



GLASS EXPANSION

Quality By Design

ICP Sample Introduction System: Diagnostics and Care



Presenter:

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www.geicp.com

About Glass Expansion

Expertise:

- Over 40 years focused on ICP sample introduction
- Design focus: **Quality, Value, Analytical Performance, Usability**

Engineering & Innovation:

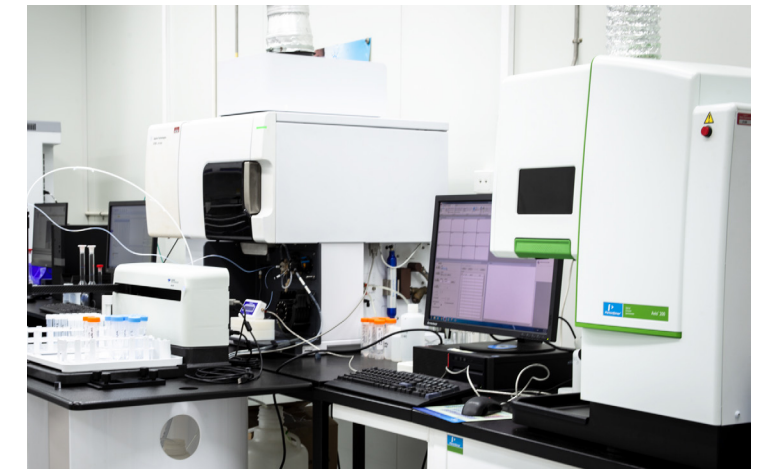
- ~10% annual investment in R&D
- **Advanced manufacturing:** CNC machining, electron beam welding, laser technology, particle analyzer, 3D printing

Quality & Testing:

- **Full control of manufacturing process** from raw material to finished product
- **6 in-house ICP instruments** for testing and quality assurance

GE Warranty: Components design to **meet or exceed OEM specifications**

Global Support: Offices in Australia, USA, and Germany



**GE fully equipped ICP laboratory
for QC and R&D**

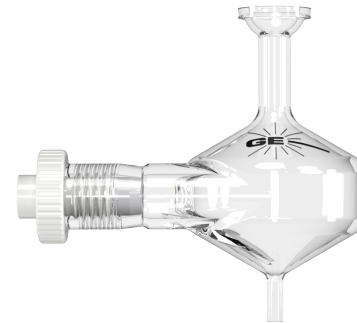


Glass Expansion Germany

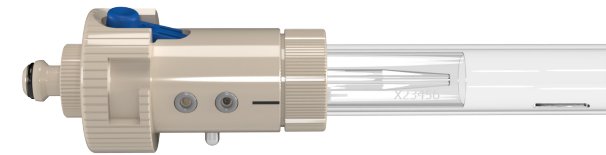
Product Lineup



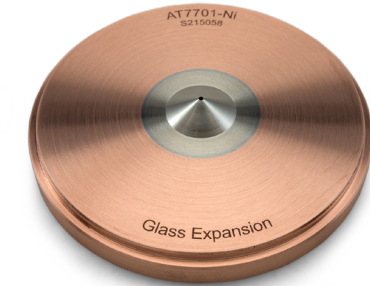
Nebulizers



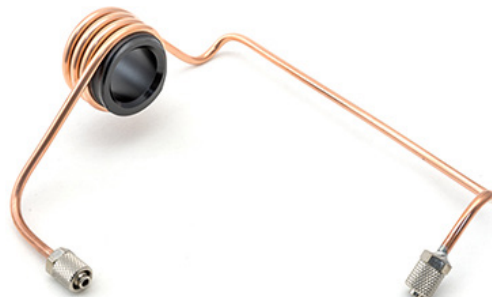
Spray Chambers



Torches



ICP-MS Cones



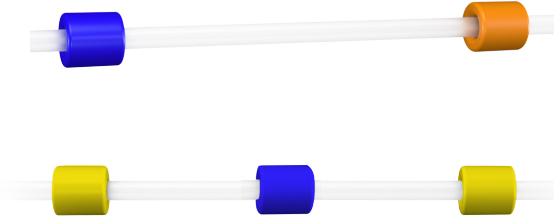
RF Coils



Accessories



Laser Ablation Adaptors



Peristaltic Pump Tubing

All Products Manufactured to Exacting Specifications

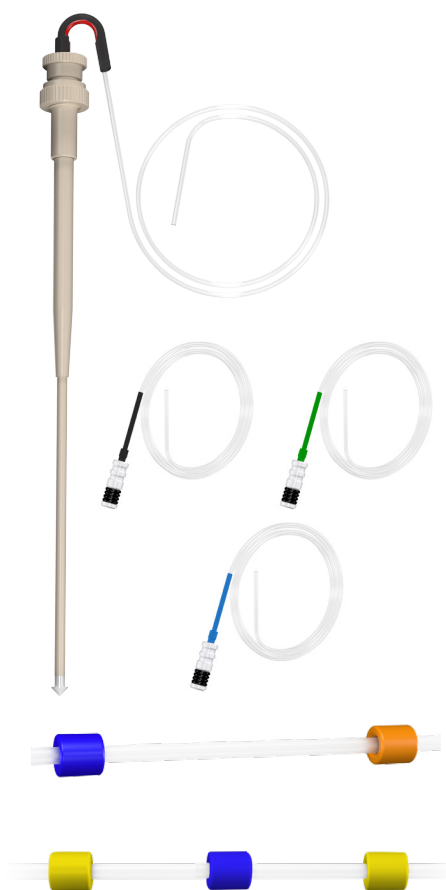
Trademarks: SeaSpray™ , MicroMist™ , IsoMist™ , E-Torch™ , D-Torch™ , Elegra™ , Twister™ , and many others

