

SAGE ACTION, INC.

PRECISION AIRFLOW VISUALIZATION SYSTEMS

SAI™ Model 5

Helium Bubble Generator



USER MANUAL

Setup, Operation, Calibration & Specifications

sageaction.com

Table of Contents

What Is a Helium Bubble Generator?3

Description & Components.....3

Setup & Operation6

Filling the BFS Cylinder9

Operating Suggestions.....9

Shutdown10

Precautions.....11

Specifications.....11

Initial Calibration.....13

What Is a Helium Bubble Generator?

Airflow visualization is a powerful tool for understanding complex aerodynamic phenomena. It can save valuable time when evaluating design configurations and makes test data far easier to interpret. Flow velocities can be measured by tracking the motion of discrete particles — or groups of particles — that don't diffuse into the surrounding air.

The SAI™ Helium Bubble Generator is a compact, purpose-built tool that produces helium-filled, neutrally buoyant bubbles of controlled size for airflow visualization. The bubbles can trace airflow patterns at speeds up to 60 m/s. Because they follow flow streamlines, they rarely collide with objects in the airstream and are highly durable — for example, they pass through fans and blowers with ease.

Conventional lighting can be used to photograph or record bubble motion in low-speed flows. For better results at higher speeds, we recommend the SAI Basic Light; for illumination combined with velocity measurement, we recommend the SAI Modulated Arc Lamp.

Key Features

- **Superior Tracing of Air Motions** — The helium-filled bubbles follow complex laminar and turbulent airflows that no other technique can trace.
- **Ease of Operation** — The console is designed for simple operation almost anywhere. Fine-control metering valves on the panel adjust bubble size, specific weight, and generation rate.
- **Safe Operation** — The bubble film solution is non-toxic and non-corrosive, allowing for clean, safe operation.
- **Quality of Construction** — Quality components ensure high reliability and durability.

Description & Components

The SAI™ Model 5 Bubble Generator is a compact, purpose-built tool for visualizing complex airflow patterns. It produces helium-filled, neutrally buoyant bubbles of uniform size — adjustable from 1 mm to 4.5 mm in diameter — simultaneously from one or two outputs. These bubbles trace intricate air motions without bursting or disturbing objects in the airflow.

The Model 5 supports up to two Plug-In Heads, each paired with a Mini-Vortex Filter. Together, the Plug-In Head and Mini-Vortex Filter provide the most advanced method for generating clean, high-rate, neutrally buoyant bubbles in a compact space.

External sources of helium and air are required. The control console accurately meters helium, air, and BFS (Bubble Film Solution) flow to the Plug-In Heads, which generate the bubbles. BFS is stored in a tank below the console panel; pressure from the helium circuit drives BFS from the internal tank to the Plug-In Heads.



Figure 1 — The SAI Model 5 case, fully equipped with Plug-In Heads, Mini-Vortex Filters, wands, tubing, and accessories.

The Plug-In Head consists of two stainless steel hypodermic tubes, one inside the other, mounted in a cantilever fashion to a cylindrical manifold body (Figure 2). Helium passes through the inner tube, and BFS passes through the annulus between the inner and outer tubes, forming helium-filled bubbles at the tip. A larger, concentric air jet then continuously blows the bubbles off the end of the outer tube as they form.

Some bubbles produced this way are too heavy, and some are too light. The Mini-Vortex Filter removes these unwanted bubbles. It's a clear plastic cylinder that uses the air jet exiting the Plug-In Head to create a rotational, cyclonic motion inside. The resulting radial forces trap any bubble that isn't neutrally buoyant.

