

### Summary

The C-Flow 700d is the first truly universal nebulizer – tolerant of very high matrix samples and with a wide sample uptake range, in addition to the usual C-Flow benefits of high sensitivity, ultralow blank, zero dead volume, fast washout and unmatched chemical inertness. The C-Flow700d also has a removable uptake line for complete flexibility in application, and features SavilleX's new PFA zero dead volume connector – specially designed for the C-Flow 700d. Unique among nebulizers with removable uptake lines, the C-Flow 700d features a large bore, constant ID sample uptake path from sample to nebulizer tip for maximum resistance to blockages. While it can free aspirate, the C-Flow 700d is designed to be pumped and can operate from 0.2-1.2mL/min sample uptake rate. The C-Flow 700d also operates over a wide range of gas flow rates – from 0.6-1 SLPM, making it equally suited to both ICP-OES and ICP-MS.



## C-Flow Design - Body

Unlike all other PFA nebulizers, the C-Flow is unique in that the body assembly is comprised of two parts: an outer body and an inner support (both are molded PFA) that supports the capillary. Savillex'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 4mm nebulizer gas fitting is shown connected to the outer body.



*C-Flow nebulizer prior to assembly, showing outer body and inner capillary support.*

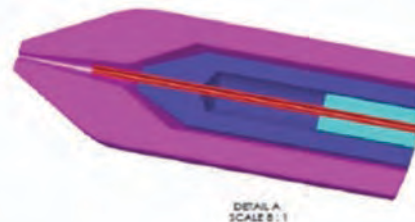
## C-Flow Tip Design

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. Savillex's unique molding expertise and design capabilities make this possible. Because the capillary is positioned with very high accuracy and precision, the free aspiration uptake variability is much lower than with other PFA nebulizer designs. The benefits of the unique tip design of the C-Flow are apparent at ultra low flow rates where reproducibility in performance becomes even more critical.

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 total dissolved solids (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
- Reliable, reproducible performance even at ultra low flow rates
- 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.



## Savillex PFA Zero Dead Volume Connector

Like other general purpose nebulizers, the C-Flow 700d features a removable uptake line. A common problem with nebulizer uptake line connectors, however, is dead volume caused by small voids, leading to increased washout and memory problems. Poor reproducibility of alignment following disconnection and reconnection can also be a problem with screw type connectors. For the C-Flow 700d, 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.



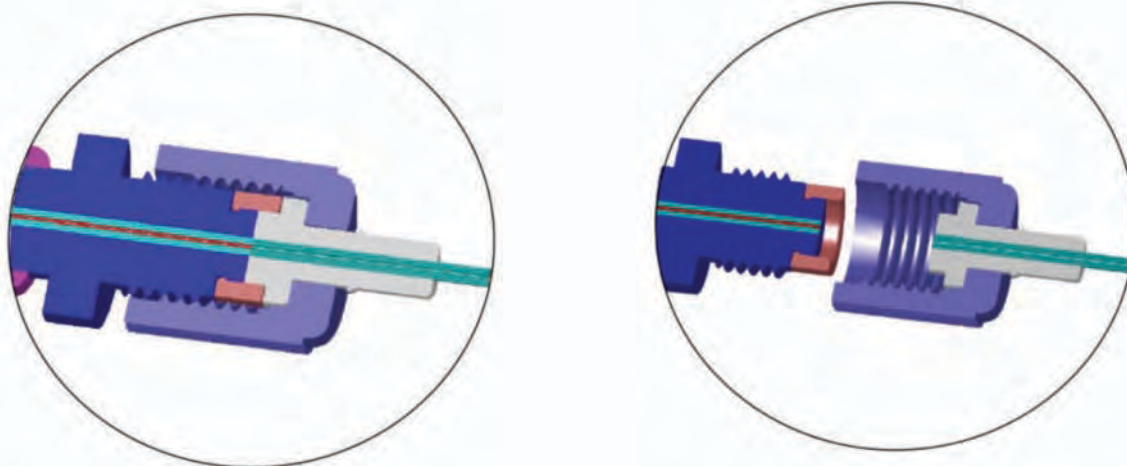
*C-Flow 700d showing uptake line connected*



*C-Flow 700d 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.





