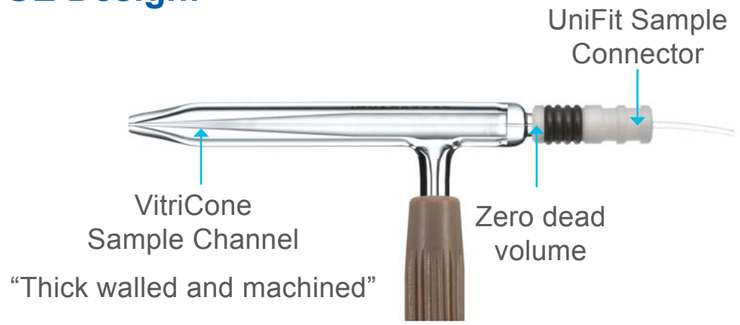
Design Challenges:

All ICP Nebulizers are not created equal: they vary in quality, performance and consistency

Drawn-out capillary tubing design leads to:

- Narrowing, promoting salt buildup
- Fragility and vibration under high-speed argon flow, reducing precision
- Inconsistent taper affects seal and depth in the spray chamber

GE Design:



eg. SeaSpray™, MicroMist™, Conikal™, Slurry™

GE DC Nebulizer Benefits:

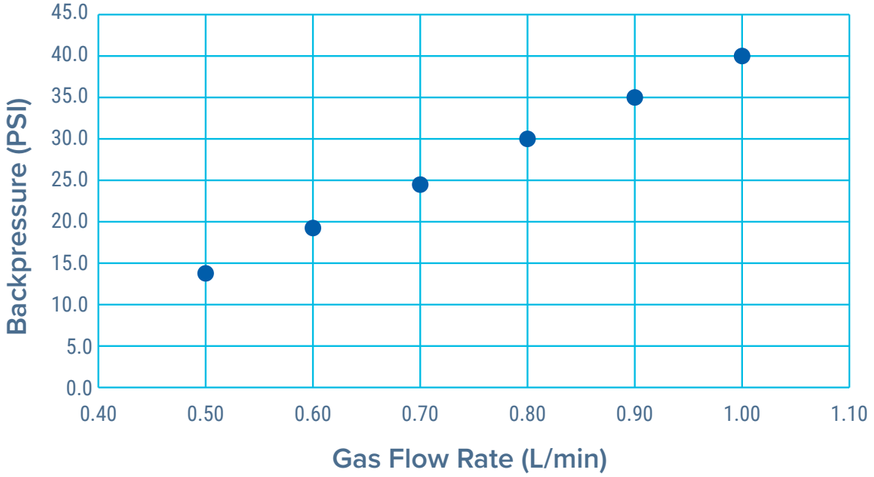
- **VitriCone™ Technology:** Precision-machined heavy glass capillary ensures reliability
- **Clog-Resistant:** Uniform sample channel prevents particulate buildup
- **UniFit Sample Line Connector:** Easy to install, creates a secure seal, and reduces dead volume for faster washout
- **Flexible Argon Line:** Ensures efficient, consistent gas flow, unlike rigid tubing that can restrict flow

DC Nebulizer Selection

Selecting the right nebulizer requires careful consideration of various factors:

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
Quartz SeaSpray™		20	75	No	High	Excellent	Quartz
OpalMist™		15	75*	Yes	High	Excellent	PFA
DuraMist™		30	75*	Yes	High	Good	PEEK
VeeSpray™		30	300	Yes	Moderate	Good	Ceramic

Backpressure (PSI) Gas Flow Rate (L/min)



