

### Summary

The Savillex C-Flow 700d (C700d) is a concentric PFA nebulizer designed specifically for ICP-OES, combining extreme matrix tolerance and unmatched chemical inertness with high sensitivity and precision.

The C700d features a large bore, constant ID sample uptake path from sample to nebulizer tip for maximum resistance to blockages. It can handle total dissolved solids (TDS) levels up to 25% and 80  $\mu\text{m}$  diameter particles. The C700d is optimized for use at 0.6 SLPM carrier gas flow, and while it can free aspirate, it is designed to be pumped and can operate from 0.2 to 1.2 mL/min sample uptake rate. Molded from high purity virgin PFA, the C700d is chemically inert and offers several unique features not found in other inert nebulizers. Its two-piece precision molded design allows precise optimization of back pressure during manufacture for reproducible high performance. It also features an inner body that supports the capillary all the way to the tip, making it more robust and giving it a longer lifetime compared to other PFA nebulizers. And because the capillary is supported at the tip, the C700d can be easily and safely backflushed – without the need for tools.

A removable sample uptake line connects to the body using Savillex's unique zero dead volume connector, which assures reproducible connections with very fast washout for high sample throughput. An 80 cm long uptake line is included. The C700d has a 6 mm OD body that fits all common spray chamber end caps and a screw threaded PFA gas inlet fitting gives a reliable carrier gas connection and includes a range of adapters to connect to common gas line sizes.

The C700d is part of Savillex's d-type (removable uptake line) nebulizer range. Like all Savillex nebulizers, d-type nebulizers are designed, molded and assembled by Savillex, and the design of the d-type nebulizers has enabled a significant reduction in assembly time and subsequent cost reductions. As a result, Savillex d-type nebulizers offer all the benefits of PFA nebulizers, plus additional unique features, all at a price point lower than other PFA nebulizers.

Combining high performance and ruggedness with fast washout, high matrix tolerance, chemical inertness and long lifetime, all at an excellent price point, makes the C700d the ideal choice for ICP-OES use with HF-containing samples.



*Savillex C700d Concentric Nebulizer, Demounted*



*Savillex C700d Concentric Nebulizer*

## C-Flow Design - Body

Unlike all other PFA nebulizers, the C-Flow is unique in that the body assembly is comprised of two molded PFA parts: an outer body and an inner body that supports the capillary. Saville's molding expertise allows for the parts to be manufactured to extremely tight tolerances. The photograph below shows the two components prior to assembly. Note the quality of the molding and finish. The 4 mm nebulizer gas fitting is shown connected to the outer body.



*C-Flow Nebulizer Prior to Assembly;  
Showing Outer Body and Inner Capillary Support*

## C-Flow Tip Design

The C-Flow is unique among PFA nebulizers in that the capillary is physically supported all the way to the inside of the nebulizer tip and the capillary is positioned centrally within the body, making it the only PFA nebulizer that is a true concentric nebulizer. The design requires highly accurate moldings to ensure the inner support axially aligns with the orifice. Saville's unique molding expertise and design capabilities make this possible. Because the capillary is positioned with very high accuracy and precision, performance variability is much lower than with other PFA nebulizer designs.

A schematic diagram of the nebulizer is shown in the drawings below. Ar carrier gas flows around the inner support, forming an annular gas stream around the end of the capillary. The capillary protrudes into space behind the tip, several mm from the orifice itself. As sample liquid exits the capillary, the annular gas stream shears the liquid, causing prefilming around the entire inner circumference of the tip. Liquid/gas interaction and energy transfer is optimized, resulting in a very fine aerosol with narrow droplet size distribution. The high, annular gas velocity around the end of capillary also prevents salt deposition – even with very high TDS solutions.

