



**GLASS EXPANSION**  
Quality By Design

# SeaSpray™ Nebulizer

**Educational Tutorial & Best Practices Guide**



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# 1. SeaSpray™ Nebulizer Educational Tutorial & Best Practices Guide

## Maximizing Performance with Outstanding Efficiency and Tolerance to Dissolved Solids

The Glass Expansion SeaSpray™ Direct Connection (DC) Nebulizer represents the pinnacle of concentric glass nebulizer technology, offering the highest sensitivity of any concentric glass nebulizer on the market. Customer testimonials and its adoption as the default nebulizer on many commercial ICP instruments have consistently demonstrated the SeaSpray's superior analytical performance, from trace metal analysis to handling a variety of challenging sample matrices.

This educational tutorial will guide you through understanding, optimizing, and utilizing the unique advantages of the SeaSpray DC nebulizer for a wide range of analytical applications, **including agricultural, batteries, cannabis, clinical, environmental, food and beverage, forensic and toxicological, geochemical, isotopic and speciation, marine, metallurgical and advance materials, mining, petrochemical, pharmaceutical and nutraceutical, radiological, and tribology, with a specific focus on EPA, ASTM, and other standard testing methods.**

### 1.1.1. Key Performance Characteristics

- Outstanding sensitivity and precision, achieving RSD values as low as 0.26% for trace-level analyses<sup>1</sup>
- Exceptional tolerance to dissolved solids up to 20% TDS (Total Dissolved Solids)
- Superior nebulization efficiency with minimal dead volume (4.0 µL)
- Fastest washout characteristics due to uniform sample channel design
- Direct connection capability with UniFit sample connector system

### 1.1.2. Industry Leaders

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

All Glass Expansion concentric nebulizers use the unique VitriCone™ construction delivering the best possible precision. Other manufacturers heat and draw a thin fragile capillary from glass tubing to create the internal capillary. This process is prone to a number of problems including inconsistent diameters, an increase in the porosity of the glass, and harmonic vibrations from the flow of argon, all of which can degrade performance and lifetime.

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 sample channel, assuring tolerance to nasty samples and excellent reproducibility.

##### The VitriCone design features:

- A. Controlled overall length precision:**  $\pm 0.2\text{mm}$
- B. Shell Diameter:**  $\pm 0.05\text{mm}$
- C. Full length precision bore capillary:**  $\pm 0.004\text{mm}$
- D. Precision formed jet nozzle:**  $\pm 0.005\text{mm}$
- E. Depth positioning stop:**  $\pm 0.2\text{mm}$



## 1.2. SeaSpray Review

### 1.2.1. Industry Recognition and Customer Testimonials

**Industry Recognition:** The SeaSpray nebulizer has earned its reputation as the industry gold standard through its unmatched performance and analytical precision. Its widespread acclaim is evidenced by its inclusion in nearly every major ICP manufacturer's catalog and its role as the default component for leading ICP-OES instruments. With nearly 1,000 citations in peer-reviewed publications<sup>2</sup>, the SeaSpray's performance and reliability are established as the industry standard in both routine and demanding analytical environments.

**Comparative Performance Studies:** A comprehensive internal study published in Spectroscopy Magazine's Application Notebook (2020) directly compared the SeaSpray against four other popular nebulizer designs under identical conditions.<sup>1</sup> The study demonstrated that the SeaSpray achieved the best short-term analytical precision, significantly outperforming competing designs.

**Detection Limit Superiority:** The same study revealed that the SeaSpray offers the highest signal-to-root background ratio (SRBR) among all tested nebulizers, directly translating to the lowest detection limits—a critical advantage for trace-level environmental and regulatory analyses.<sup>1</sup>

**Customer Testimonials:** The superiority of the SeaSpray nebulizer is not just our claims—it has been consistently validated by other industry professionals. Most notably, Inorganic Ventures – a leading manufacturer of certified reference materials (CRMs) and high-purity inorganic standards since 1985 – relies on the SeaSpray nebulizer for its demanding ICP-OES and ICP-MS applications:

*I have used the SeaSpray nebulizer for at least 12 years. It has consistently given excellent results across different applications. Low RSDs are a hallmark of the nebulizer. The SeaSpray has been used for analyses requiring the highest accuracy and precision, e.g., during the development of primary certified reference materials for precious metals.*