Important Nebulizer Operating Parameters

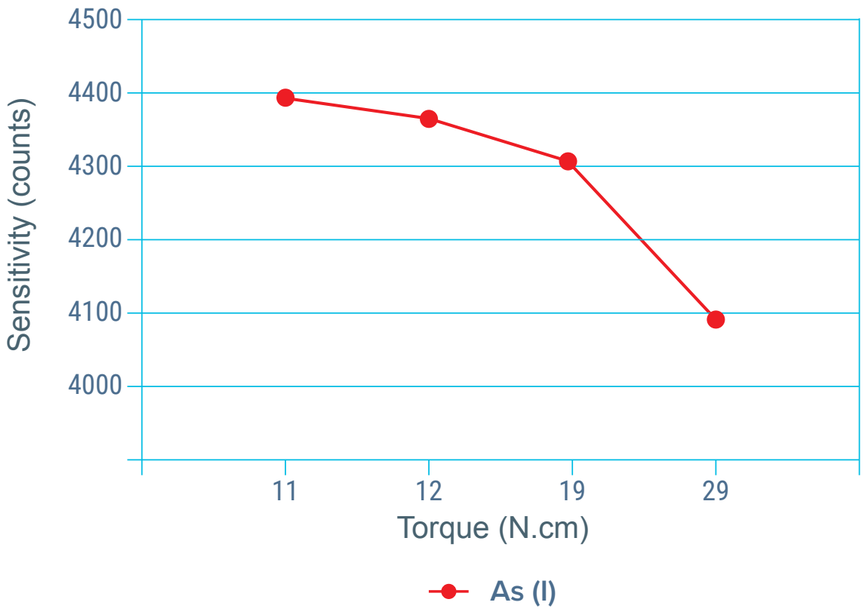
Example: GE P/N A13-1-UM04

- Optimum nebulizer gas flow = 1.0 L/min (40 psi)
- Sample uptake rate ≤ 0.4 mL/min

