



A Practical Guide to ICP Sample Introduction System and Maintenance



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Introduction: About Glass Expansion

- GE have been specializing in sample introduction components for ICPs since 1983
- Global recognition for manufacturing precision and reliability
- We are dedicated to:
 - **Quality By Design**
 - **Value**
 - **Analytical Performance**
 - **Better usability**

Industry Standard Trademark Designs:

- Conikal™, SeaSpray™, Tracey™, Twister™, IsoMist XR™, Helix CT™, others

We provide our customers with full technical support:

- Diverse industry/research partnerships
- **Extensivley equipped laboratory with 6 in-house ICPs**
- Satisfaction Guarantee: Guaranteed to meet or exceed OEM specifications.



SeaSpray™ & MicroMist™
Nebulizers



Tracey™ & Twister™ Cyclonic
Spray Chambers with **Helix CT™**



D-Torch™ Demountable Super
Torch

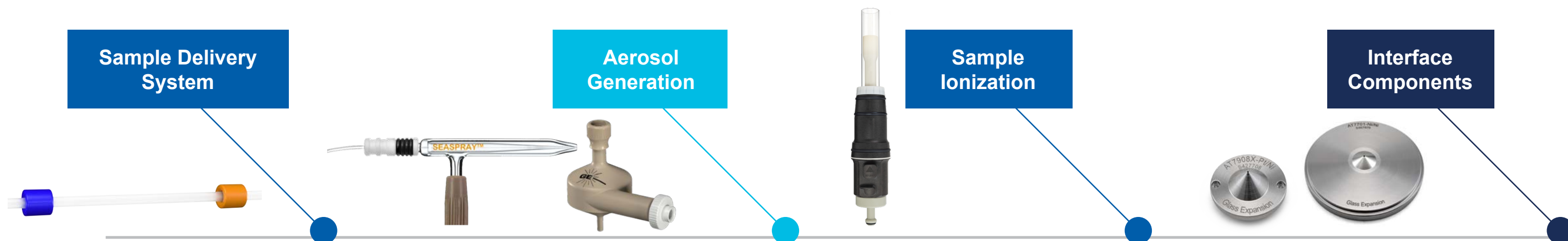
Product Lineup

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



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

Agenda



- **Sample Probe and Pump Tubing**

- Practical Selection Considerations
- Internal Standard Addition Kit
- Care and Maintenance

- **Nebulizer and Spray Chamber**

- Optimal Design Considerations
- Application Suitability
- Care and Maintenance

- **Torch and Injector**

- **RF Coil**
- Selection Considerations
- Care and Maintenance

- **Cone Material**

- Care and Maintenance

Sample Delivery System

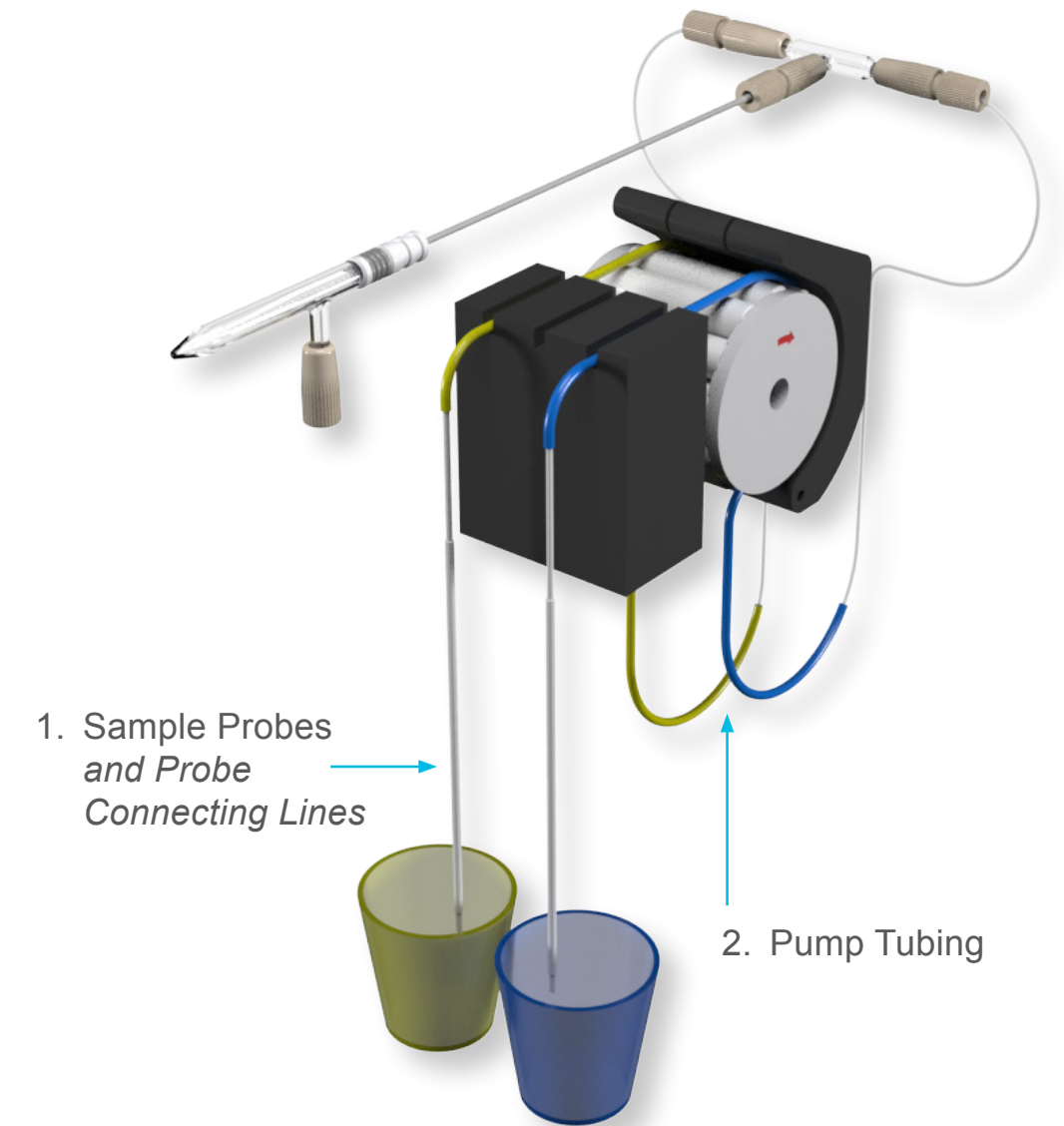
- **Sample Probe**
- **Peristaltic Pump Tubing**
- *Teflon connecting tubing*
- *Internal Standard Addition Kit*

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

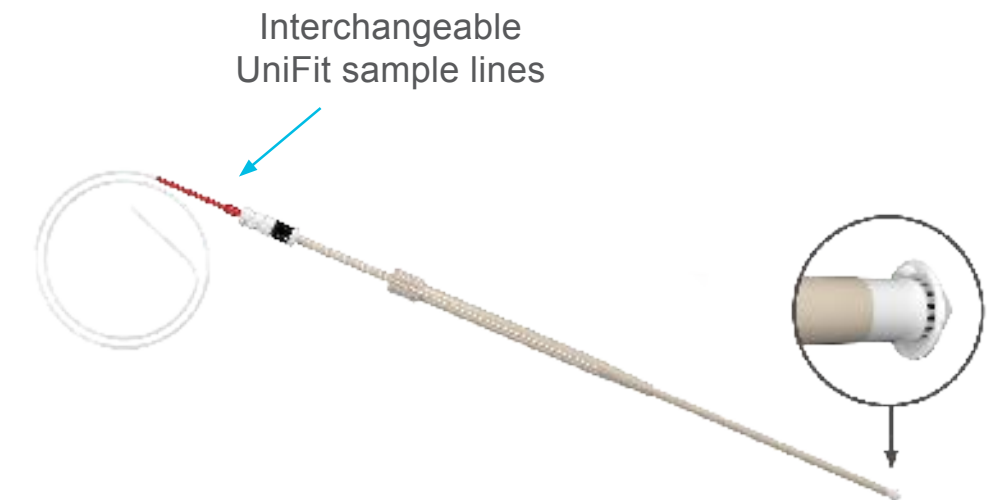
1. Standard Option: Carbon Fibre Probe

- 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

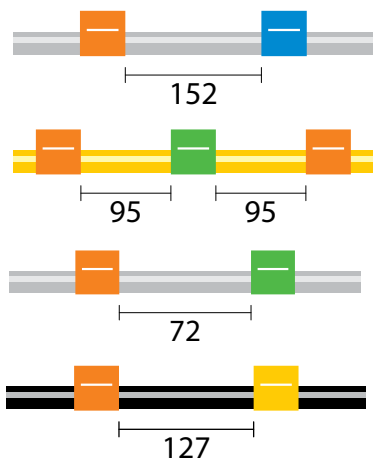


2. Advanced Option: Guardian Autosampler Probe Features:

- **Robust tip** design eliminates 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
- **Interchangeable UniFit sample lines** IDs: 0.3, 0.50, 0.75 and 1.0mm
- **Autosamplers:** Teledyne Cetac, PE S20, AimLab, and Agilent SPS3/SPS4



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

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.