Manufacturers Supported: Thermo® | Agilent® | PerkinElmer® | Shimadzu® | Spectro® | Analytik Jena® | Others

Sample Introduction: Critical Source of ICP Variability

Sample Delivery

Sample Probe & Tubing



Challenges:

Clogging
Tubing misfit/wear
Pump instability
Air bubbles

Impact:

Variations in flow lead to:

Signal drift/ High RSDs
Inconsistent sample transport
Reduced reproducibility

Aerosol Generation

Nebulizer & Spray Chamber



Challenges:

Blockages
Large/Dense Droplets
Sample Matrix Deposits
Dead volume

Impact:

Inefficient aerosol formation:

Reduces sensitivity and DLs
Results in unstable signals

Plasma Interface

Torch; Injector; RF Coil & Cones



Challenges:

Devitrification
Blockages
Cone deposits
RF coil degradation

Impact:

Signal loss
Reduced stability
Poor accuracy

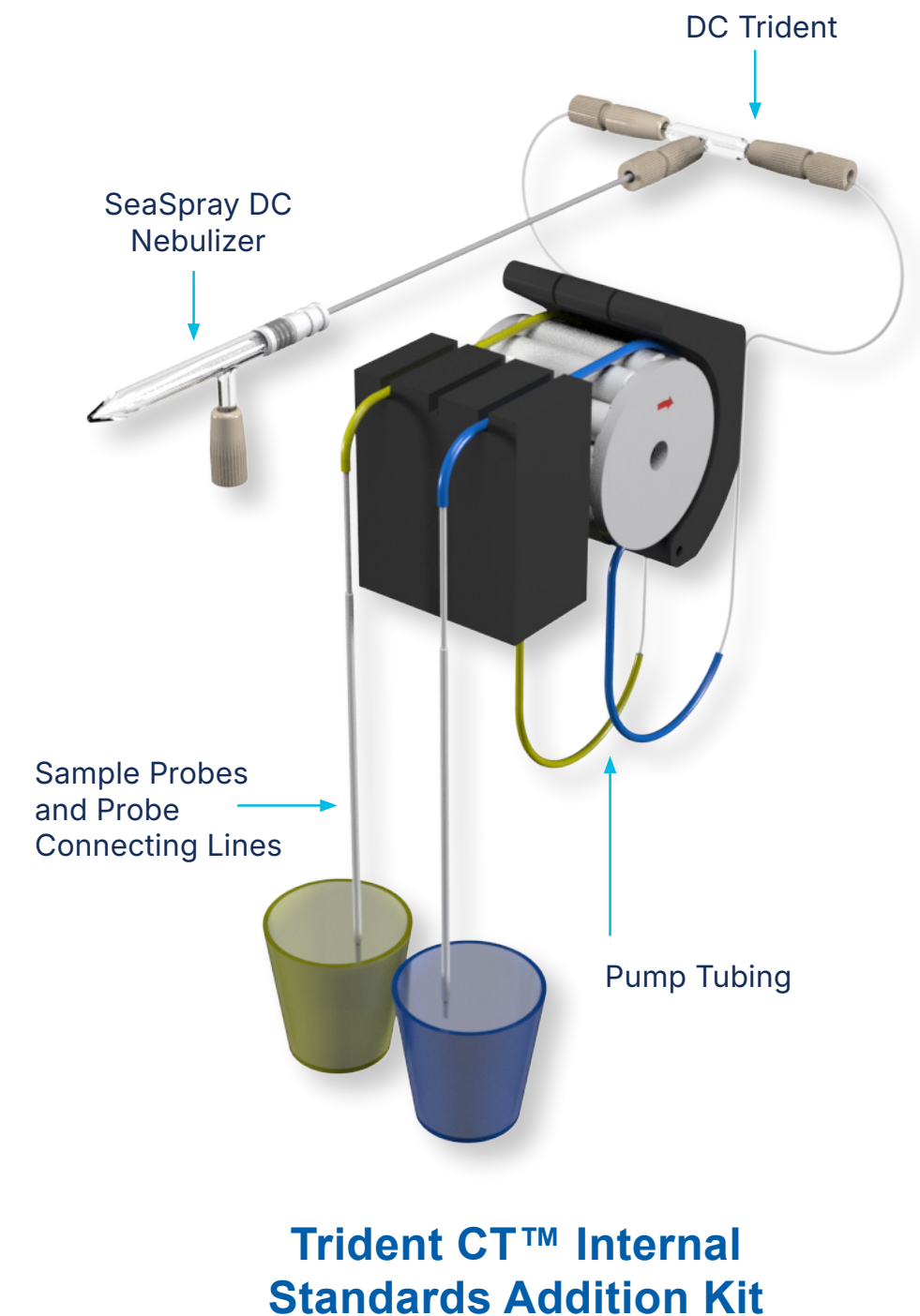
- Since only a small fraction of the sample reaches the plasma, the efficiency of each stage strongly influences analytical performance.