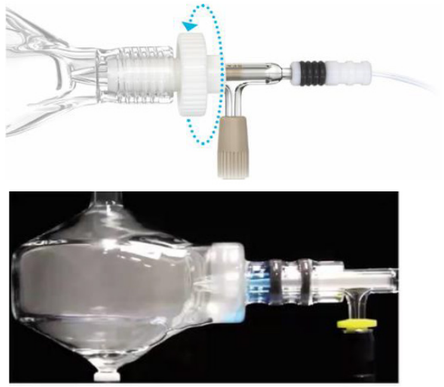
Spray Chambers: Helix CT Interface

Helix CT: Constant Torque = Reproducible day-to-day ICP Performance

Optimum Sensitivity

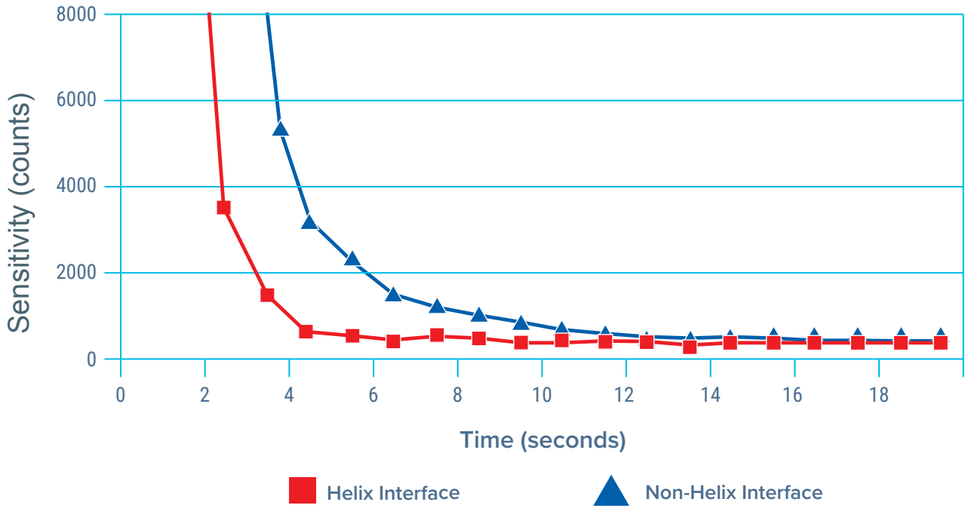


Built-in torque control mechanism



Non-Helix Interface

Improved Washout

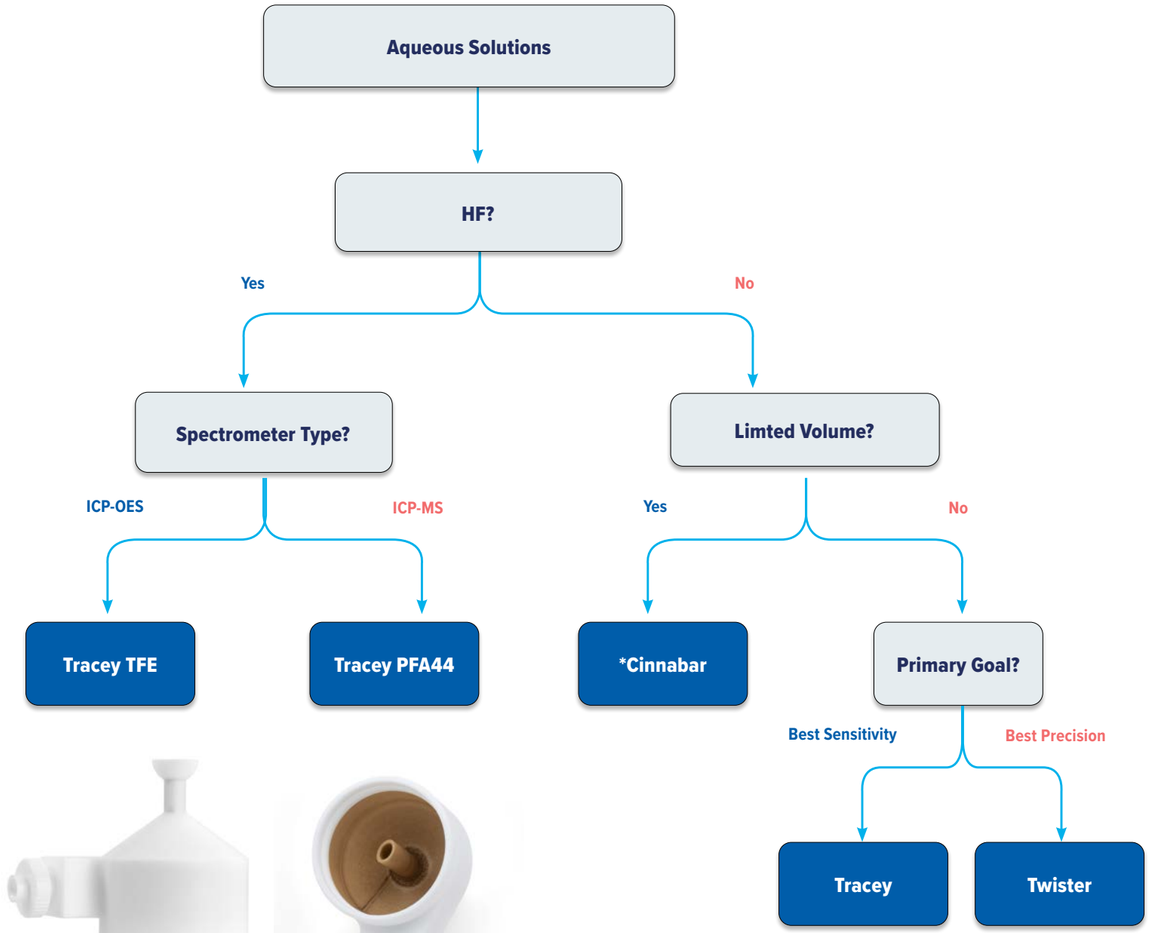


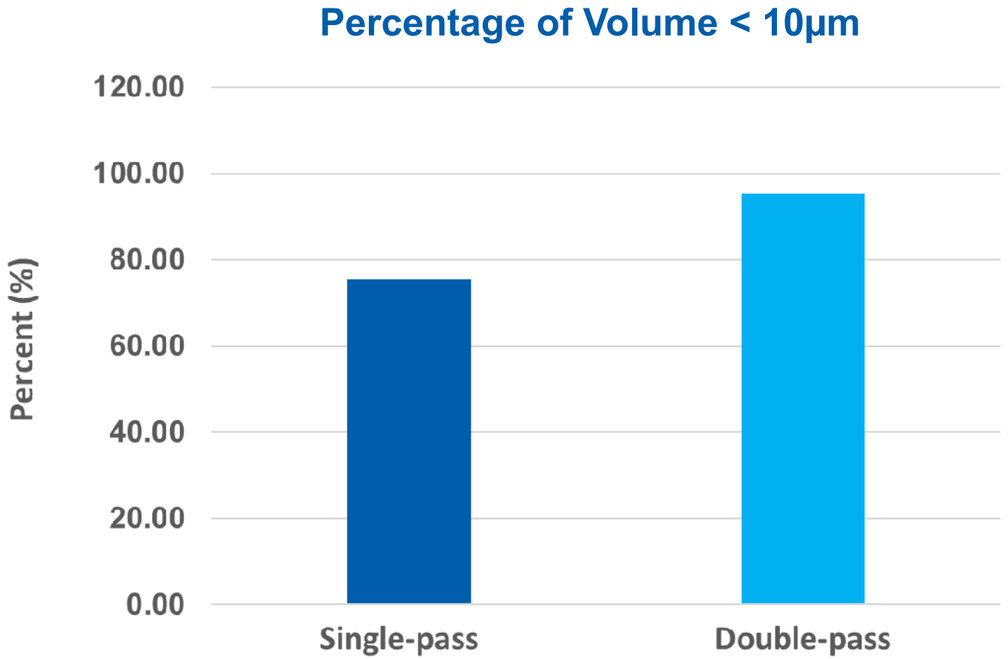
Drawbacks of an O-ring Seal:

- **Contamination:** Dead volume around the O-ring can trap contaminants
- **Chemical Resistance Limitations:** O-rings may degrade with strong acids or organic solvents
- **Difficult Maintenance & Fragility**

Spray Chambers: Selection

Profound Effect on: Transport Efficiency, Precision and Washout





Latest Design: Direct Connect (DC) Spray Chambers

Features & Benefits:

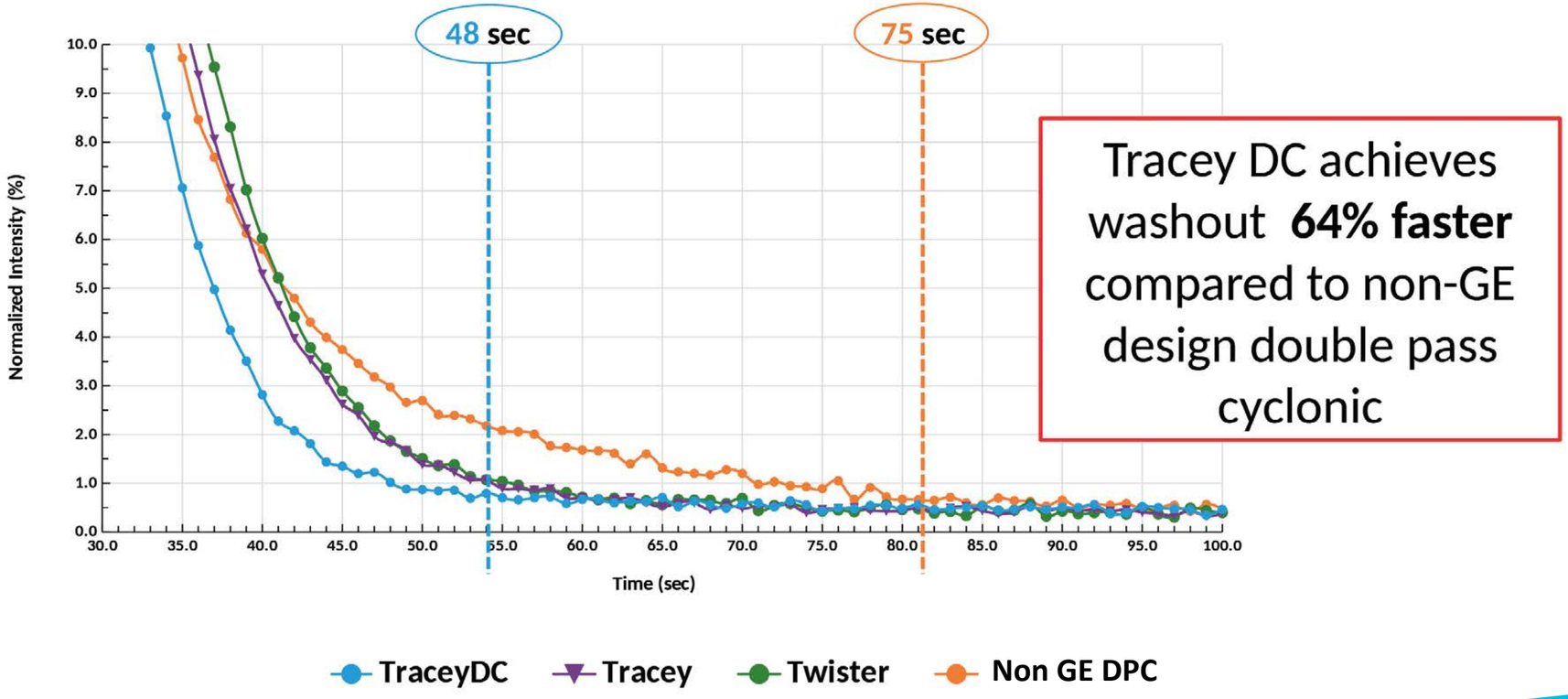
1. **Inert DC Connection:** PEEK Construction ensures durability and chemical resistance. No ball joint clamps that corrode over time
2. **Consistent Alignment:** Provides precise alignment for enhanced accuracy and efficiency
3. **Efficient Washout:** 30mL low-volume cyclonic chamber with Helix CT technology
4. **Cost-Effective:** More affordable than traditional glass spray chambers
5. **Wide Compatibility:** Fits most common ICP-OES models with E-Torch, D-Torch, and SDT/ FDT
6. **DC PEEK Spray Chamber:** HF-resistant up to 5%, with excellent wetting properties. No internal surface treatment required, unlike TFE or PFA chambers

P/N 20-809-4880

P/N 20-809-4801

Direct Connect (DC) Spray Chambers

Washout Profiles for 1 ppm Hg:



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

Torch: Selection

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:

- *Narrow bore quartz: 1.0mm or less:* volatile organics
- *Large bore quartz, 2.0mm or greater:* High TDS
- *Ceramic (alumina):* HF-containing samples

3. **D-Torch and E-Torch:**

- Removable: injector, outer tube

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

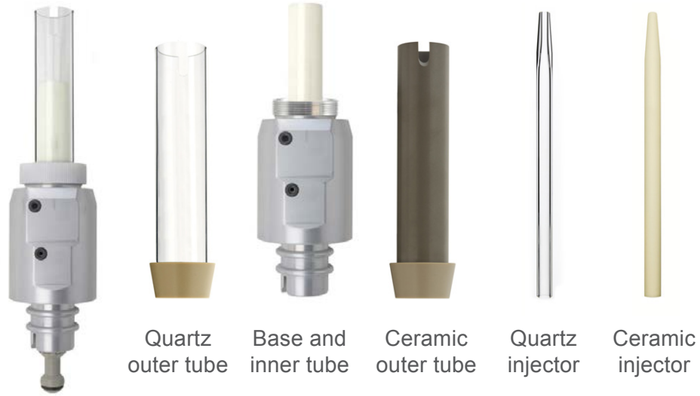
- Removable: injector, intermediate tube, outer tube

Torch: Demountable D-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
- In contrast, other demountable torch designs typically feature quartz intermediate tubes, which add to consumablel costs
- *The D-Torch is covered by US Patents*



For PerkinElmer® Avio

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

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 (~1.8mm)**
- 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

ICP-MS Cones

Cone Environment

- High temperature (6,000 – 8,000 K)
- Thermal degradation
- Chemical degradation (exacerbated by TDS, acid content, organic solvents, etc.)