*Both with a peristaltic pump and natural aspiration, the SeaSpray nebulizer provides excellent performance. The nebulizer's sturdy construction also makes it ideal for routine analyses. Having the Glass Expansion Eluo nebulizer cleaning tool keeps the nebulizer in perfect condition while protecting it during cleaning. The UniFit sample lines and the DC gas line fittings with ratchet connector prevent breakage and provide reliably sealed connections, which make for excellent precision. I have used the SeaSpray nebulizer for the analysis of aqueous solutions, from those with very low analyte concentrations to those with high dissolved solids.*

*More recently, the SeaSpray nebulizer has been a powerful addition to our introductory system for the analysis of metals in edible oils. Even with this vastly different matrix, an organic solvent and oils, the SeaSpray nebulizer is helping us to achieve accurate, high-precision results.*

**Madeline Gozzi – Innovation & Applications Development Chemist – Inorganic Ventures**

As highlighted by Inorganic Ventures, the SeaSpray nebulizer stands out for its consistent, high-quality performance with a wide range of samples and applications, as confirmed by additional customer testimonials.

*The SeaSpray nebulizer is used in our lab... RSDs are between 0.3-0.7% in 10% NaCl solutions.*

**Photographic company - The Netherlands**

*I switched from Scott style spray chamber and cross-flow nebulizer to GE's Twister cyclonic spray chamber and SeaSpray nebulizer. I now get excellent performance with much faster washout times.*

**Environmental laboratory – USA**

*It is, without a doubt, the best nebulizer I have ever used--in over 20 years of ICP analysis.*

**Environmental Laboratory – Canada**

RSD averages with the SeaSpray and Twister have ranged from 0.24 to 0.35 for the most part.

#### **Reference material manufacturer – USA**

*The precision is outstanding, better than I have ever seen on an ICP. Great nebulizer. The new design is perfect for this application because of the reduced dead volume; it washes out very quickly.*

#### **Wastewater laboratory – USA**

*I have just installed and tested the Twister spray chamber and SeaSpray nebulizer on our Spectro™ Genesis ICP, and at this stage it appears to be performing very well, with sensitivities about twice what we were getting with the Scott/crossflow combination.*

#### **Minerals laboratory – Australia**

## **1.2.2. Industry Standard Methods**

Based on current industry trends, we reviewed some of the most popular yet challenging standardized testing methods and highlighted how the SeaSpray nebulizer's combination of high resistance to TDS and superior analytical performance helped meet demanding regulatory requirements. For samples with TDS >5%, using an argon humidifier is recommended for optimum performance and improved long-term stability (see section 1.3.4 for detailed guidance).<sup>3</sup>

#### **EPA 200.7 - Determination of metals and trace elements in waters and wastes by ICP-OES<sup>4,5</sup>**

- The common presence of high TDS can crystallize at the nebulizer tip as the dry argon gas flow evaporates the solvent, leading to clogging, signal drift, and frequent maintenance downtime. The SeaSpray's high tolerance to TDS enables it to handle a wide range of environmental samples from clean drinking water to the more challenging surface water, groundwater, and soil samples.
- Method 200.7 requires strict adherence to performance checks, within +/- 5%. Maintaining this precision over long automated runs (often hundreds of samples) is difficult if the aerosol produced is not highly consistent. The SeaSpray's highly-efficient nebulization and unmatched precision manufacturing tolerances directly translates to higher sensitivity, lower Method Detection Limits (MDLs), and very low RSDs, typically < 1%.
- Elements like Mercury (Hg) can lead to prolonged washout and issues with high blank readings. The SeaSpray's low dead volume (4.0 µL) and robust uniform VitriCone sample path allows for rapid washout, reducing the memory effects between a high-concentration sample and a subsequent blank, increasing the overall throughput of the lab.

#### **EPA 6010D (SW-846) – Trace elements in solid waste, soils, sediments, sludges, industrial waste, and groundwater by ICP-OES<sup>6</sup>**

- Solid waste samples present high TDS matrices with complex sample compositions that can lead to rapid salt deposition at the nebulizer tip, resulting in a blockage and signal instability. The SeaSpray's unique self-washing tip resists the deposition of salts and can maintain excellent long-term stability even with these harsh environmental samples.
- Method requires detection limits down to µg/L (ppb) levels for trace contaminants in complex soil matrices with high dissolved solids. The SeaSpray's superior nebulization efficiency delivers enhanced sensitivity enabling reliable quantification even below the required regulatory levels.
- Automated workflows generate hundreds of samples with varying matrix complexity requiring uninterrupted operation. The SeaSpray's design minimizes interruption due to a blocked nebulizer and ensure consistent performance throughout extended analytical runs.