1. Sample Delivery System

The sample delivery system transports liquid samples from the sample tubes to the nebulizer at a controlled and stable flow rate.

Requirements for Optimal Sample Delivery

- Ensure optimal, stable and consistent sample uptake rate
- Unobstructed flow from sample container to nebulizer
- Proper mixing when internal standards are added
- Minimal carryover or contamination between samples



Sample Delivery: Component Considerations

1. Sample Probe:

- Ensure optimal Internal Diameter (ID) Selection:
 - 1.0 mm ID: for high-TDS samples or fast valve systems
 - 0.75 mm ID: standard applications
 - 0.3 and 0.5 mm ID: limited sample volumes

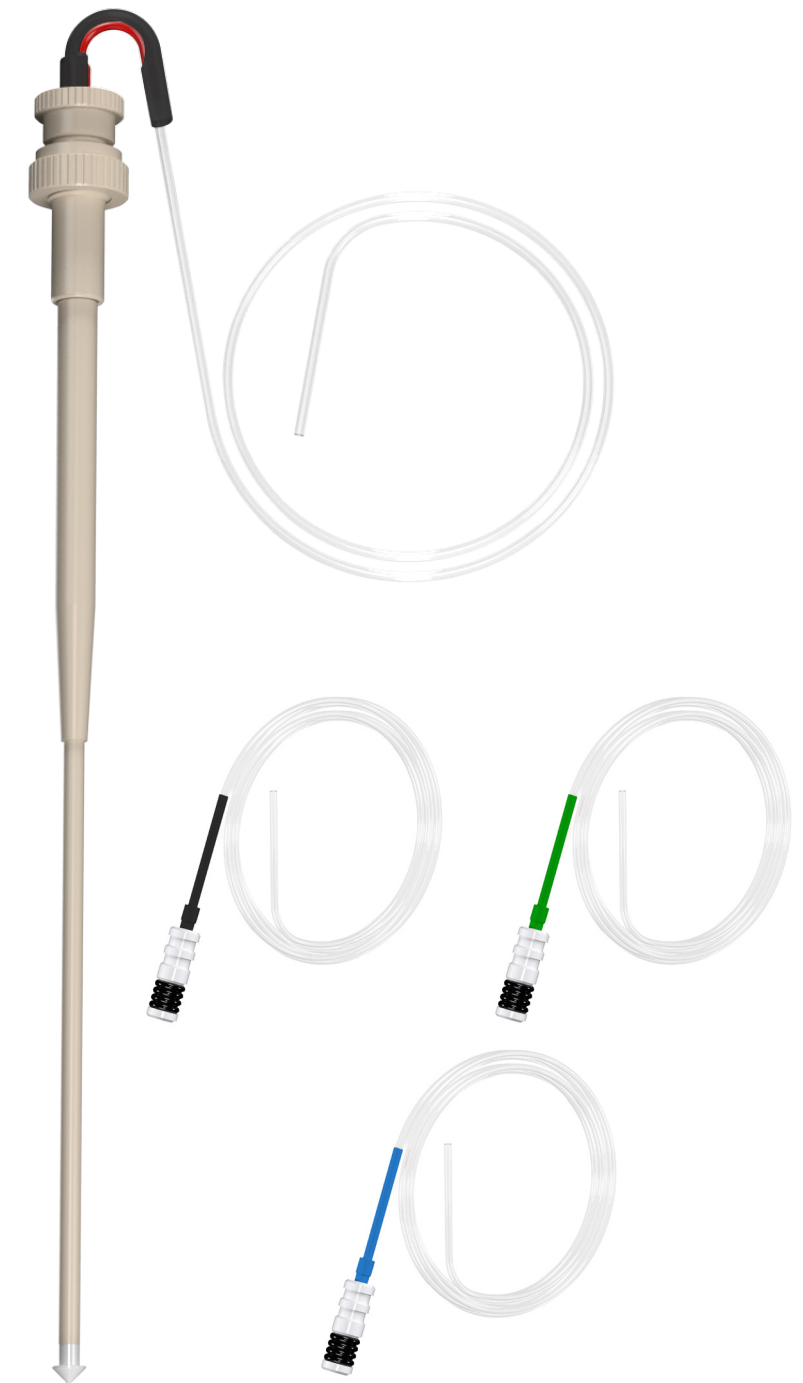
2. Teflon Sample Transfer Tubing:

- Probe → Pump Tubing → Nebulizer
- Typically made from PTFE/PFT/PFA because these materials are:
 - Chemically inert
 - Resistant to strong acids
 - Low adsorption (minimal contamination)