*C-Flow 700d connector – close up showing locating ring (brown)*

## Large Bore Sample Uptake Path

The capillary ID of the C-Flow 700d is 0.3mm – 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 0.3mm, 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 C-Flow 700d 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 C-Flow 700d was pumped at approx. 400uL/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 4 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 4 hours, and also the nebulizer tip directly after the completion of the experiment. No deposits were observed.

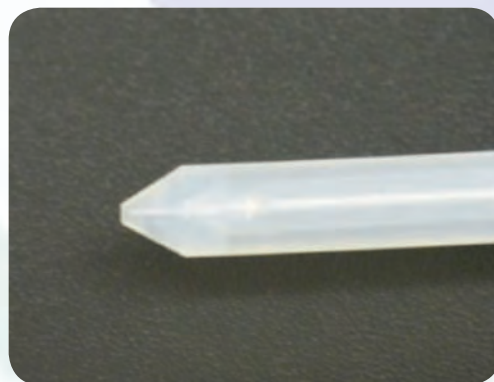
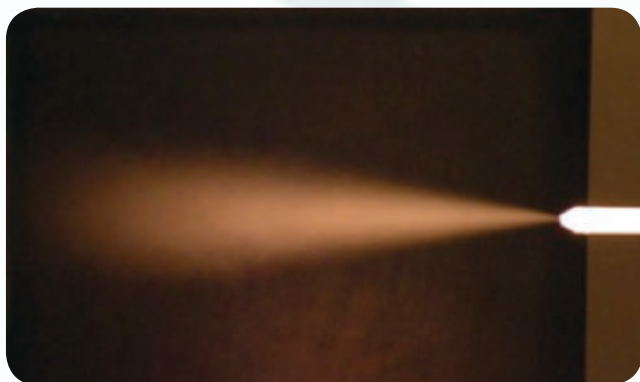
25% Salt Solution	
Time (hrs)	Uptake rate (g/min)
0	0.487
0.5	0.482
1	0.481
1.5	0.480
2	0.478
2.5	0.478
3	0.475
3.5	0.474
4	0.475



Aerosol of 25% w/v NaCl solution. (left), and nebulizer tip (right) – both after 4hrs.

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. 400uL/min and the weight loss of the container was measured over 4 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 4 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 C-Flow 700d to handle samples containing particles up to 80uM in diameter. The TDS and particulate handling capability of the C-Flow 700d meets or exceeds the specification of any high solids concentric nebulizer.

80uM Particulate Solution	
Time (hrs)	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



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

## Cleanliness and Chemical Compatibility

The C-Flow 700d 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 blow molding grade PFA resin. Unlike borosilicate glass nebulizers which generate a very low, but measurable (by ICP-MS) contribution to the boron background, the C-Flow does not generate any measureable background contribution. 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 700uL/min at 1 SLPM gas flow, but the C-Flow 700d can be pumped at any flow rate from 0.2 – 1.2mL/min. Its high efficiency generates high signal sensitivity: pumped at 1.2mL/min in ICP-OES applications, the sensitivity of the C-Flow 700d is equivalent to glass nebulizers pumped at 2mL/min. In addition, the C-Flow 700d can be operated from 0.6 – 1 SLPM gas flow, making equally suitable for both ICP-OES and ICP-MS. The C-Flow 700d is supplied with an 80cm long uptake line and its 6mm OD body fits all standard spray chambers and end caps.

## Ordering Information

C-Flow 700d nebulizer, with 80cm uptake line

Part number 800-2-070-01-00

Replacement uptake line for C-Flow 700d (80cm)

Part number 830-050

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