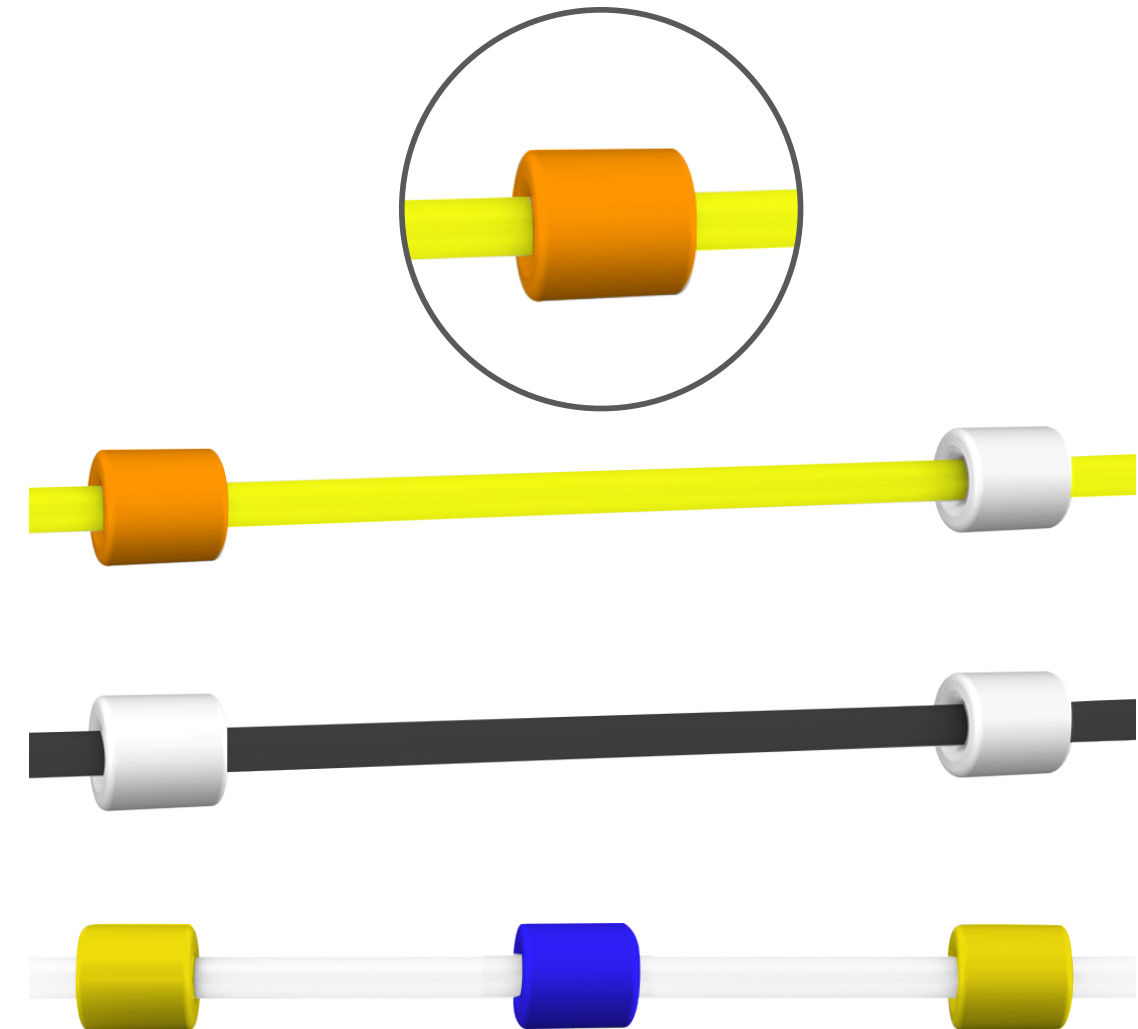


Traditional Pump Tubing

ProLok™ Peristaltic Pump Tubing

Features & Benefits:

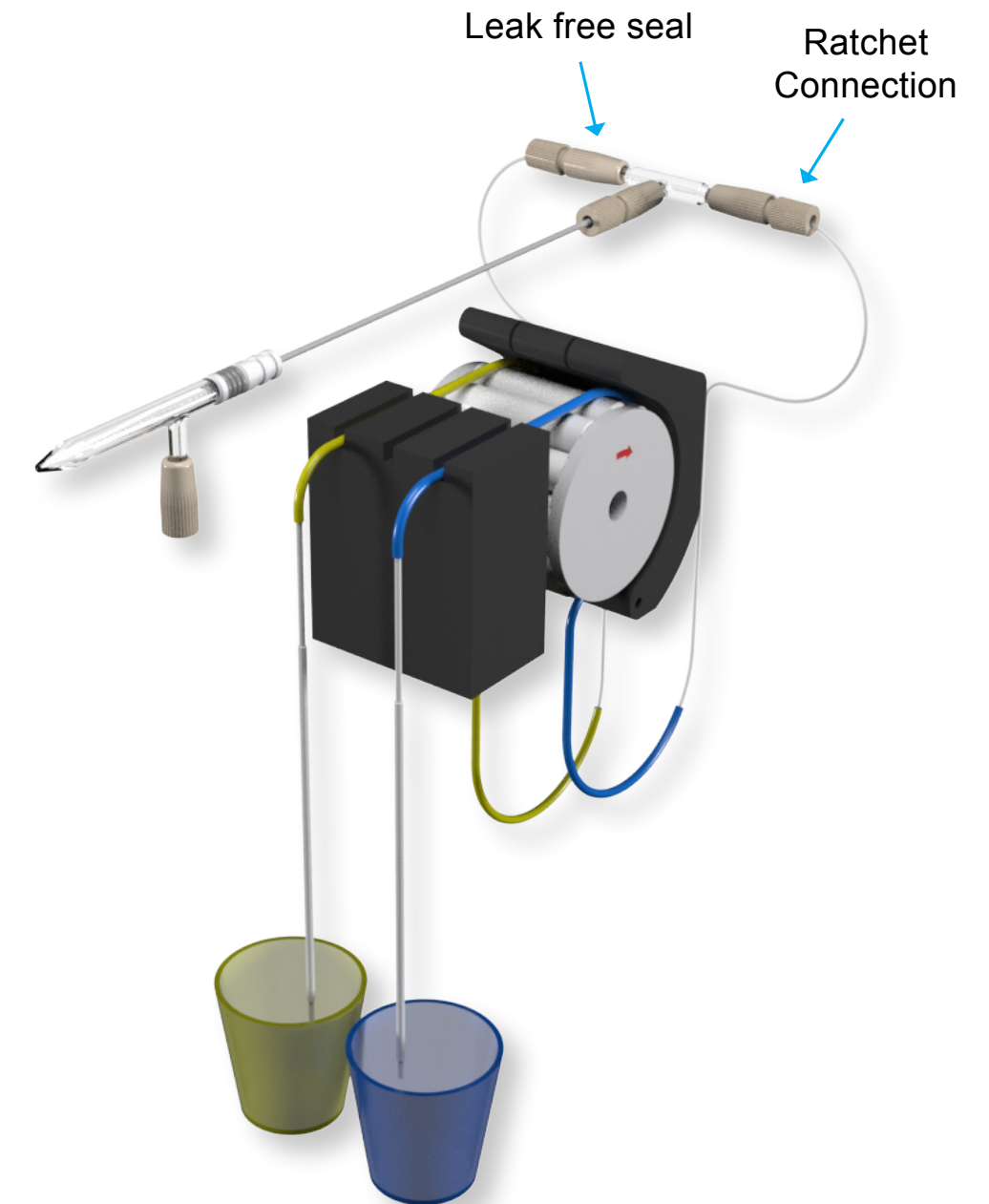
- 1. Enhanced Bonding Strength:** The color tag now features twice the surface area, ensuring a stronger and more secure attachment to the pump tubing.
- 2. Durability:** Designed to prevent premature failure, the reinforced tags eliminate issues with loose tubing connections.
- 3. Superior Material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



ProLok™ Peristaltic Pump Tubing

Trident CT™ Internal Standard Addition Kit

- Efficient mixing chamber ensures complete mixing of 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.
- [Click here for P/N 60-703-1179](#) Trident CT Internal Standard Kit inclusions and options.
- Trident CT for HF Solutions P/N [60-808-1150](#)



Trident CT P/N 60-703-1179

Sample Delivery System: Maintenance

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



Regular cleaning protocols:

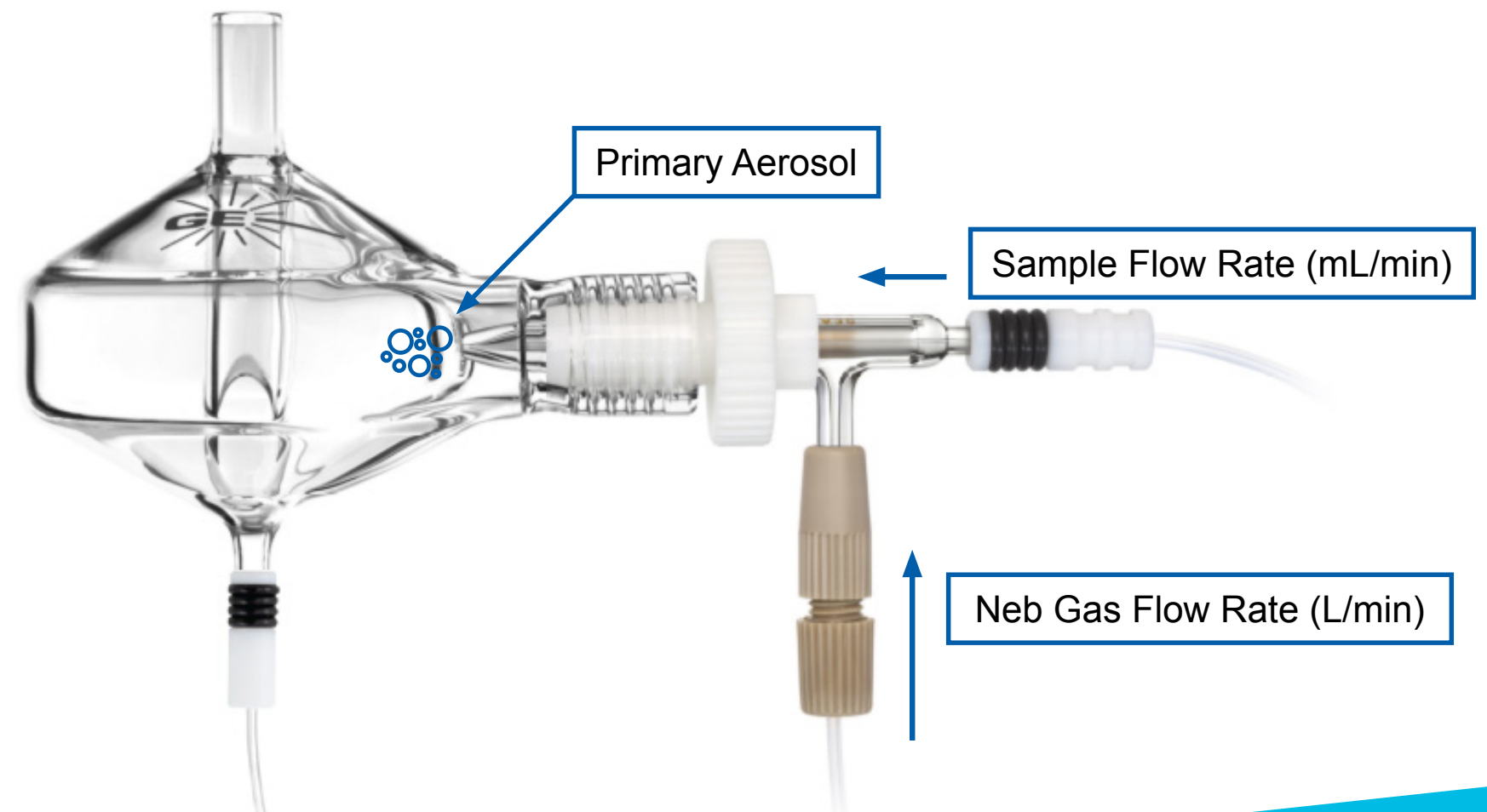
- Implement a rinsing protocol between sample types using dedicated solutions to remove residual materials
- Start and finish each run by aspirating a mildly acidic blank solution or the sample matrix, followed by DIW for 5-10 min

Check out the [Pump Speed and Sample Uptake Calculator](#).

2. Aerosol Generation: Nebulizer & Spray Chamber

- Only the smallest droplets (<10 µm) are transmitted to the plasma & 95-98% of nebulized sample is drained as waste.
- **Primary aerosol is produced by the nebulizer**
- Droplet size decreases as argon gas velocity increases and sample liquid flow rate decreases
- For optimal performance, **aim for a higher concentration of droplets with a diameter of <10 µm**

Quality of Aerosol $\propto$ Quality of Results



Concentric Nebulizers: Key Design Considerations (I)

- The most commonly used nebulizers due to their: efficiency, stability, ruggedness, natural aspiration
- Constant and reproducible nebulization efficiency is crucial for accurate analysis = nebulizers evaluated by stability

Potential Design Challenges:

- All ICP Nebulizers are not created equal
- Inconsistent taper which effects seal and depth within spray chamber

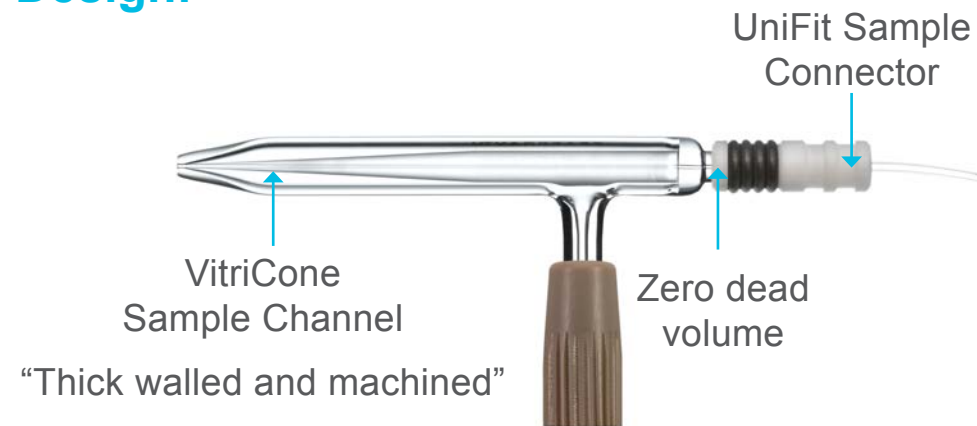


Sample channel constructed from drawn-out capillary tubing:

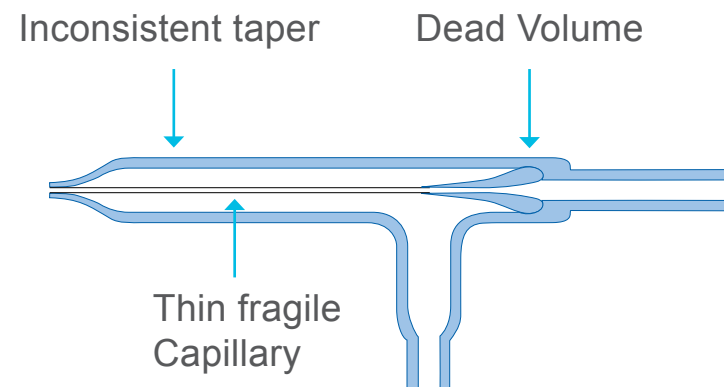
- The tube is tapered, encouraging salt deposition as the tube narrows.
- The tubing is very fragile and can vibrate under the influence of the high speed argon flow, leading to poor precision.
- It is very difficult to reproduce the same performance with different nebulizers.

Concentric Nebulizers: Key Design Considerations (II)

GE Design:



Other Nebulizer Design:



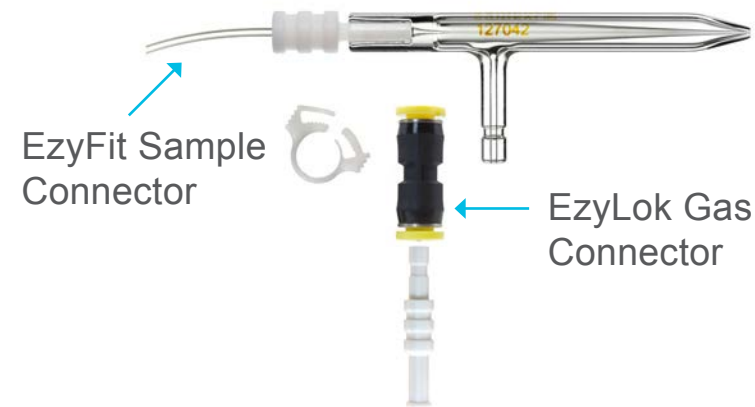
Practical Design Features of GE DC Nebulizers:

- **VitriCone™** is constructed from a heavy glass capillary which is machined to very high tolerances
- **Resists blockage:** A uniform sample channel prevents particulate trapping
- The rugged precision machined capillary **resists vibration**
- **The industry's tightest tolerances** ensure that each nebulizer will perform to the same high standards as the previous one

Design Considerations: Nebulizer Sample and Gas Connector

Optimal connection solutions support achieving accurate and reproducible results:

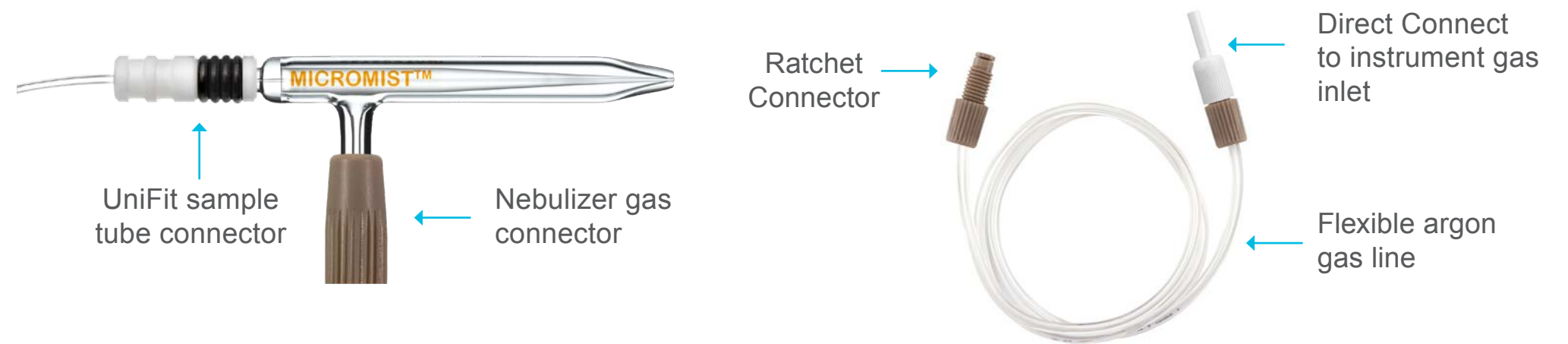
GE Old Design:



UniFit sample line connector:

- UniFit connector slides easily over the sample arm and creates an excellent seal
- Minimizes Dead Volume: Faster washout compared to EzyFit

Current GE DC Nebulizer Developments



Inert metal-free argon connector:

- To prevent contamination and false positives (vs. EzyLok)

Instrument-specific Direct Connect flexible argon line:

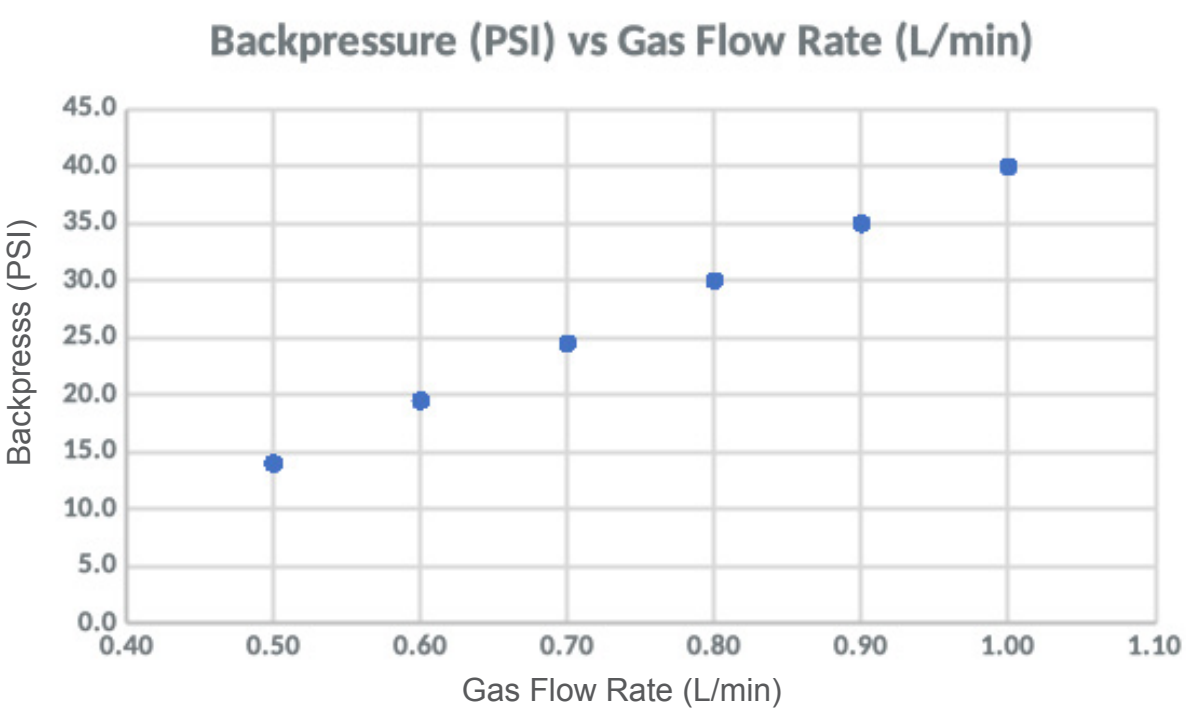
- Unlike hard tubing, which can restrict gas flow, the DC design ensures efficient, consistent gas flow
- **Reliable ratchet fitting:** Ensures leak-free gas connection