3. Pump Tubing & IS Kit



PFA Sample Tubing 1/16 OD x
0.13mm ID x 10m long



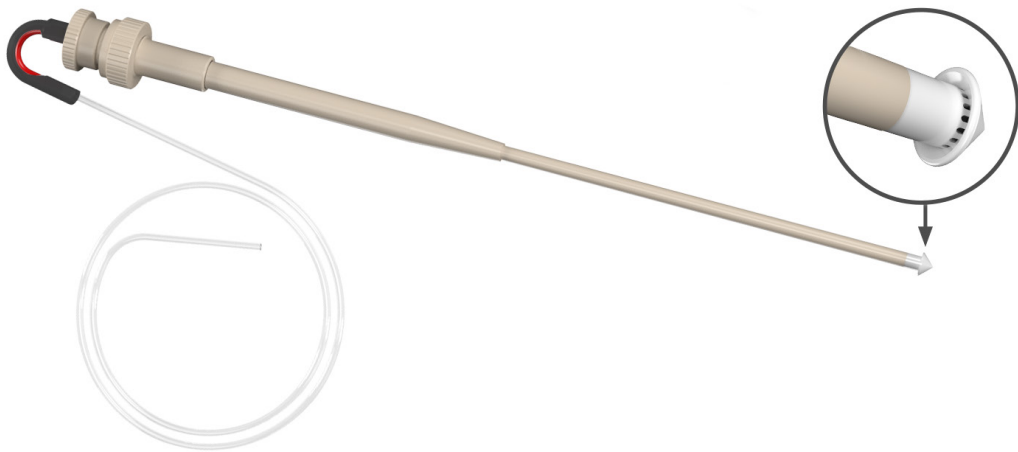
Guardian Probe for Agilent
SPS3, SPS4, AIMS, 0.75mm

1a. Sample Delivery: Sample Probe

Common Issue	Possible Cause	Practical Recommendation
Unstable Signal (High RSDs) Reduced or Inconsistent Uptake Rate Sudden Signal Loss	Probe/ probe connecting line partially clogged by particulates or precipitates	- Inspect the probe and connecting tubing (use a magnifier tool) - Attempt backflushing using the pump in reverse - If unresolved, remove/replace the affected tubing (e.g., UniFit™ interchangeable sample lines) Apply Guardian accessories (Guardian Probe with built-in filter or Guardian inline filter) to minimize particulate blockage
Delayed Washout Memory Effect	Carryover from previous samples	Adjust rinse and washout procedures. - If available, use Smart Rinse in the software; otherwise run a blank before the next sample. Guardian Probe will help to minimize carryover.



10x magnification with LED illumination



Guardian Accessories help prevent clogs in capillary tubing

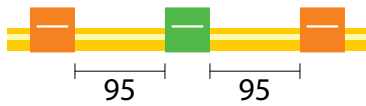
1b. Sample Delivery: Pump Tubing Materials

3. Peristaltic Pump Tubing:

PVC Standard (Tygon ST): Economical and suitable for most routine aqueous samples using diluted acid solution.



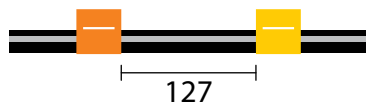
Solva (Tygon HC or Solvaflex): Special tubing for hydrocarbons, petroleum products and distillates.



Tygon MH: Special PVC of high purity; No additives and no plasticizer; enviro-friendly; highly resistant to solvents (MIBK).



Viton (Fluran): Fluoropolymer elastomer; special tubing for concentrated acids and corrosive solvents.



Chemical Resistance Chart

Important note on service life, temperature, compatibility and chemical resistance:
The data provided in the tables are advisory values and not guaranteed. In all cases customers should conduct tests to ensure compatibility with their chemicals and processes.

We recommend:
Place the tubing in the medium to be used for a period of 48 hours. After this time, examine the tubing for signs of swelling, softening or hardening. A judgement can then be made as to the likely suitability of the tubing.

Legend
X = Satisfactory
O = Use only after testing
U = Unsatisfactory
- = No data available