The tip design provides several key benefits:

- Excellent reproducibility from nebulizer to nebulizer
- High sensitivity due to efficient gas/liquid energy transfer and fine aerosol
- Extremely resistant to salt deposition
- Longer lifetime than other PFA nebulizers, because the capillary is physically supported at the tip so its axial position is very stable.
- Rugged – can be backflushed without damaging the nebulizer

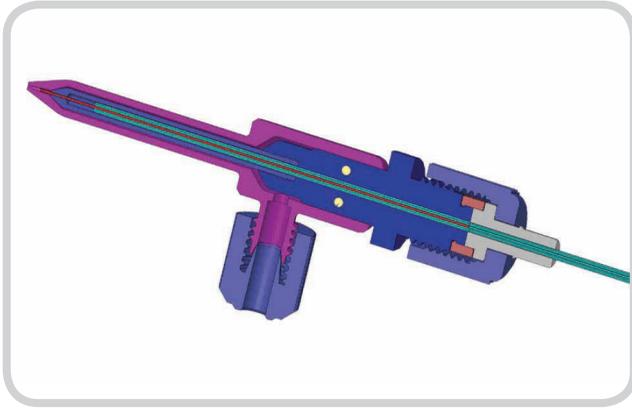


Figure 1 C-Flow - Inner Support Shown in Blue

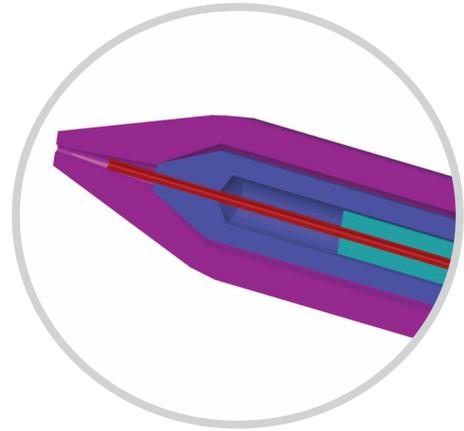


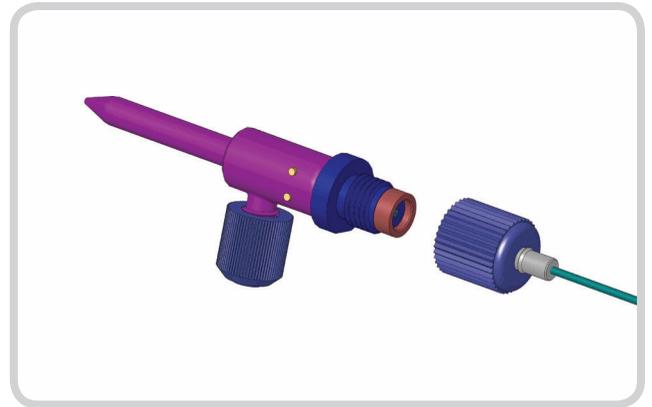
Figure 2 Nebulizer Tip - Capillary Shown in Red

### Savillex PFA Zero Dead Volume Connector

Like other general purpose nebulizers, the C700d features a removable uptake line (d-type). A common problem with nebulizer uptake line connectors, however, is dead volume caused by small voids, leading to increased washout and memory. Poor reproducibility of alignment following disconnection and reconnection can also be a problem with screw type connectors. For the d-type nebulizers, we designed the ultimate zero dead volume connector. The uptake line is secured to the nebulizer body by a threaded connector, which is captive on the uptake line.