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

* Varies with nebulizer uptake



Important Nebulizer Operating Parameters

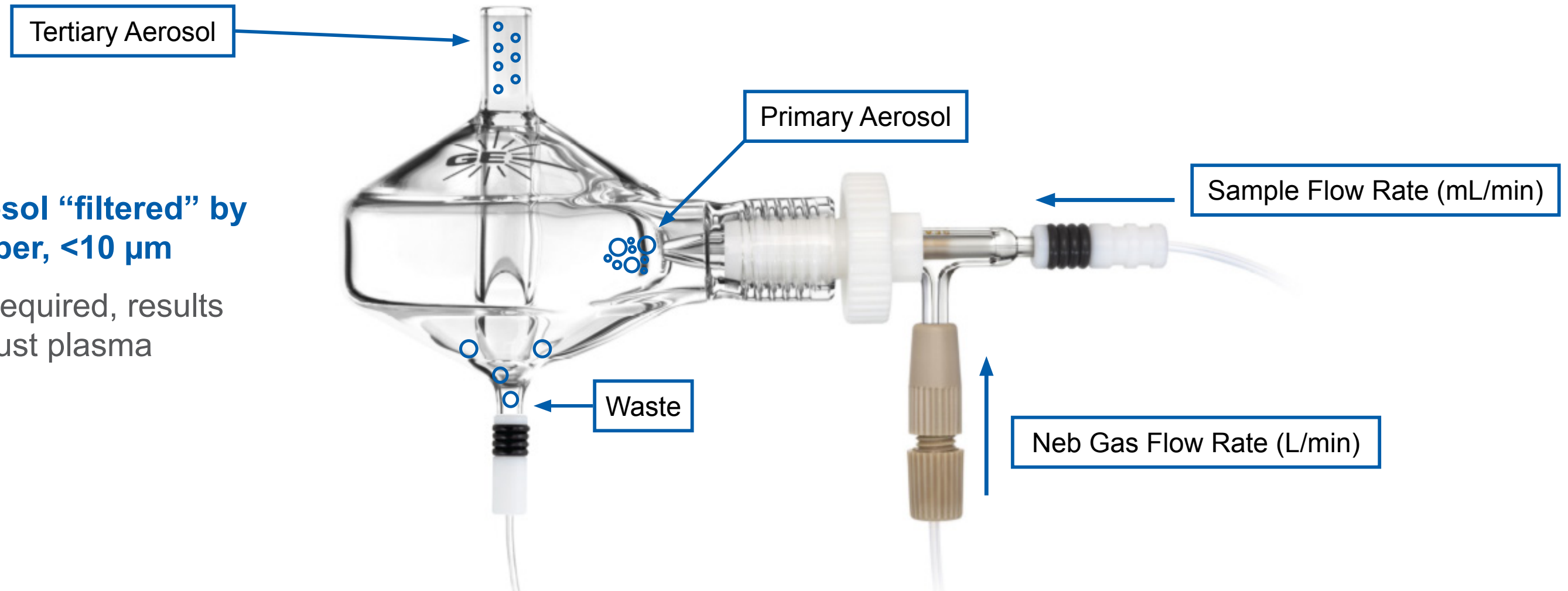
Example: GE P/N A13-1-UM04

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

Precision & Sensitivity: Design Considerations

Quality of Aerosol $\propto$ Quality of Results

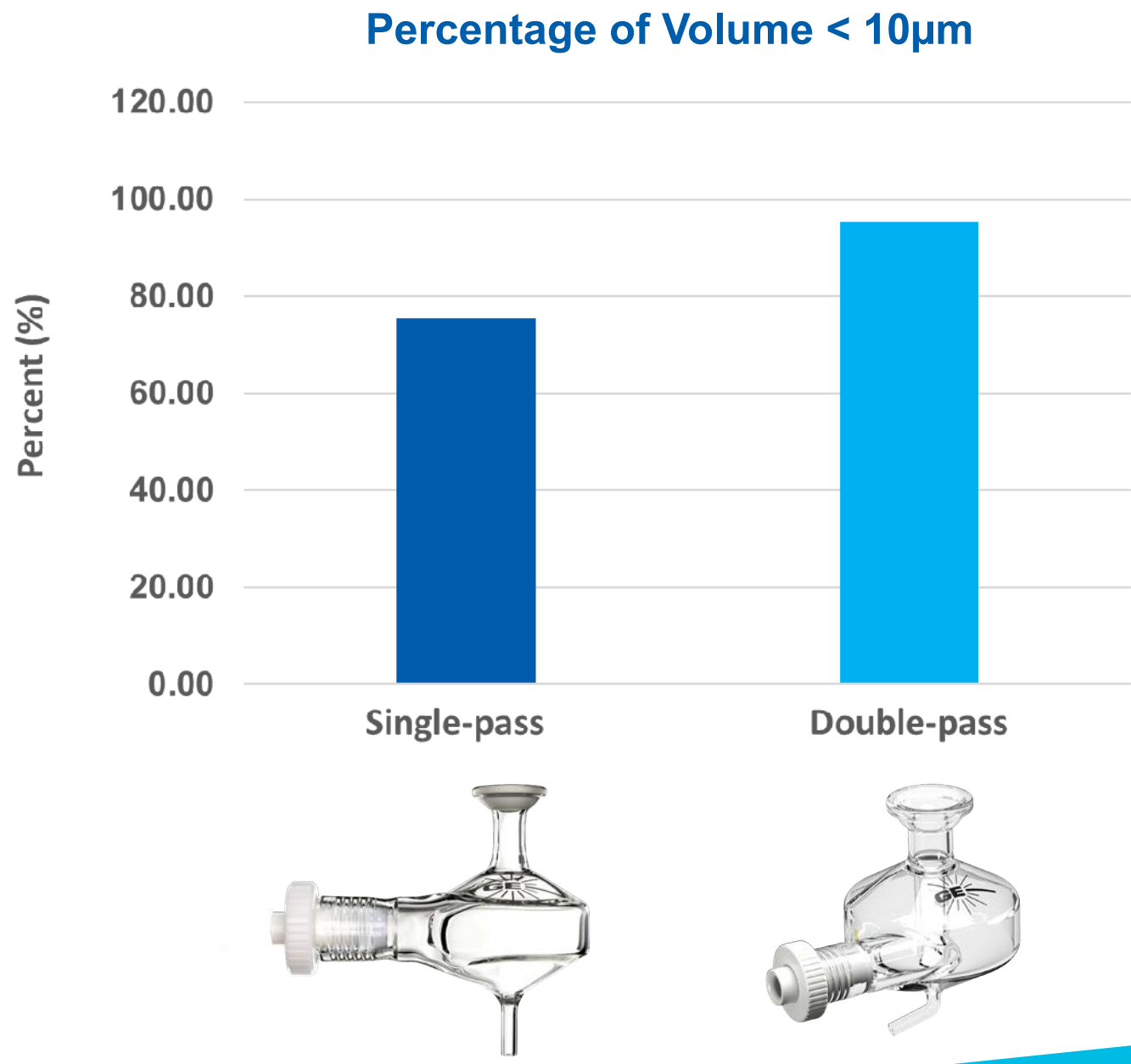
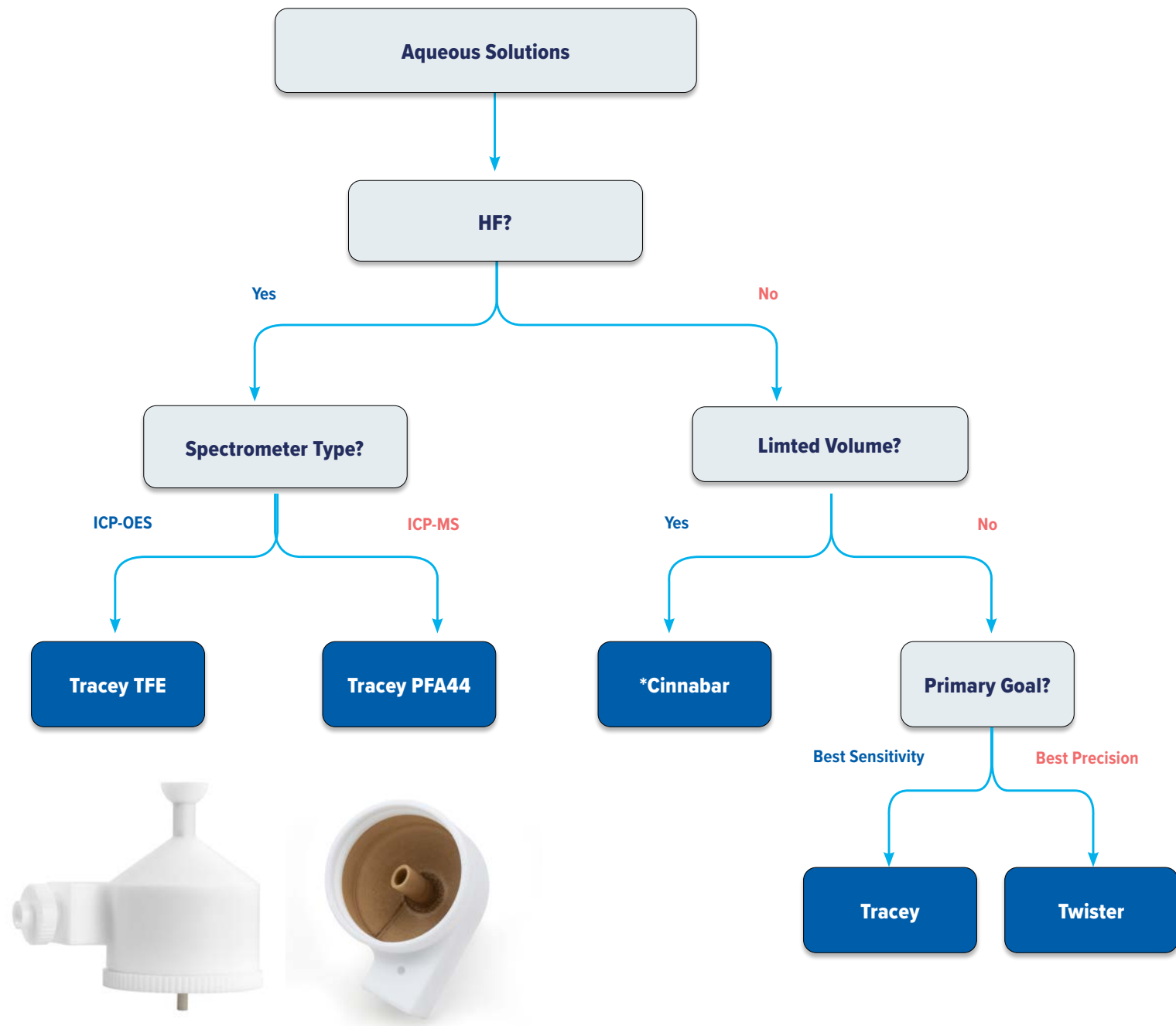
- **Tertiary Aerosol “filtered” by Spray Chamber, $<10\ \mu\text{m}$**
- Less energy required, results in a more robust plasma condition



Smaller Droplets Require Less Energy = Efficient Ionization

Spray Chambers: Selection

Profound Effect on: Transport Efficiency, Precision and Washout

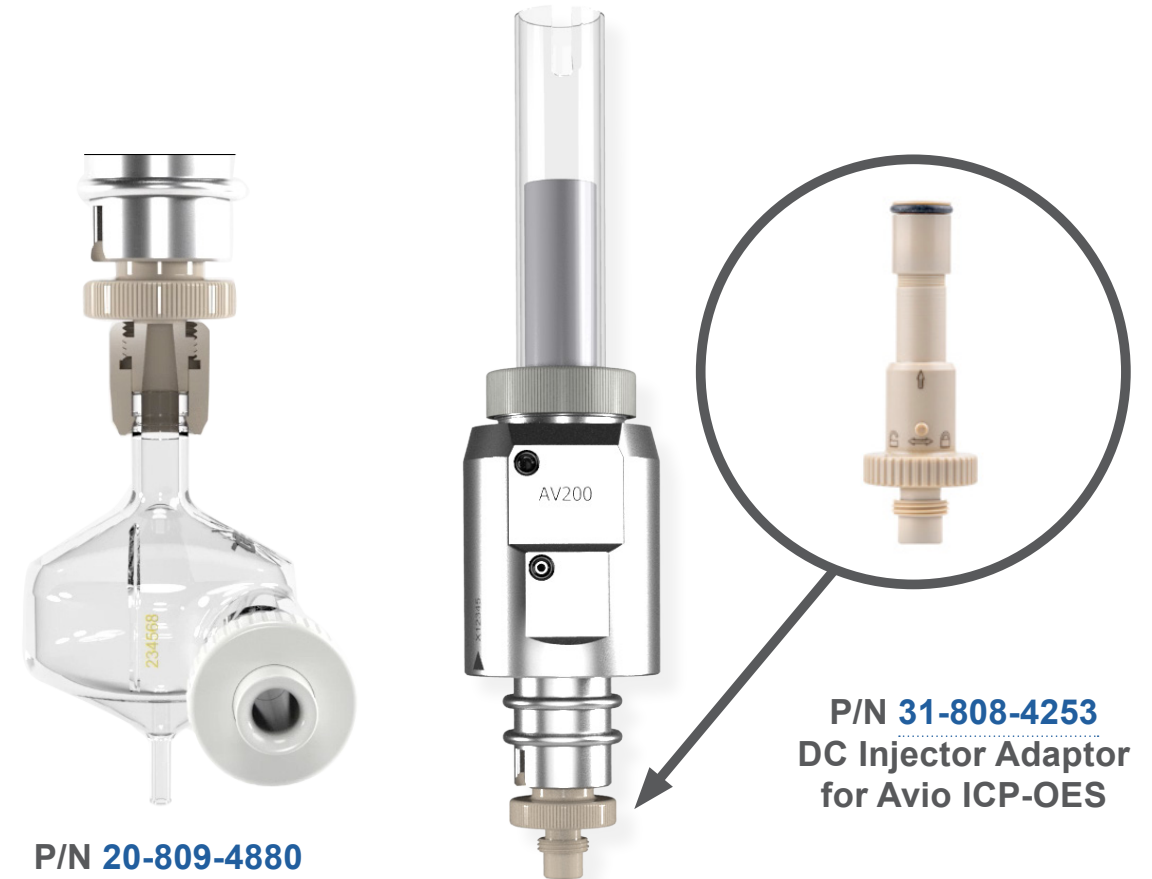


Latest Design: Direct Connect (DC) Spray Chambers

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.