Medium	PVC	Silicone	Viton	PVC Solva	Santo-prene	Medium	PVC	Silicone	Viton	PVC Solva	Santo-prene	Medium	PVC	Silicone	Viton	PVC Solva	Santo-prene
Acetaldehyde	U	X	U	X	X	Benzaldehyde	U	U	U	U	X	Ethyl bromide	U	-	X	X	-
Acetates (low mol. wt.)	U	O	U	X	X	Benzene	O	U	X	U	U	Ethyl chloride	U	U	X	X	U
Acetic acid (<5%)	X	X	X	X	X	Benzene sulfonic acid	O	-	X	X	-	Ethylamine	U	-	U	X	-
Acetic acid (>5%)	X	U	O	X	X	Benzoic acid	X	O	X	U	U	Ethylene chlorohydrin	U	U	X	X	U
Acetic anhydride	O	O	U	X	U	Benzyl alcohol	X	-	X	U	X	Ethylene di-chloride	U	U	X	X	U
Acetone	U	X	U	U	U	Bleaching liquors	X	O	X	X	X	Ethylene glycol	X	X	X	X	X
Acetyl bromide	U	-	-	X	-	Boric acid	X	X	X	X	X	Fatty acids	O	O	X	X	-
Acetyl chloride	U	-	-	X	-	Bromine	X	U	X	X	U	Ferric chloride	X	O	X	X	-
Air	X	X	X	X	X	Butane	O	U	X	U	U	Ferric sulfate	X	O	X	X	X
Alcohols	X	X	X	X	-	Butanol	X	O	X	-	-	Ferrous chloride	X	O	X	X	-
Aliphatic hydrocarbons	X	O	U	U	-	Butyl acetate	U	-	U	U	U	Ferrous sulfate	X	O	X	X	-
Aluminium chloride	X	O	X	X	-	Butyric acid	U	-	O	X	X	Fluoborate salts	X	-	-	X	X
Aluminium sulfate	X	X	X	X	X	Calcium salts	X	O	X	X	X	Fluoboric acid	X	-	-	X	X
Alums	X	-	X	X	-	Carbon bisulfide	U	-	X	U	-	Fluo-silicic acid	X	-	-	X	X
Ammonia (gas-liquid)	O	X	U	X	X	Carbon dioxide	X	O	X	X	X	Formaldehyde	X	O	U	X	X
Ammonium acetate	X	-	-	X	-	Carbon tetrachloride	O	U	X	X	U	Formic acid	X	O	U	X	X
Ammonium carbonate	X	-	-	X	-	Chloroacetic acid	U	-	U	X	U	Freon	U	U	O	U	U
Ammonium chloride	X	-	X	X	-	Chlorobenzene	U	-	X	U	U	Gasoline (non-aromatic)	U	U	X	U	U
Ammonium hydroxide	O	X	X	X	X	Chlorine (wet)	O	U	X	X	U	Gasoline (high aromatic)	U	U	X	U	-
Ammonium nitrate	X	O	-	X	-	Chlorine (dry)	O	U	U	X	U	Glucose	X	X	X	X	X
Ammonium phosphate	X	X	-	X	-	Chloroform	O	U	X	U	U	Glue	X	-	X	X	-
Ammonium sulfate	X	X	X	X	X	Chlorosulfonic acid	O	U	U	X	U	Glycerine	X	X	X	X	X
Amyl acetate	U	U	U	U	U	Chromic acid	X	U	X	-	X	Hydroiodic acid	X	-	X	X	-
Amyl alcohol	X	U	X	U	X	Chromium salts	X	-	-	X	X	Hydro-bromic acid	X	U	X	X	X
Amyl chloride	O	U	X	U	-	Copper salts	X	X	X	X	X	Hydrochloric acid (dil.)	X	U	X	X	X
Aniline	O	U	O	X	X	Cresol	O	X	X	U	U	Hydrochl. acid (med. conc.)	X	U	X	X	X
Aniline hydrochloride	O	U	X	X	-	Cyclohexanone	U	U	X	U	U	Hydrochloric (conc.)	O	U	X	X	X
Animal oils	U	O	X	X	X	Essential oils	O	-	-	X	X	Hydrocyanic acid	X	U	X	X	X
Antimony salts	X	-	O	X	-	Ethers	O	U	O	U	U	Hydrofluoric acid	O	U	X	X	O
Aqua regia	U	-	O	X	U	Ethyl acetate	U	O	U	U	U	Hydrogen peroxide (dil.)	X	X	X	X	U
Aromatic hydrocarbons	U	O	X	U	-	Ethyl alcohol	O	O	X	X	X						
Arsenic salts	X	-	X	X	X												
Barium salts	X	X	X	X	X												

Example of a chemical compatibility chart for pump tubing

Pump Tubing ID

3. Peristaltic Pump Tubing ID:

Ensure optimal ID selection: Directly determines the sample uptake rate to the nebulizer, which affects sensitivity, stability, and washout.

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

Larger ID Tubing (0.76 – 1.02 mm): Suitable for higher flow rates and sample volumes.

Internal standard tubing (0.25 – 0.38 mm): Controls IS flow and dilution.

Waste tubing (1.30 – 1.65 mm): Ensure efficient drainage.

Pump Speed and Sample Uptake Calculator

Step 1.
Select the ICP model you are using or select "Custom Inputs" to enter custom parameters.

Step 2.
Select the pump tubing you are using from the drop down box.

Results
Your **Pump Speed** and **Sample Uptake** will automatically be displayed.

Optional: You can enter your required sample uptake to calculate the **Pump Speed** or enter your actual **Pump Speed** to calculate the **Sample Uptake**.

Select an ICP model:

Select an ICP

Pump diameter (mm):

0

Number of rollers:

0

Roller diameter (mm):

0

Select pump tubing:

Select your Pump Tubing

Your pump speed and sample uptake results:

Sample Uptake (µl/min):

Pump speed:

This calculation should be used as a guide only. Variations between pump tubes and roller pressures mean that the accuracy of the calculation cannot be guaranteed.

**Use Sample Uptake Calculator (GE website or software) to estimate flow rate, then verify using clean/new SIS.*

Pump Tubing: Practical Recommendations

Performance Considerations

- Tubing elasticity determines consistent sample flow and signal stability.
- Worn or flattened tubing can cause **flow rate variations and high RSD values**.
- Incorrect tubing size may result in improper nebulizer uptake rates.

Maintenance Guidance

- **Inspect pump tubing regularly** for flattening, cracks, or discoloration.
- Replace tubing periodically depending on system usage and sample matrix.
- **Maintain correct pump tension** and roller alignment.

****The **EzyGlide Cloth** can be used to lubricate pump rollers. This lubrication reduces pump tubing wear to increase the service life of pump tubing.*