### **EPA 200.8** – Determination of metals and trace elements in waters and wastes by ICP-MS<sup>7</sup>

- Regulatory labs often run hundreds of samples in a single batch. Maintaining the mandatory  $\pm 10\%$  Continuing Calibration Verification (CCV) over 12–24 hours is difficult if the nebulizer tip begins to “salt up,” or if the aerosol becomes unstable. The SeaSpray’s unique design allows it to handle up to 20% TDS, ensuring that the CCV’s pass without interruption.
- The high and stable nebulization efficiency of the SeaSpray nebulizers is critical for meeting the ultra-low MDLs required by 200.8.
- Certain elements mandated by 200.8, such as Mercury (Hg) and Thallium (Tl), are notorious for being “sticky,” leading to “false positives” in the subsequent samples due to poor washout. The SeaSpray’s low dead volume (4.0  $\mu\text{L}$ ) and robust uniform VitriCone sample path allows for rapid washout reducing memory effects between a high-concentration sample and a subsequent blank, increasing the overall throughput of the lab.

### **EPA 6020B and ISO 17294-2** – Test method for ultra-trace elements in solid waste, soils, sediments, sludges, industrial waste, and groundwater by ICP-MS<sup>8</sup>

- Samples encountered in 6020B and ISO 17294-2 are typically much “dirtier” and more complex, which significantly amplifies the high TDS and matrix challenges, while still requiring ultra-trace detection limits. Due to these high matrix samples, labs often rely on aerosol dilution to improve the robustness of the plasma and reduce build-up on interface cones. For aerosol dilution to be effective requires a nebulizer with the SeaSpray’s capabilities of handling high TDS and producing a very stable aerosol.
- Waste analytical labs often run 24/7. Maintaining the stability required to pass the Continuing Calibration Verification (CCV) and stability checks is difficult to achieve when the nebulizer and cones are constantly bombarded with heavy salts. The SeaSpray’s unique self-washing tip resists the deposition of salts while preserving analyte signal integrity.
- 6020B requires interference check solutions (ICS) continuously throughout the analysis. The ICS contains high concentrations of Fe, Al, Ca, and Mg, which with a standard nebulizer could result in an immediate signal drift. The nebulization efficiency and high matrix tolerance of the SeaSpray allows for exceptional signal stability throughout extended analyses, eliminating the need for recalibration due to a blocked nebulizer.

### **ASTM D1976** – Standard test method for the determination of elements in water (drinking water, surface water, wastewater, or brines) by ICP-OES (industry/commercial counterpart to EPA 200.7)

- Unlike EPA 200.7, which is primarily focused on drinking water and wastewater, ASTM D1976 is often used for industrial process water, cooling tower water, and brines. These samples can contain extremely high levels of dissolved solids (up to 20%), organics, and varied acidities that fluctuate wildly between batches. The SeaSpray’s unique self-washing tip, excellent nebulization efficiency, and unmatched long-term stability is a perfect match for these complex and diverse range of samples.
- ASTM D1976 testing labs often run 24/7. Maintaining a stable calibration over thousands of samples without frequent, manual recalibration is a significant hurdle when the sample introduction system is constantly exposed to these complex matrices. The SeaSpray’s precision-manufactured design and high tolerance to TDS helps ASTM D1976 testing labs easily meets the method precision requirements of  $\leq 10\%$  RSD.
- If you are running EPA 200.7, you use the SeaSpray for regulatory peace of mind (passing QC every 10 samples). If you are running ASTM D1976, you use the SeaSpray for operational survival against high-salt industrial matrices that would clog a standard nebulizer within minutes. The SeaSpray features the VitriCone design—a constant-diameter thick-walled sample capillary, which makes it durable enough to survive the high-volume workload of a busy commercial laboratory.