[DC Spray Chamber Video](#)



DC PEEK Spray Chamber

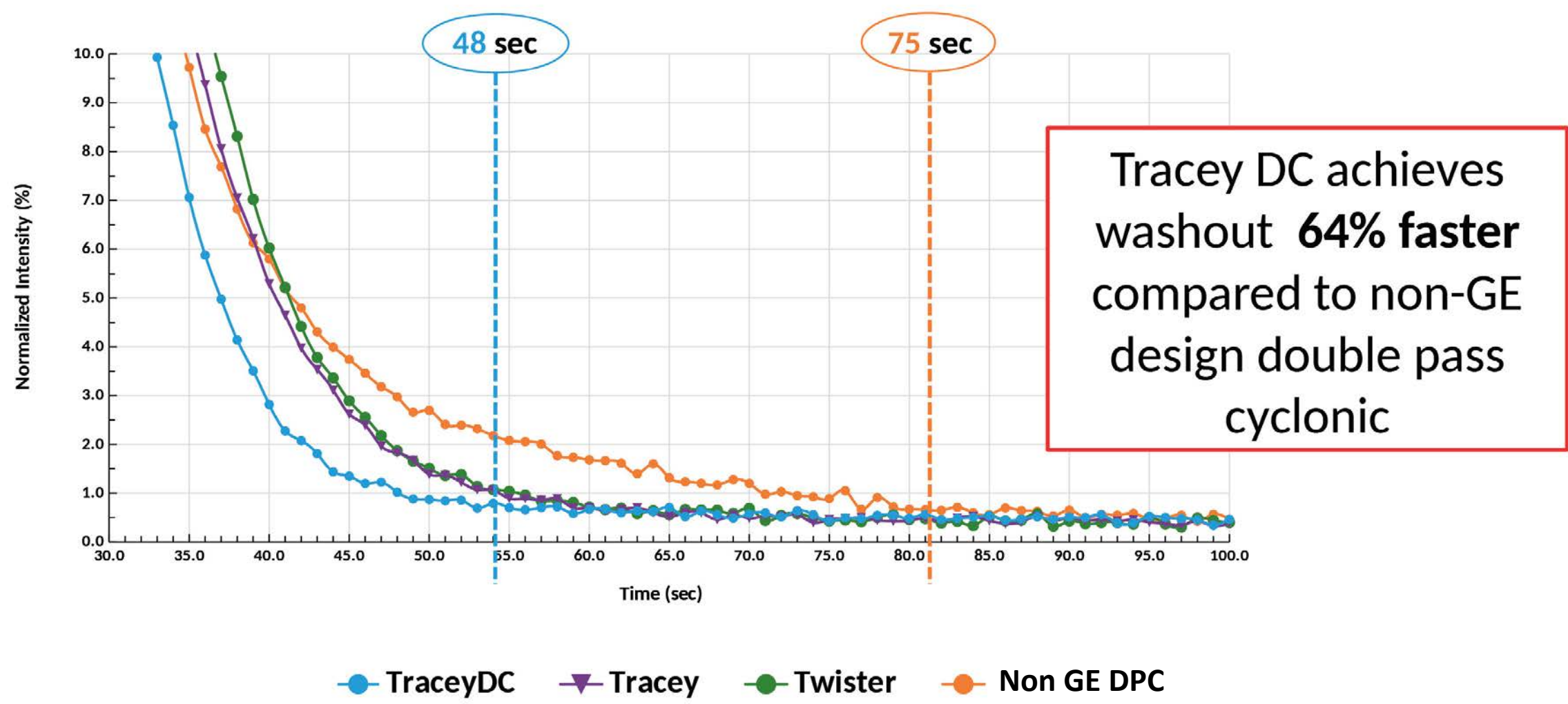
Benefits of Tracey DC PEEK Spray Chamber:

- HF resistance up to 5%
- **Excellent wetting characteristics** of PEEK ensure the wetting properties are retained with general maintenance.
- Spray chamber **doesn't require internal surface treatment** compared to TFE or PFA spray chambers.
- Lower cost structure vs other HF spray chambers.
- No metal clamp required



Direct Connect (DC) Spray Chambers

Washout Profiles for 1 ppm Hg:



Design Considerations: Spray Chamber Interface

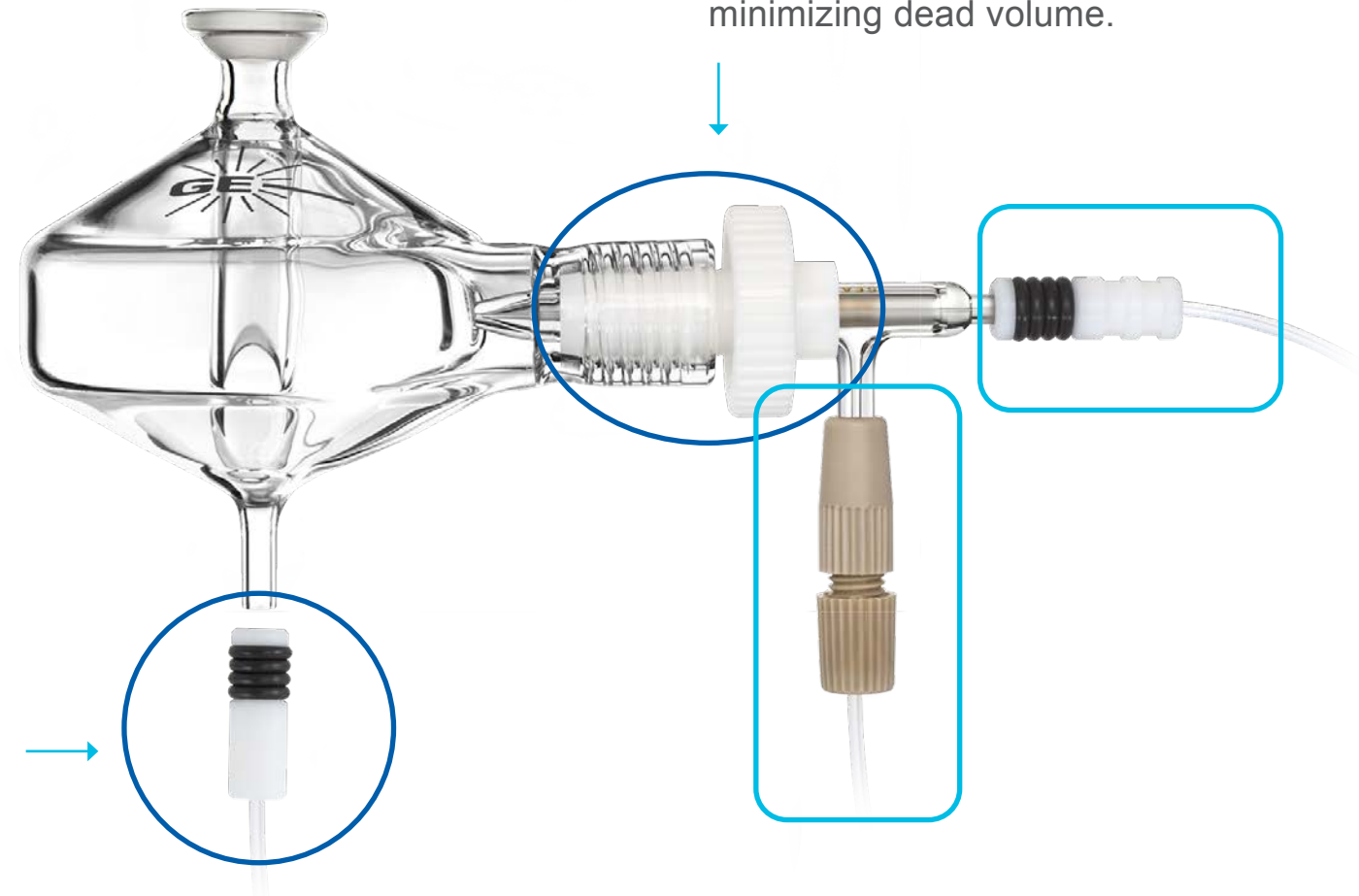
Drawbacks of an O-ring Seal:

- **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:** Replacing O-rings often requires tools and can be challenging.
- **Fragility:** Bonding of the O-ring to the nebulizer.



Latest Developments:

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

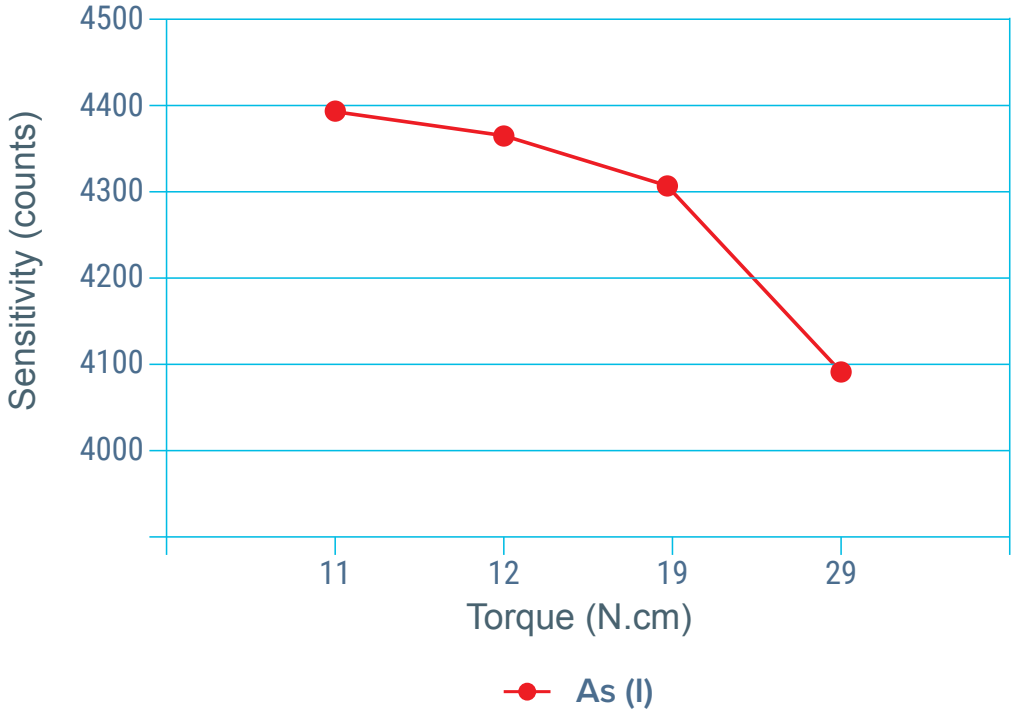


UniFit connector helps prevent the pulsating effect often associated with ineffective draining caused by push-fit connectors found in other spray chamber designs.