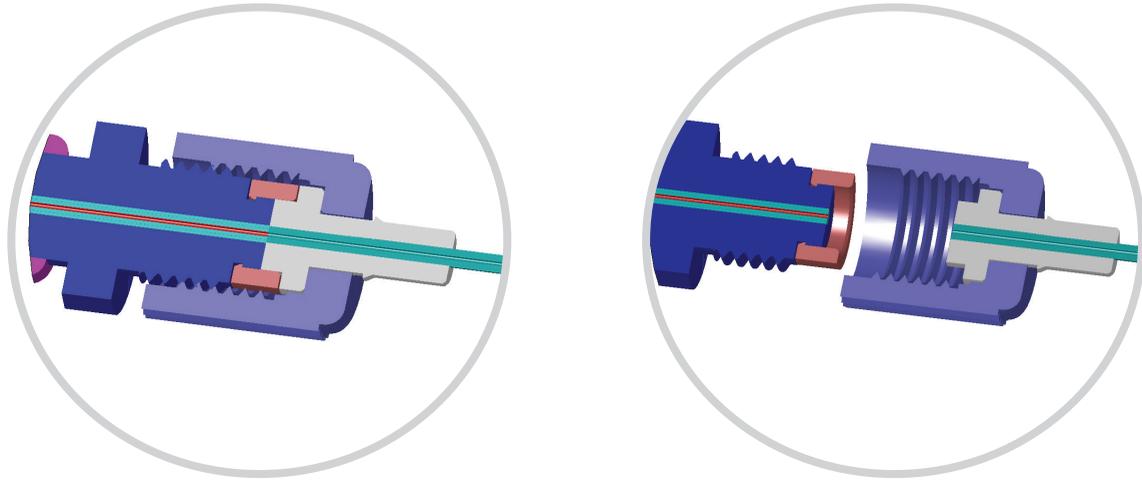


C700d Showing Uptake Line Connected



C700d Showing Uptake Line Disconnected

A PFA fitting, bonded to the uptake line, locates into a PFA ring on the back of the nebulizer body, which ensures that the uptake line and capillary inside the nebulizer body are precisely aligned every time. The mating faces of the connector are smooth and perfectly flat, eliminating voids that could cause washout or memory issues – a significant benefit for high throughput labs. All components are PFA.



*C700d Connector – Close Up Showing Locating Ring Shown in Brown*

### **Large Bore Sample Uptake Path**

The capillary ID of the C700d is 0.3 mm – larger than any other PFA nebulizer and most glass nebulizers. And unlike other PFA nebulizers, the capillary ID inside the nebulizer is uniform all the way to the tip. The uptake line ID is also 0.3 mm, resulting in a constant ID flow path from sample to nebulizer tip, ensuring exceptional resistance to blockages. Very high TDS and particulate containing samples can be aspirated over long periods without deposition or clogging.

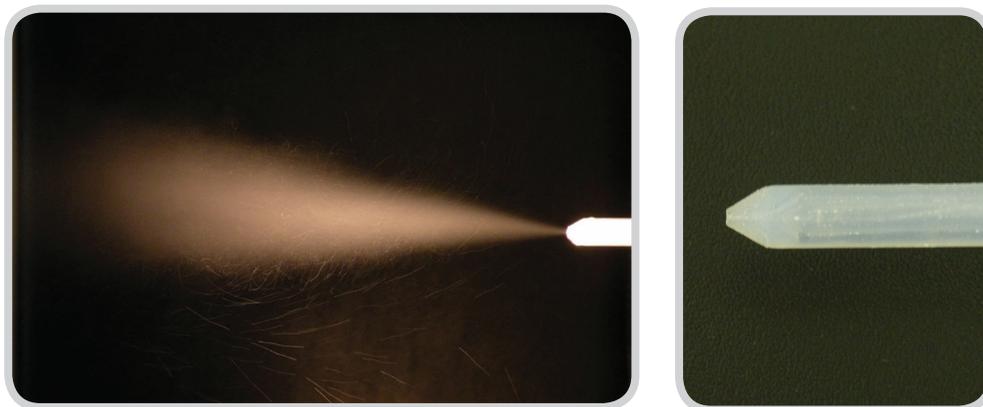
If a blockage should occur, the C700d can be easily cleared by backflushing with nebulizer gas. With the nebulizer gas flowing, a gloved finger is placed over the nebulizer tip, forcing gas back down the capillary and uptake line. Because the capillary is supported at the tip, it is not damaged by backflushing. And because there is no ID reduction at any point in the uptake line, any blockage would occur at the end of the tubing connected to the autosampler.