Key Factors for High Quality Cones:

1. **Purity of Raw Materials:**

- Ensures performance and durability

2. **Advanced Machining:**

- CNC, laser, and electron beam welders for precise manufacturing

General Guidelines on Cone Material Selection

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:

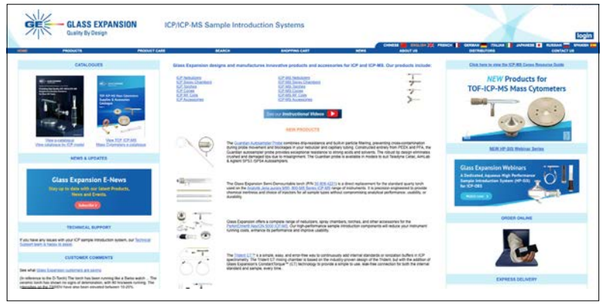
- Often the **“standard”** option
- Good thermal and chemical resistance –more than Cu but less than Pt
- Moderate heat transfer: runs ”hotter” than Cu but “colder” than Pt

Platinum:

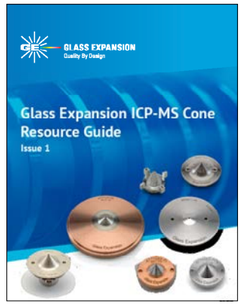
- Typically the most durable and longest-lasting option
- Excellent chemical resistance: **Suitable for aggressive acids or high-matrix samples**
- Least-efficient heat transfer– this means it “runs hotter” than both Cu and Ni
- **Can be refurbished**

Helpful ICP Resources

- Application notes
- Newsletters
- Catalogs
- Product flyers
- Website
- Product care advice
- Operating instructions
- Videos
- Webinars



Website



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Application Notes

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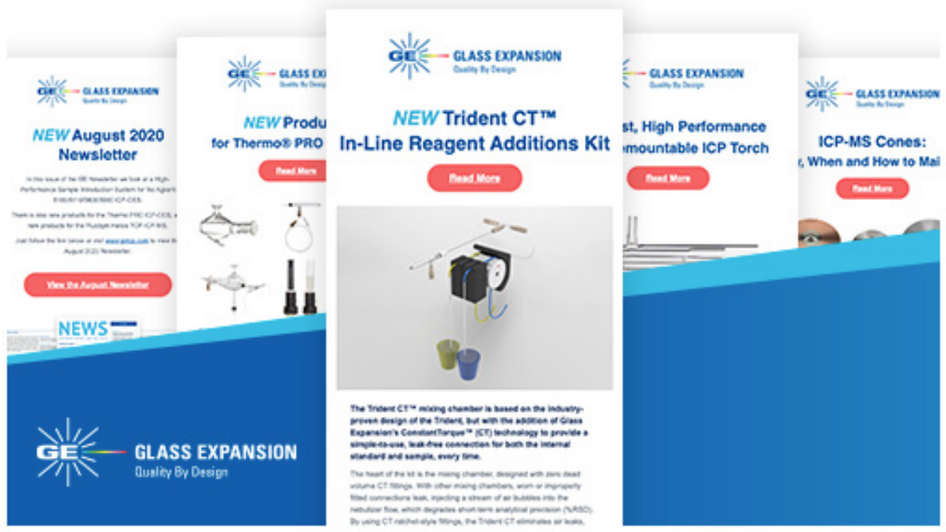

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