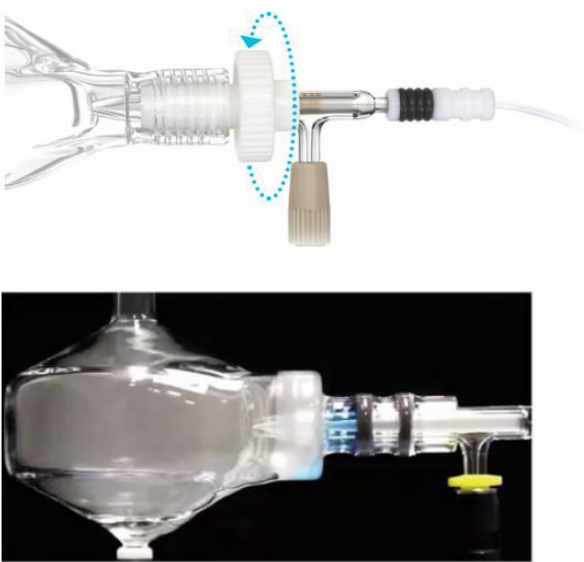
Spray Chambers: Helix CT Interface

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

Optimum Sensitivity

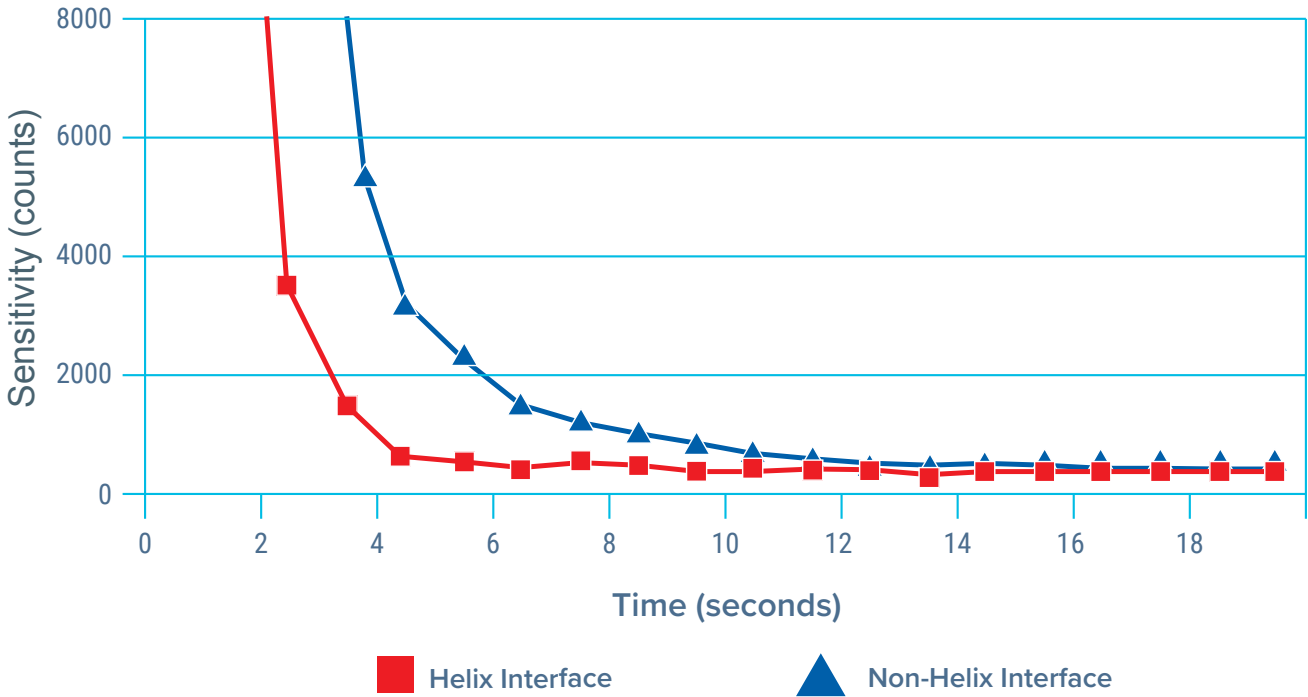


Built-in torque control mechanism



Non-Helix Interface

Improved Washout



[*Download the Helix CT ICP Spray Chamber Application Note*](#)

Nebulizer: Troubleshooting

Suggestions:



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 Ar nebulizer gas connection at the instrument and at the nebulizer gas arm
- Nebulizer gas supply tubing can harden over time, losing their flexible, gas-tight seal
- Argon loss: Even a 1% loss can lead to significant changes in ICP analytical results



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

- Clean nebulizer or replace if necessary

Record your normal sample uptake rate

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

Nebulizer: Cleaning Procedure

Good Practice: To maintain your nebulizer, start and finish each run by nebulizing a mildly acidic blank solution, followed by DIW for 5-10 min.

Practices to avoid:

- Avoid inserting wires into the nebulizer orifice.
- Never touch the nebulizer tip.
- Avoid cleaning glass or quartz nebulizers with HF.
- Do not use ultrasonic baths for glass nebulizers.

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% HNO_3 .*
5. Flush 3x with water using the Eluo.
6. *For faster drying, flush with methanol.*



ICP Nebulizer Maintenance Made Easy Video



Spray Chambers: Maintenance

Suggestions for Glass Spray Chambers:

- **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.

Care and Maintenance of Inert Spray Chambers



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



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

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:

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 consumable costs

**The D-Torch is covered by US Patents*



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 (~1.8 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

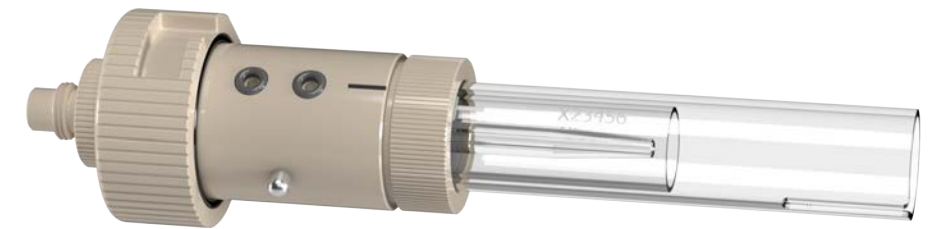


Ceramic outer tube

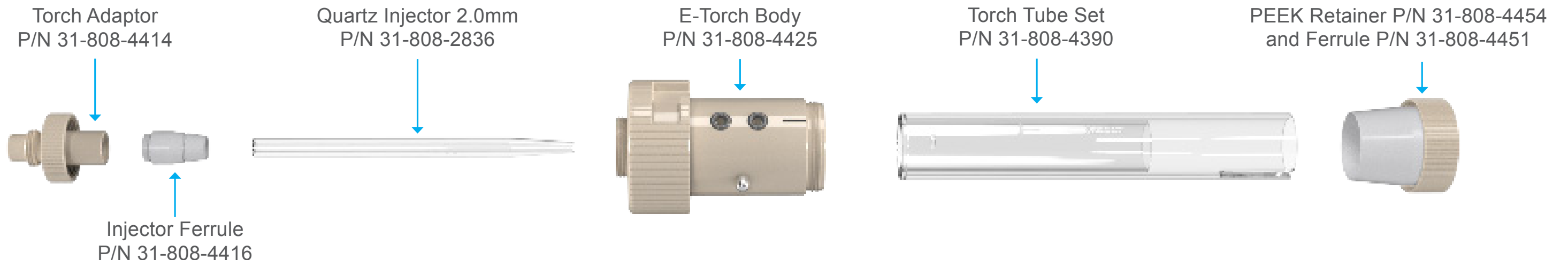
Latest Design: E-Torch

Benefits

- Made from PEEK, PTFE & Quartz
- Shipped with P/N [31-808-2836](#), Capillary Quartz Injector 2.0mm (EMT)
- Interchangeable injectors, (Quartz, Ceramic, Sapphire)
- Compatible with Tracey™ DC spray chamber which eliminates ball joint clamps
- Performance equivalent to the D-Torch
- Ceramic tube set available on request for HF and high TDS applications.
- Low cost Inner and Outer tube assembly which simplifies deposit removal maintenance and allows for oven cleaning of Carbon deposits.
- Compatible with the Jet Vortex Interface (JVI)



P/N 30-808-4388
E-Torch for Thermo® PRO



D-Torch: Maintenance

Suggestions:

Always wear safety gloves

Carbon Deposits Removal:

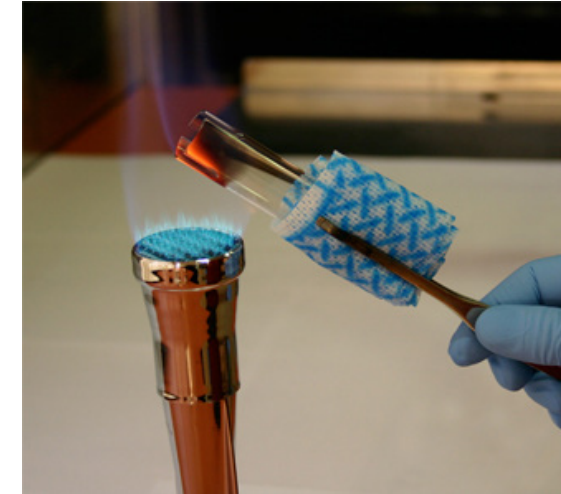
- Use a portable hand-held propane torch to burn off deposits.
- Avoid heating the outer tube in a muffle furnace (due to the polymer ferrule).