**ASTM D5673** – Standard test method for the determination of ultra-trace elements in water (drinking water, surface water, wastewater, or brines) by ICP-MS (industry/commercial counterpart to EPA 200.8)

- Unlike EPA 200.8, which is primarily used for drinking water and wastewater, ASTM D5673 is frequently used for surface water, groundwater, and industrial effluents and validated for over 60 elements. These samples often contain significantly higher levels of TDS and organics, which can cause significant signal suppression. The robust aerosol generation of the SeaSpray is less sensitive to changes in viscosity. This means that the “thick” industrial sample will behave more like your “clean” calibration standard, resulting in more stable and accurate results. Without the design features of the SeaSpray these variations in sample matrices would cause instrument to drift, nebulizer to clog, and stability checks to fail rather quickly in a high throughput environment.
- Commercial laboratories demand reliable ng/L (ppt) detection capabilities for regulatory compliance testing requiring exceptional day-to-day reproducibility. The SeaSpray's robust construction and stable operating characteristics provide long-term analytical consistency meeting stringent quality assurance requirements.

**ASTM D5185-18** – Determination of elements in used and unused lubricating oils and base oils<sup>9</sup>

- Used oil samples vary significantly in viscosity (e.g., a thick gear oil vs. a thin hydraulic fluid). These differences affect the “uptake rate” and nebulization efficiency, leading to inaccurate results. As a high-performance concentric nebulizer, the SeaSpray produces a much finer and more uniform aerosol compared to a v-groove. This leads to higher signal intensities and significantly lower detection limits, which is critical for detecting trace-level wear metals.
- Analyzing oils involves introducing organic solvents (typically kerosene) into the plasma. This high carbon load can lead to carbon deposits on the injector tip and torch body, which disrupts the aerosol flow and can eventually extinguish the plasma. The SeaSpray allows for the use of much lower sample flows compared to a V-groove type nebulizer. By reducing the amount of organic solvent vapor entering the plasma, the SeaSpray helps maintain a more stable, robust plasma, reducing the risk of carbon buildup (coking) on the injector, while still providing significant sensitivity gains.
- Method demands quantification of both additive elements (Zn, P, Ca) at percent levels and wear metals (Fe, Cu, Pb) at ppm levels. The SeaSpray is the “optimal” choice because it provides the sensitivity and precision required for modern ASTM D5185-18 monitoring without sacrificing the ruggedness needed to handle dirty, used oils.

**EN 71-3** – Migration of elements in toys<sup>10</sup>

- EN 71-3 ensures that toys do not contain harmful heavy metals that could be absorbed by a child's body during play or accidental ingestion. For certain elements like Lead and Chromium migration limits have been lowered repeatedly pushing the detection limit capabilities of ICP-MS. As a high-performance concentric nebulizer, the SeaSpray produces a much finer and more uniform aerosol. This leads to higher signal intensities and significantly lower detection limits, which is critical for detecting trace-level heavy metals.

### 1.2.3. Application Highlights

The common nebulizer requirement for most of the standard testing methods and applications we reviewed is resistance to high-matrix samples while still providing higher sensitivity, lower MDLs, and very low RSDs, typically < 1%. Similar to the previous section, we also reviewed several “hot” industry application topics to highlight why the SeaSpray was fit for purpose and helped to provide superior stability and excellent sensitivity in a variety of challenging applications. Although we may have reviewed only a small selection of testing methods and applications, the SeaSpray is the optimal nebulizer choice for many more. If your application was not listed and you have questions about whether the SeaSpray is the best option for your laboratory, please [contact us](#).

\*Disclaimer: All listed company names are trademarks™ or registered trademarks® of their respective owners. Use of them does not imply any affiliation with or endorsement by them. The SeaSpray nebulizer was listed in the Experimental section.

#### Elemental Analysis of Solid Electrolyte Lithium Lanthanum Zirconate Tantalum Oxide by ICP-OES<sup>11</sup>

- **Challenge:** LLZTO solid electrolytes for next-generation lithium batteries require precise Li, La, Zr, and Ta quantification to verify stoichiometric composition, but high-lithium matrices create severe TDS challenges and require 10,000-fold dilutions for ICP-OES analysis.
- **SeaSpray Solution:** SeaSpray’s exceptional TDS tolerance and stability can improve plasma robustness and enable direct analysis of high-matrix LLZTO samples over extended periods without frequent shutdowns. Its precision manufacturing also contributes to the excellent precision (<0.16% RSD) required for critical verification.