*Clearing a blockage by backflushing a C-Flow – no need for tools or wires. Simply place a gloved finger over the tip while Ar nebulizer gas is flowing.*

## High Sample Matrix Capability

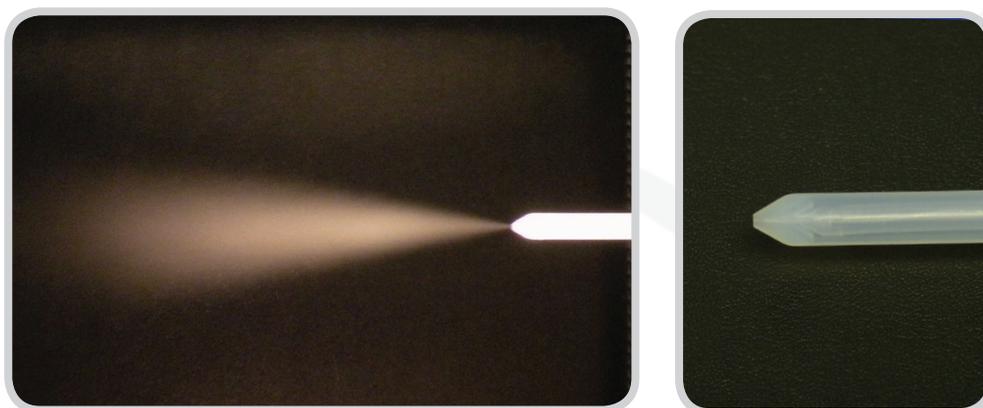
A C700d was pumped at approx. 400 uL/min with a peristaltic pump. The nebulizer aspirated NaCl solution from a container on a balance. The rate of aspiration of the salt solution was calculated by measuring the weight loss of the container with time, measured at intervals over four hours. The experiment was carried out with 25% w/v NaCl solution (saturated solution). No humidifier was used. As can be seen from the consistent flow rate, no clogging or salt deposition occurred. The photographs below show the aerosol produced by aspiration of 25% NaCl solution, taken after four hours, and also the nebulizer tip directly after the completion of the experiment. No deposits were observed.



*Aerosol of 25% w/v NaCl solution (left) and nebulizer tip (right) – both after four hours*

25% Salt Solution	
Time (hours)	Uptake Rate (g/min)
0	0.487
0.5	0.482
1	0.481
1.5	0.480
2	0.478
2.5	0.478
3	0.475
3.5	0.474
4	0.475

A second experiment, designed to test the capability of the nebulizer to aspirate particulate containing samples was performed. Using the same set up as the salt test, the nebulizer aspirated a 5% solution of a NIST-traceable Megabead particle size standard containing 80uM diameter polystyrene microspheres. The solution was pumped at approx. 400 uL/min and the weight loss of the container was measured over four hours. The rate of aspiration of the particle solution was calculated by measuring the weight loss of the container with time. Photographs of the aerosol produced by the particle standard solution and the nebulizer tip after four hours are shown below. As can be seen, the solution aspirated cleanly with no loss in aspiration rate over the test period, demonstrating the ability of the C700d to handle samples containing particles up to 80 uM in diameter. The TDS and particulate handling capability of the C700d meets or exceeds the specification of any high solids concentric nebulizer.



*Aerosol of 5% w/v 80uM Megabead particle standard (left), and nebulizer tip (right) – both after 4hrs.*

80 uM Particulate Solution	
Time (hours)	Uptake Rate (g/min)
0	0.409
0.5	0.407
1	0.405
1.5	0.405
2	0.402
2.5	0.401
3	0.399
3.5	0.398
4	0.400

### Cleanliness and Chemical Compatibility

The C700d is designed, molded and manufactured in house at Savillex. Savillex uses only the purest grades of PFA resin. These grades have the lowest leachable trace metals levels of any injection molding grade PFA resin. Also, the chemical compatibility of PFA is higher than any other material including PEEK. In addition to concentrated HF, PFA is resistant all other concentrated mineral acids, and to every organic compound except certain halogenated complexes containing fluorine.

### Operating Parameters

Nominal free aspiration rate is 700 uL/min at 0.6 SLPM gas flow, but the C700d can be pumped at any flow rate from 0.2 – 1.2 mL/min. Its high efficiency generates high signal sensitivity: pumped at 1.2 mL/min in ICP-OES applications, the sensitivity of the C700d is equivalent to glass nebulizers pumped at 2 mL/min.

### Ordering Information

Item	Part Number
C700d Nebulizer, with 80 cm Uptake Line	800-2-070-01-00
Replacement Uptake Line for C-Flow d-Type Nebulizer (80 cm)	830-050