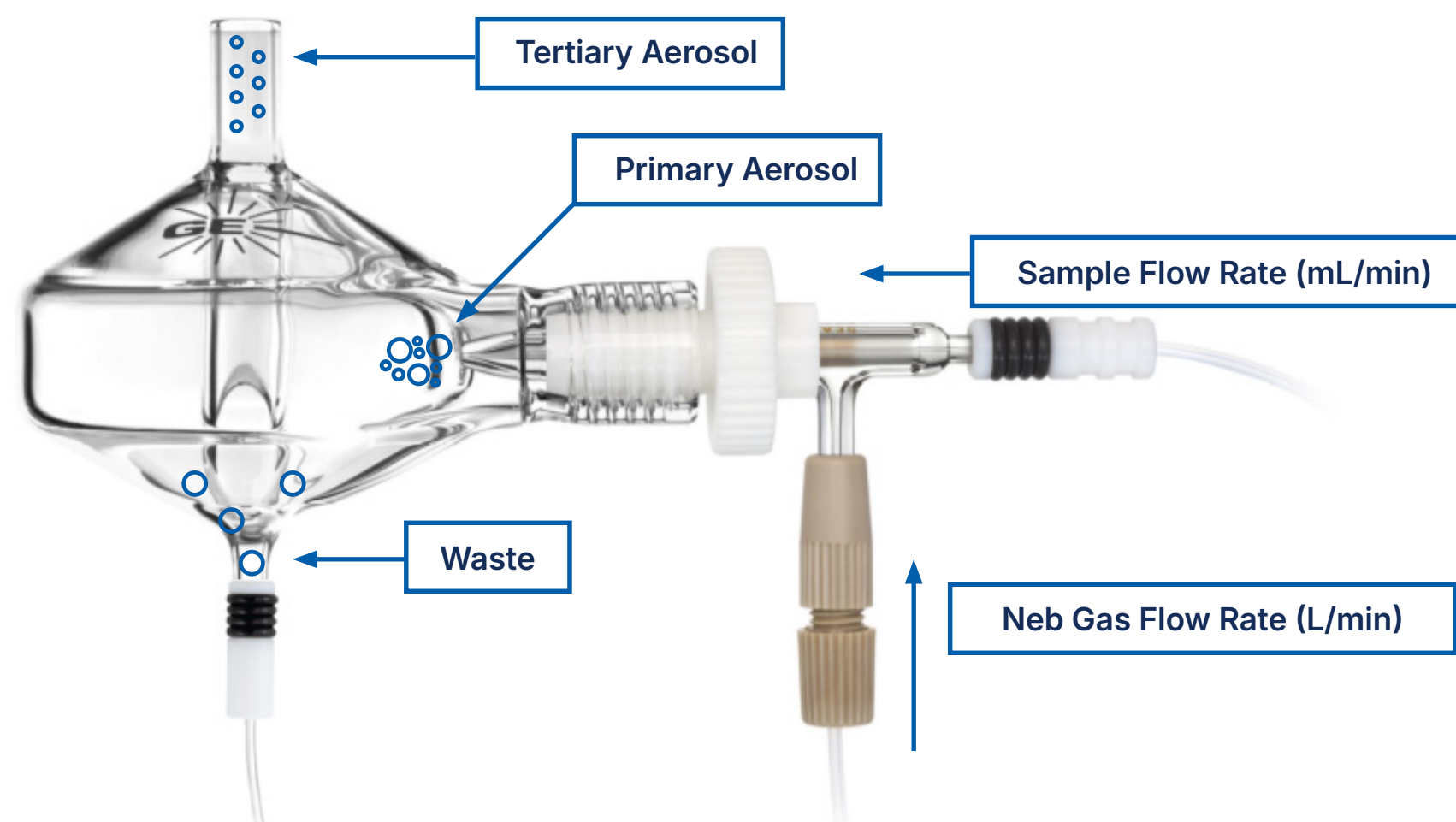


		Tag Colours	ID (mm)
		orange/black	0.13
		orange/red	0.19
		orange/blue	0.25
		orange/green	0.38
		green/yellow	0.44
		orange/yellow	0.51
		white/yellow	0.57
		orange/white	0.64
		black/black	0.76
		orange/orange	0.89
		white/black	0.95
		white/white	1.02
		white/red	1.09
		red/red	1.14
		red/grey	1.22
		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

2. Aerosol Generation: Nebulizer & Spray Chamber

- Only the smallest droplets ($<10\text{ }\mu\text{m}$) are transmitted to the plasma and around 95-98% of nebulized sample is drained as waste.
- **Tertiary Aerosol “Filtered” by Spray Chamber, $<10\text{ }\mu\text{m}$.**
- Less energy required, results in a more robust plasma condition.

*****Because only ~1-2% of the sample reaches the plasma, even small disturbances can significantly affect signal stability and sensitivity.**



Smaller Droplets Require Less Energy = Efficient Ionization

2a. Nebulizer Assessment

Order Summary

- 1. Check aerosol production
- 2. Check nebulizer pressure
- 3. Check gas connections
- 4. Inspect for blockages
- 5. Replace component if damaged



Common Symptom	Possible Cause	Practical Recommendation
Poor sensitivity / Signal Loss	Partial nebulizer blockage, gas flow issue, improper installation, or spray chamber seal problem	Verify nebulizer aerosol production. If aerosol is weak, check nebulizer backpressure, gas connectors, and inspect the nebulizer tip for blockage.
High nebulizer backpressure	Salt deposits, particulates, or dried residues from high-TDS samples	Clean the nebulizer and inspect the tip using a magnifier. If deposits cannot be removed or damage is observed, replace the nebulizer.
Low nebulizer backpressure (often with sensitivity loss)	Gas leak, damaged nebulizer, or kinked tubing	Inspect argon connectors and tubing for leaks. Replace damaged tubing or the nebulizer if necessary.
Poor precision (high RSD)	Blocked or damaged nebulizer, unstable gas flow, worn pump tubing, or poor spray chamber draining	Inspect nebulizer and gas connectors; verify pump tubing condition and spray chamber draining.
No aerosol production	Complete blockage in nebulizer, sample tubing valve, or autosampler probe; damaged nebulizer tip	Identify the blockage location and clean or replace the affected component. If the nebulizer tip is damaged, performance cannot be restored and the nebulizer must be replaced.