#### Determination of Elements in a Solid Sulfide Electrolyte using ICP-OES<sup>12</sup>

- **Challenge:**  $\text{Li}_{10}\text{GeP}_2\text{S}_{12}$  solid electrolytes require multi-element impurity screening to ensure ionic conductivity performance, but sulfide matrices generate odorous hydrogen sulfide gas during digestion and create complex analytical challenges with 29 target elements across wide concentration ranges.
- **SeaSpray Solution:** The SeaSpray’s stable aerosol generation enables reliable analysis of all 29 elements in an aggressive reverse aqua regia matrix, while its high TDS tolerance can eliminate the need for high dilution factors, streamlining the analytical workflow for battery quality control.

#### Enhanced RoHS Compliance Testing - Accurate measurement of multiple elements in plastic materials<sup>13</sup>

- **Challenge:** RoHS compliance testing of electronic equipment plastics requires accurate quantification of restricted elements (Cd, Cr, Pb, Hg) at strict regulatory limits while handling complex organic matrices and achieving ultra-low detection limits.
- **SeaSpray Solution:** SeaSpray’s robust design and excellent stability enable precise analysis of RoHS elements in aggressive aqua regia-digested plastic matrices, helping achieve MDLs well below regulatory thresholds and maintain 100±10% recoveries throughout 7+ hour analytical sequences.

#### Sustainable Lithium-Ion Battery Recycling: Recovery of Metals in Green Solvents by ICP-OES<sup>14</sup>

- **Challenge:** Battery recycling using deep eutectic solvents (DES) requires analysis of extracted metals, in varying concentrations, within highly viscous, high-TDS solvent matrices that cause severe strain on the nebulizer efficiency and stability.
- **SeaSpray Solution:** The SeaSpray’s exceptional TDS tolerance aids in the ability to directly analyze metals in a  $\text{ChCl}:\text{Urea}$  DES solution with 100±10% spike recoveries. The robust VitriCone construction minimizes wear from high-matrix samples. The SeaSpray’s versatile compatibility with high-throughput switching valves, such as the AVS, helped reduce analysis time from 90 to 41 seconds per sample.

### Quantification of Impurity Elements in Vanadium Sulfate Electrolytes<sup>15</sup>

- **Challenge:** Vanadium redox flow battery electrolytes contain >1.5 mol/L vanadium creating extreme matrix effects that limit conventional ICP sensitivity, while requiring precise quantification of 11 trace impurity elements to ensure optimal battery performance and cost-effectiveness.
- **SeaSpray Solution:** The SeaSpray's robust design and superior matrix tolerance assists the direct analysis of high-vanadium electrolytes, resulting in excellent linearity ( $R > 0.9999$ ) and 94-103% spike recoveries, while maintaining <2.3% RSD stability throughout 4-hour analytical sequences.

### Determination of Multiple Elements in Lithium Salts<sup>16</sup>

- **Challenge:** Battery-grade lithium salt production requires simultaneous quantification of 28 trace impurity elements alongside major lithium content in high-matrix LiCl samples, demanding wide calibration ranges and automated dilution to prevent easily ionizable element (EIE) interference effects that enhance sodium signals beyond acceptable limits.
- **SeaSpray Solution:** The SeaSpray's robust matrix tolerance helped to maintain <3% RSD precision over 10-hour analytical sequences while its excellent transport efficiency aided in the simultaneous quantification of trace elements at <1 mg/kg and lithium at >1000 mg/L (ppm).

### Robust Elemental Analysis of Sodium-Ion Battery Cathode Materials<sup>17</sup>

- **Challenge:** Sodium-ion battery cathode materials such as Prussian Blue, sodium iron phosphate, and sodium manganese oxide require quality control analysis of up to 30 trace impurity elements in matrices containing extremely high concentrations of Na, Fe, Mn, and P. These major matrix elements create severe spectral interferences and easily ionized element (EIE) effects that can produce false high or false low concentrations, while the emerging industry lacks established regulatory standards to guide analytical methods.
- **SeaSpray Solution:** The SeaSpray's precision aerosol generation and robust TDS tolerance aided in the accurate analysis of all 30 elements in high-matrix cathode digests, with spike recoveries within 100 ±10% across all three cathode types, while also helping to maintain excellent stability over a 10-hour (410 measurements) analytical sequence, with all CCV recoveries within ±10% and RSDs below 3%.