Salt Deposits Cleaning:

- Soak in a 25% Fluka RBS-25 solution or dilute acid.
- Stand the tube upright in a beaker, covering the deposits with cleaning solution.

Metallic Films Removal:

- Soak in acid, preferably the same one used for sample preparation.
- Ensure the acid covers the metallic deposits while the tube stands upright.



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

The Role of the RF Coil

RF Coil Condition: Alignment, plating, and cleanliness improve energy transfer.

Key Factors for Energy Transfer:

1. Alignment

- Ensures a well-shaped and consistently positioned plasma.

2. Correct Dimensions

- Essential for circuit tuning and stability.
- Minor deviations can alter resistance and inductance.

3. Base Metal & Plating

- **Copper:** Cost-effective but oxidizes quickly.
- **Silver:** Best conductivity but tarnishes.
- **Gold:** Best corrosion resistance, slightly less conductive.

Corrosion Resistance



Benefits of Maintaining your RF Coil:

Key Challenge: Corrosion

- Caused by heat or chemical oxidation.
- Reduces energy transfer efficiency, increasing stress on RF components.

Steps for Prolonging Coil Life:

- **Periodic Cleaning:** Removes tarnish and buildup.
- **Avoid Acid-Based Polishes:** Use abrasive metal polish to clean without damage.
- **Replace When Needed:** Replace coils with copper migration or significant tarnish.

Advantages of GE RF Coils:

- High-quality, consistent plating for longer life.
- Supplied on a plastic former for correct dimensions and easier installation.
- Proper alignment minimizes devitrification of the outer tube.



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**



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.
- Glass Expansion Warranty
- Refurbishment program for Pt Cones



Copper Cones

When to Clean Cones

Suggestions:

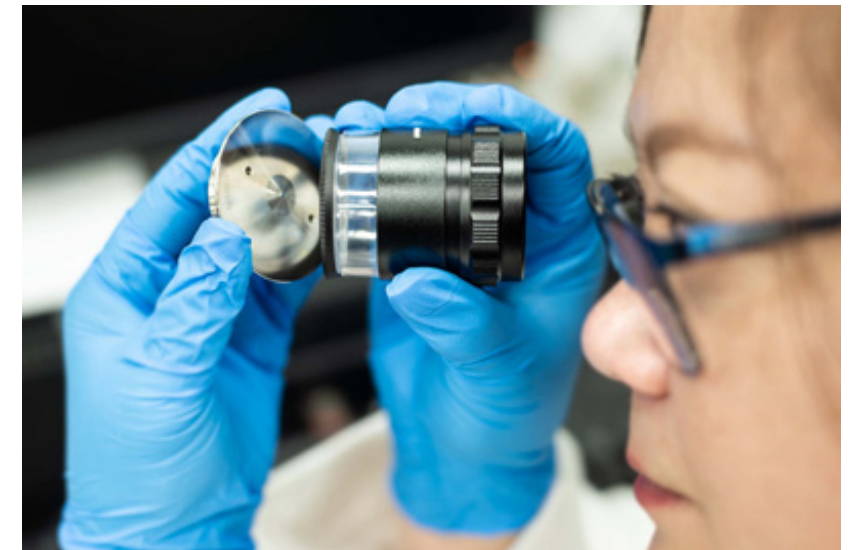
- Physical observation of cone condition using **Magnifier Inspection Tool** (P/N [70-803-1923](#)) or indicated by the data and results
- Sampler cone is more exposed to the plasma: more frequent cleaning
- *Always end the day by aspirating an acidified rinse solutions followed by UPW*

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](#)

How to Clean Cones

Suggestions:

3 recommended methods, from gentlest to most aggressive:

- Method A (**Soak in Citranox**);
- Method B (**Sonicate in Citranox**);
- Method C (**Sonicate in Nitric Acid**)

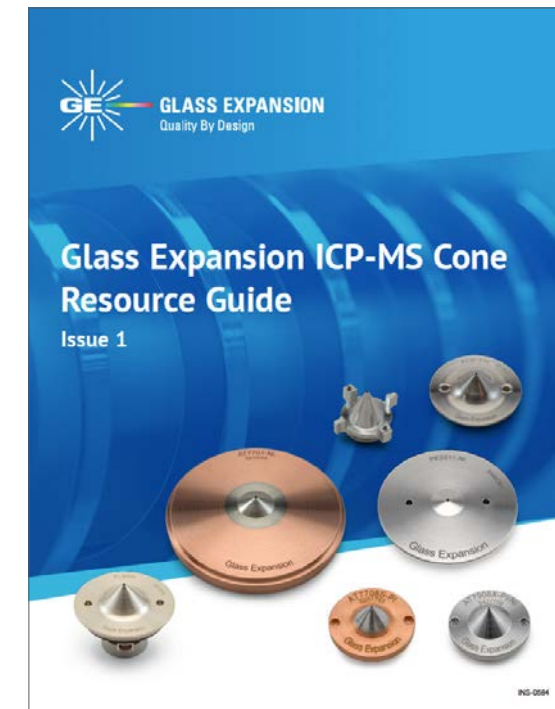
Order of severity (Don't use aggressive cleaners if it isn't needed):

1. **Fluka RB-25**
2. Citranox
3. HNO_3

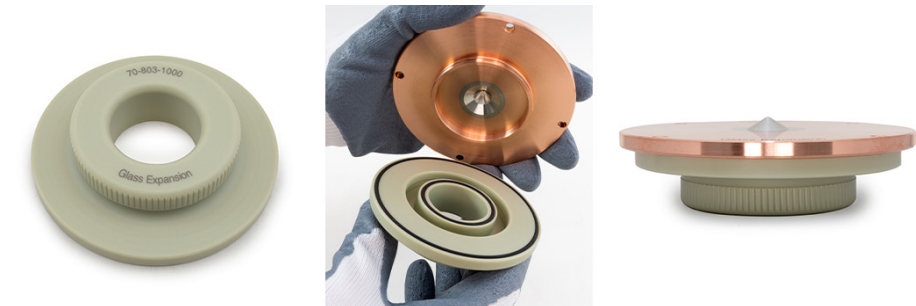
Use of a ConeGuard is highly recommended:

Damage to the threads, whether by corrosion or distortion, can lead to premature failure of the cone or worse - damage to the interface housing

Tips on Care & Maintenance



[“Click here”](#)
to view the Cone
Resource Guide

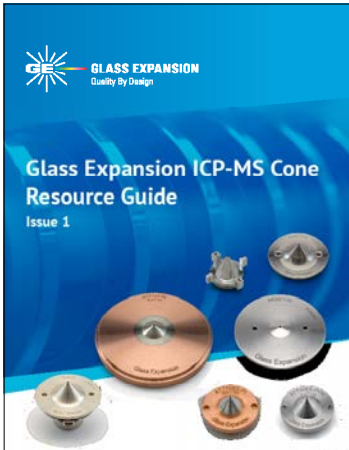


ConeGuard with Agilent® Sampler Cone:
Protects the threads during the cleaning process

Helpful ICP Resources

www.geicp.com

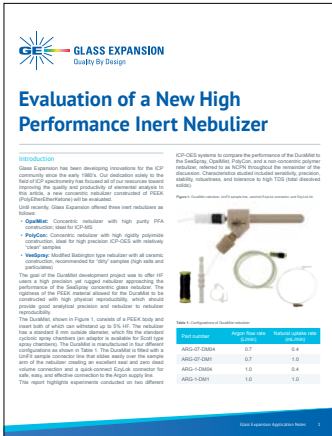
Application dedicated SIS solutions: Suggestions for Common Issues



Catalogs



Instructions



Application Notes

Agilent®: 5100, 5110, 5800, 5900

[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](#)
- [Soil and sediment with HF](#)
- [Soil and sediment without HF](#)
- [Waste water and sludge](#)
- [Wear Metals in oil](#)

Example: <https://www.geicp.com/cgi-bin/site/wrapper.pl?c1=Productsbyinstrument&inst=5100-5110-5800-5900&appno=4>

Click on: [View Recommended Products for your Application](#)



A13-07-USS2



20-808-8882HE



30-808-3560



30-808-3590



31-808-3576



70-900-5100G



0.76-BLK-F



1.14-RED-F



70-803-1108

Thank You



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