Care of Nebulizers: Other Practical Tips

Check Argon Connections

- Increasing RSDs may indicate a small argon leak at the nebulizer connection.
- Polymer gas tubing can harden over time and lose a gas-tight seal.
- Even **~1% argon loss can significantly affect ICP signals.**

Quick Sample Uptake Check

- Observe the speed of an air bubble in a 10 cm section of uptake tubing.
- Example estimates:
 - 1.0 mm ID tubing: 10 cm in 10 s $\approx$ 470 μ L/min uptake
 - 0.5 mm ID tubing: 10 cm in 10 s $\approx$ 118 μ L/min uptake

Storage Recommendations

- Always **store nebulizers in their protective storage case.**
- Prevent dust or particles from entering the capillary.



Inspect gas connections



All Glass Expansion nebulizers are supplied in specially designed storage boxes

Nebulizer Cleaning Procedure

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

For Blockages:

1. Initially flush with water using the Eluo.
2. Soak nebulizer tip in 25% Fluka for 24 hours.
An initial flush of 25% Fluka may be required.
3. Flush 3x with water using the Eluo.
4. Stubborn deposits may require an additional soaking for 2 hours with 5% HNO_3 .
5. Flush 3x with water using the Eluo.
6. For faster drying, flush with methanol.



ICP Nebulizer Maintenance Made Easy



**GE Nebulizer
Resource Guide**

2b. Spray Chamber Assessment

Common Symptom	Possible Cause	Practical Recommendation
Poor sensitivity / signal drift	Inefficient aerosol transport due to deposits contamination inside the spray chamber	Clean spray chamber and verify proper nebulizer installation
Poor precision / high RSD	Droplet accumulation on internal chamber walls causing unstable aerosol transport	Clean spray chamber to remove deposits and ensure proper draining
Delayed washout / memory effects	Residual sample trapped in spray chamber or drain line	Inspect drain tubing and increase rinse time if necessary
Excess liquid entering plasma	Blocked or poorly draining spray chamber outlet	Inspect and clear drain tubing to ensure proper drainage
Sensitivity varies with time or temperature	Spray chamber temperature fluctuations affecting aerosol transport efficiency	Use temperature-controlled spray chamber (e.g. IsoMist™) to stabilize conditions



Inspect UniFit Drain Connector (Left) and Helix CT Seal (Right)



Spray Chamber: Cleaning Procedure

Standard Cleaning

1. Aspirate 2.5% Fluka RBS-25 solution (40× dilution) for ~15 minutes.
2. Rinse thoroughly with deionized water.

Deep Cleaning (if performance is not restored)

1. Soak overnight in 25% Fluka RBS-25 solution (4× dilution).
2. Rinse thoroughly with deionized water before reinstalling.

PTFE / PFA Spray Chambers

- Internal surface is specially treated to promote uniform wetting and efficient drainage.
- If the treated surface no longer recovers after cleaning, the chamber may need **Surface Re-treatment***.



PTFE and PFA spray chambers



Tracey BC PEEK
Spray Chamber

No Internal Surface Treatment

3a. Interface: Torch and Injector Assessment

Torch failure can result from gas leaks, damaged/misalign RF coil, or suboptimal torch selection.

Common Symptom	Possible Cause	Practical Recommendation
Plasma instability Difficulty igniting plasma	Gas leaks from torch connection, worn O-rings, or injector ferrule deformation	Inspect torch connections, O-rings, and injector ferrule; replace if worn or damaged.
Poor sensitivity Signal drift	Injector partially blocked by salt deposits from high-TDS samples	Inspect injector tip for salt buildup or blockage; clean or replace if necessary. Use Elegra™ Argon Humidifier to reduce salt deposition.
Frequent torch cracking Short torch lifetime	RF coil damage, deformation, or misalignment causing uneven plasma heating	Inspect RF coil for damage/ discolouration; clean or replace if needed.
Outer tube devitrification	Chemical attack or prolonged exposure to high plasma temperatures	Inspect torch outer tube for clouding or crystallization; clean or replace torch if necessary

***Even if gas flows are set correctly in the software, poor mechanical connections can cause flow instability and plasma issues.



Devitrification of quartz due to salt deposits (Left), and RF Coil corrosion (Right)

Torch and Injector: Cleaning Procedures

Contamination of quartz torches can reduce torch lifetime due to high-temperature interaction with sample deposits.

Carbon Deposits (Organic Samples):

- Bake the torch in a muffle furnace (~500 °C) to remove carbon deposits.
- Alternatively, use a hand-held propane torch to burn off carbon deposits.

Salt Deposits:

- Soak the torch or outer tube in 25% Fluka RBS-25 solution (4× dilution).
- Rinse thoroughly with deionized water.

Metal Deposits:

- Soak the affected section of the outer tube in acid (typically the same acid used for sample preparation, except HF).
- Keep the acid level limited to the contaminated region to avoid damaging polymer components.



Removing carbon from
outer tube



Elegra™ Argon Humidifier
helps reduce salt deposition

RF Coil: Assessment

Common Issue: RF Coil Corrosion

Can occur due to heat or chemical oxidation:

- Reduced energy transfer efficiency.
- Increased load on the RF generator / RF power tube.
- Less robust plasma and lower analytical signal intensity.