### Elemental Analysis of Animal Feed and Fertilizers<sup>18,19</sup>

- **Challenge:** Insect-derived animal feed and organic fertilizers such as Black Soldier Fly larvae, insect meal, and frass require multi-element analysis of 26+ elements across widely varying concentrations and matrix types—from powdered insect meal to sludge-like organic waste. High concentrations of easily ionized elements (Ca, K, Mg, Na) cause severe signal enhancement or suppression, while diverse sample matrices demand robust performance without matrix-matched calibration standards across extended analytical runs.
- **SeaSpray Solution:** The SeaSpray's consistent aerosol generation and superior matrix tolerance assisted with the accurate analysis of all elements in five distinct sample types with SRM recoveries within 100 ±10% and post-digestion spike recoveries of 90–108%. QC check solutions remained within ±4% over eight-hour stability runs with no signs of instrumental drift, a true performance indicator of the SeaSpray's TDS tolerance.

## The Analysis of Brines<sup>20</sup>

- **Challenge:** Sodium chloride brines used in chlorine gas production via membrane cell electrolysis contain 20–30% total dissolved solids, requiring accurate measurement of critical contaminant elements (Al, Ba, Ca, Fe, Mg, Ni, Si, Sr) at sub-0.1 mg/L (ppm) levels to prevent costly membrane poisoning. The extremely high salt matrix creates severe matrix effects and risks rapid salt deposition, causing signal instability and frequent maintenance interruptions.
- **SeaSpray Solution:** The SeaSpray's exceptional TDS tolerance and self-washing design enabled direct analysis of 2x-diluted brines (10–15% NaCl) while providing a highly precise, stable aerosol that helped achieve detection limits below 2 µg/L (ppb) for all critical elements, 15 µg/L (ppb) check standard recoveries within ±10%, and four-hour stability within ±10% deviation—all without nebulizer clogging or signal degradation from NaCl deposition. The SeaSpray was paired with an argon humidifier to enhance long-term stability.

## High Precision Analysis of Major Components in Precious Metals<sup>21</sup>

- **Challenge:** Precious metal alloys of gold, palladium, and platinum require high-precision major component quantification to stringent ISO 11494/11495 standards, where composition control within ±0.1% directly determines product quality and commercial value. Standard external calibration methods introduce measurement fluctuations and matrix effects that limit reproducibility between duplicate samples, while the final aggressive aqua regia dissolution matrices (20% HCl / 3% HNO<sub>3</sub>) demand robust sample introduction components.
- **SeaSpray Solution:** The SeaSpray's precision aerosol generation and chemical resistance to concentrated aqua regia matrices help to achieve ISO-compliant standard bracketing analysis with all individual measurement RSDs below 0.18%—well under the 0.3% ISO threshold—and duplicate sample RPDs as low as 0.00056%, representing a >400x improvement over external calibration. The SeaSpray's stable performance in 20% HCl matrices also helped to ensure consistent fineness (‰) determinations for Au (755 ‰), Pd (999 ‰), and Pt (943 ‰) alloys throughout extended analytical sequences.

## 1.3. Best Practices for Optimizing SeaSpray™ Performance

The following best practices are derived from extensive research validation, user testimonials, and decades of analytical experience. Peer-reviewed studies have confirmed that proper implementation of these protocols maximizes the SeaSpray's inherent analytical advantages.

### 1.3.1. Technical Specifications & Performance Parameters

Parameter	Specification
Dead Volume (V <sub>0</sub> )	4.0 µL (microliters)
TDS Tolerance	Up to 20% (highest among glass nebulizers)
Particle Tolerance	Up to 200 µm (depending on model)
Material	High-quality borosilicate glass
Precision Level	High precision analytical performance

### 1.3.2. Part Number Identification System

Understanding SeaSpray DC part numbers enables you to select the optimal nebulizer configuration for your specific instrument and application requirements. The SeaSpray is our most popular nebulizer and is available for any ICP-OES or ICP-MS instrument.

#### Example: A13-07-USS2

- **A13:** Agilent connector prefix
- **07:** 0.7 L/min argon flow rate
- **USS:** SeaSpray U-Series designation
- **2:** 2.0 mL/min nominal sample flow rate

### 1.3.3. Operating Conditions Optimization

- 1. Argon Flow Rate:** Nebulizer gas flow is very important for optimal nebulizer performance; the best nebulization efficiency occurs at a gas flow rate close to the specified value, as shown in the nebulizer product number and detailed in section 1.3.2. Most of Glass Expansion's nebulizers are designed to operate at an optimal back pressure of 40 psi, which is reached when the argon flow is set to the specified L/min indicated in the part number. This pressure corresponds to the gas velocity required for efficient aerosol generation, providing an optimal balance between droplet size, transport efficiency, and spray stability, thereby improving sensitivity and precision.
- 2. Sample Flow Rate:** All of Glass Expansion's concentric nebulizer designs will self-aspirate at a nominal sample flow rate as indicated in the nebulizer part number (e.g., 2.0 mL/min – Section 1.3.2.). This rate is standardized using Deionized (DI) water. However, the actual uptake depends on the sample's viscosity. It also depends on the capillary tubing length and inner diameter (ID), the sample height, and the nebulizer gas flow rate. A detailed self-aspiration table is available in the Nebulizer Resource Guide.<sup>22</sup>

The most common method for sample delivery with modern ICP instruments is using a peristaltic pump or a high-precision syringe drive. When selecting a SeaSpray model, choose one that matches your sample flow rate range. The nominal sample flow rate (e.g., 2.0 mL/min) is a typical starting point. It is not a fixed requirement. The SeaSpray performs optimally over a range of flow rates. This differs from other high-TDS nebulizer models, which require fixed, higher sample flow rates to operate efficiently.

The recommended sample flow rate range for each SeaSpray nebulizer example is shown in the table below. These recommended ranges apply to the SeaSpray and to all our 2.0, 1.0, and 0.4 mL/min concentric nebulizer models. You can rinse and uptake at much higher flow rates for short periods. However, it's important to allow enough stabilization time for the flow rate and nebulization efficiency to return to normal measurement conditions.

SeaSpray Product Number	Recommended Sample Flow Range
A13-07-USS2	0.4 to 3 mL/min
A13-07-USS1	0.4 to 2 mL/min
A13-1-USS04	0.05 to 1 mL/min

### 1.3.4. Sample Preparation Guidelines

1. **High TDS Sample Handling:** For samples with TDS >5%, use an argon humidifier, such as the Elegra<sup>3</sup>, to reduce solvent evaporation in the sample introduction system. Although the SeaSpray can handle up to ~20% TDS without immediate blockage, using an argon humidifier is recommended to minimize gradual salt deposition at the nebulizer tip and injector. This helps maintain signal stability, reduce drift, and extend maintenance intervals by minimizing salt crystallization.

[Click here](#) or scan the QR code to view the Elegra™ landing page to learn more.



2. **Particle Filtration:** Although the SeaSpray nebulizer can tolerate particles up to 200 µm without immediate blockage, pre-filtration through 0.45 µm filters is recommended to maximize lifetime and reduce instrument downtime due to particulate accumulation. While larger particles may pass through the nebulizer, finer particles can contribute to a gradual build-up at the nebulizer, within the capillary tubing, the switching valve, or the sample probe. This type of blockage will affect the long-term stability and overall efficiency of your laboratory, as it will lead to lost time troubleshooting the source of the blockage. Even when samples are filtered post-digestion, additional safeguards, such as the Guardian In-Line Sample Filter and Guardian Autosampler Probe, can help prevent accidental blockages caused by particulates introduced during sample handling or contamination from the laboratory environment prior to or during analysis, leading to improved efficiency and increasing the lifetime of your ICP sample introduction system.

[Click here](#) or scan the QR code to view the Guardian™ In-Line Filter landing page to learn more.



[Click here](#) or scan the QR code to view the Guardian™ Autosampler Probe landing page to learn more.



3. **Sample Matrix Matching:** Match the matrix of your calibration standards to that of your samples to ensure optimal accuracy. Variations in matrix composition can influence aerosol formation, transport efficiency, and plasma ionization conditions, potentially resulting in matrix-induced signal suppression or enhancement. Matrix matching helps to compensate for these effects, leading to more accurate and reproducible results.

### 1.3.5. Maintenance and Troubleshooting

1. **Daily Maintenance:** Always start and finish the use of a nebulizer by nebulizing a mildly acidic blank solution followed by demineralized water for a couple of minutes. This ensures that sample deposits or crystals don't form inside a nebulizer when the solvent inside the nebulizer dries out. Never attempt to clean nebulizers in an ultrasonic bath. If a concentric nebulizer's sample capillary becomes blocked, use the Eluo nebulizer cleaner to clean and unblock the nebulizer. The Eluo can also be used regularly to clean and maintain the nebulizer. Nebulizer blockages generally occur at the tip and can be difficult to spot without magnification. We recommend using the Magnifier Inspection Tool (P/N [70-803-1923](#)) to check for foreign objects, or a build-up of salt around the tip orifice.