*****Corroded coils may also create hotspots, leading to premature torch failure or melting.**

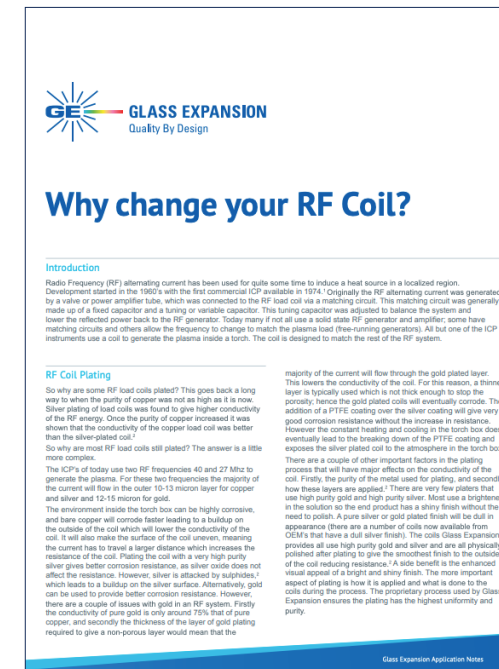
Alignment: Ensures a well-shaped and consistently positioned plasma.

Material & Plating:

- **Copper:** cost-effective but oxidizes quickly
- **Silver-plated:** highest conductivity but prone to tarnish
- **Gold-plated:** best corrosion resistance for harsh environment

Maintenance Recommendations

- Clean periodically to remove deposits and oxidation.
- Replace coils showing copper migration, severe tarnish, or damage.



RF Coil Application note



3b. Plasma Interface: Cones Assessment

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 solution followed by UPW.*

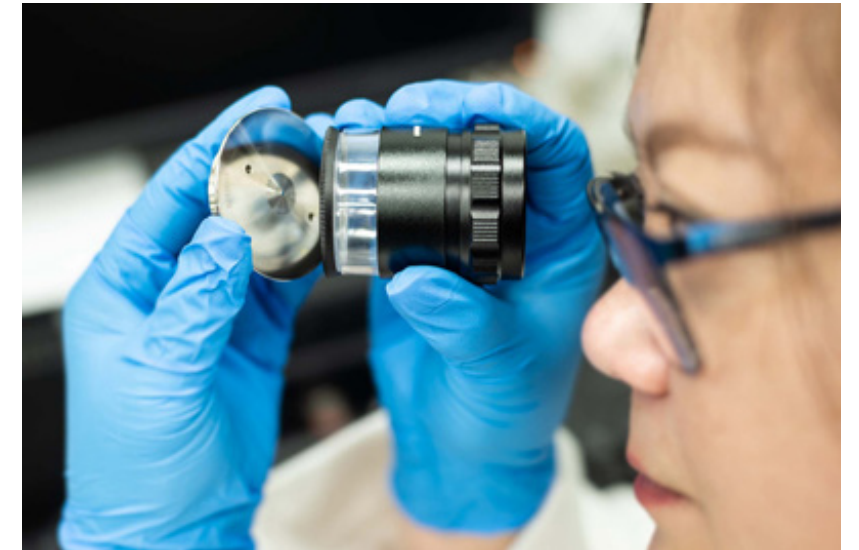
Experimental indicators of cone cleaning:

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

Observational indicators for cone cleaning:

- Visible deposits near or in the orifice
- Distorted Orifice

****Cleaning frequency depends on workload and sample matrix, ranging from daily (high-matrix samples) to monthly (clean samples).*



**Magnifier Inspection
Tool**
P/N 70-803-1923

Cone Cleaning: Progressive Approach

1. Gentle Cleaning (Routine)

- Soak cones in **detergent solution (RBS-25)**
- Follow with **Citranox solution**
- Rinse thoroughly with **deionized water**

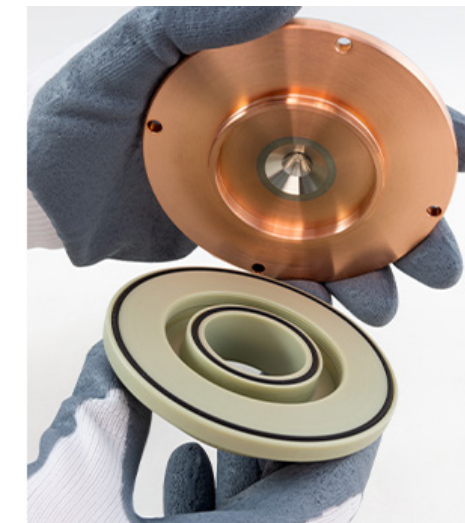
2. Enhanced Cleaning (Deposits Present)

- Sonicate cones in **Citranox solution**
- Rinse multiple times with **deionized water**
- Dry completely with clean gas or warm oven (~60 °C)

3. Deep/Aggressive Cleaning (Heavy Deposits)

- Sonicate in **dilute nitric acid** if detergent cleaning is insufficient
- Limit nitric acid exposure to prevent cone damage or orifice enlargement

Cleaning Expectations: Removing sample deposits is key; discoloration is normal and can improve signal stability.



ConeGuard to protect threaded cones from corrosion during cleaning



Thank You

www.geicp.com