[Click here](#) or scan the QR code to view the Eluo™ landing page to learn more.



[Click here](#) or scan the QR code to learn more about nebulizer maintenance.



2. **Weekly Deep Clean:** Soak the nebulizer tip in a 25% solution of Fluka™ RBS™ 25 for 24 hours. Use the Eluo to make sure the Fluka™ solution fills the nebulizer. An initial flush of 25% Fluka™ using the Eluo may be required. Flush 3 times with warm water using the Eluo. Stubborn deposits may require an additional soaking for 2 hours with nitric acid (5% concentration). Flush 3 times with warm water using the Eluo. For faster drying, flush again with methanol or isopropyl alcohol.
3. **Performance Monitoring:** Track signal intensity, analytical precision (%RSD), and nebulizer backpressure. Any changes can be an indication that your nebulizer requires maintenance, either cleaning or replacement of fittings. A detailed troubleshooting guide can be found in the Nebulizer Resource Guide, p. 18-19.<sup>22</sup>

## 1.4. Advanced Features and Connectivity

### 1.4.1. Direct Connection (DC) Technology

The DC designation indicates that the SeaSpray nebulizer comes equipped with instrument-specific gas connectors that attach directly to your ICP system, eliminating the need for additional tubing or adapters.

- UniFit Sample Connector: Slides easily over the sample arm for secure, leak-free connection
- Instrument-Specific Gas Fittings: Pre-configured for direct connection to major ICP manufacturers
- Zero Dead Volume Integration: Compatible with LC, IC, or HPLC systems using the Nexus Universal Nebulizer Kit

### 1.4.2. UniFit Flangeless Connectors for High Throughput Valves

These UniFit Flangeless Connectors are designed to connect any Glass Expansion U-Series or DC type SeaSpray nebulizer directly to the most common types of high throughput OEM valve systems. Each connector features an optimized inner diameter (ID) and length to minimize the sample path, uptake time, and stabilization time.

#### Benefits of UniFit Flangeless Connectors:

- Completely inert (metal-free) assembly
- Secure UniFit connection to the Glass Expansion nebulizer sample inlet
- Ratchet style fitting provides a torque-controlled seal to the nebulizer port on the valve
- Optimized ID and length to minimize sample path, uptake time, and stabilization time

The table below lists the most common recommendations based on the OEM valve and ICP model. If your ICP or OEM valve is not listed in the table below please contact Glass Expansion and we can help you find the most suitable connector for your setup or we can create a new product to suit your needs.

Compatibility Chart	
UniFit Flangeless Connector	Recommended ICP
70-803-2841	PerkinElmer® NexION® 1000/2×00/5000
70-803-2842	PerkinElmer® Avio® 2×0/5×0, Optima™, & NexION® 300/350
70-803-1888	Agilent® 5000 Series ICP-OES (with AVS 6/7)
70-803-2882	Agilent® ICP-MS (with prepFAST or FAST – 30 cm)
70-803-2883	Agilent® ICP-MS (with prepFAST or FAST – 50 cm)
70-803-1161	Agilent® ICP-MS (with PCC & AVS MS or ADS 2)
70-803-2882	Thermo Fisher Scientific™ Q/RQ/TQ & MX ICP-MS (with prepFAST or FAST)

## 1.5. Conclusion and Key Takeaways

The SeaSpray™ DC nebulizer's exceptional reliability and performance translate directly to cost savings that typically pay for the investment within weeks. Its superior tolerance to high-TDS samples and resistance to clogging minimize unscheduled downtime, while the consistent analytical results reduce the need for costly re-runs and sample repeats, maximizing laboratory productivity and profitability. The SeaSpray™ DC nebulizer represents the optimal choice for laboratories requiring:

- Maximum sensitivity for trace-level analyses
- Tolerance to high dissolved solids content (up to 20% TDS)
- Compliance with EPA and ASTM standard methods
- Consistent performance, minimal maintenance and maximum uptime
- Easy integration with existing ICP systems

By following the best practices outlined in this tutorial and understanding the unique advantages of the SeaSpray DC design, you can maximize the analytical performance of your ICP system while ensuring compliance with regulatory requirements and achieving optimal data quality.

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## 1.6. References

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