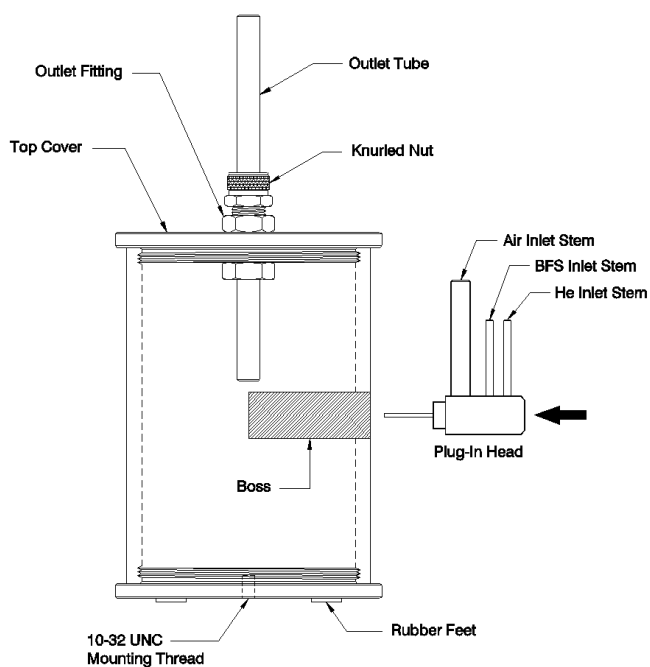


Figure 2 — Mini-Vortex Filter and Plug-In Head assembly.

The control panel is mounted on the left side of the case, with the Mini-Vortex Filters and Plug-In Heads in the middle. The right side holds outlet tubing, the Variable-Speed Wand Nozzles, the beaker, the funnel, and other accessories. The case's top cover holds the four stainless tubes that attach to the wand nozzles, letting you implant bubbles into the flow in a variety of ways.

Console Panel

Labeling on the control panel makes every valve and fitting easy to identify (Figure 3). From left to right, the columns are HELIUM, BFS, and AIR. At the top of the panel, the fittings marked IN are the console inlets — the helium and air supplies connect here via quick-connect fittings. The large center fitting is the BFS fill port.

Below each inlet is a toggle valve that turns the supply flow to the Plug-In Heads on or off. A valve is open when its handle is perpendicular to the panel and closed when it is parallel to the panel.

Below the toggle valves are two rows of micro-metering valves, labeled OUT 1 and OUT 2, which regulate the flow of each constituent to the Plug-In Heads. Vernier scales on the metering valve handles let you precisely reproduce a desired flow rate.

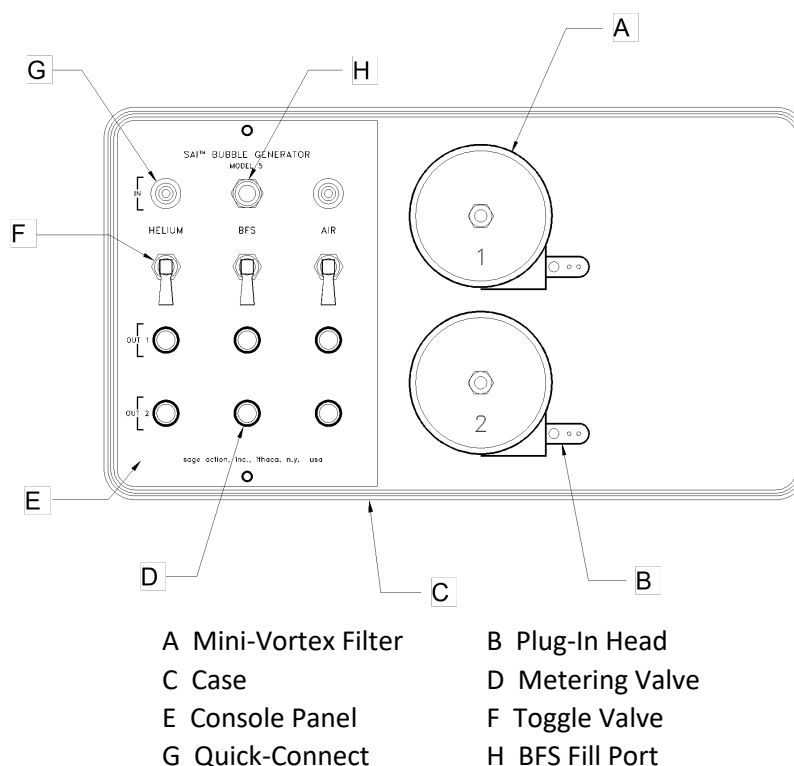


Figure 3 — Console panel layout: HELIUM, BFS, and AIR columns (left to right); IN fittings and toggle valves at top; OUT 1 and OUT 2 micro-metering valves feeding Mini-Vortex Filters 1 and 2.

Tubing & Case

Constituents travel from the console panel to the Plug-In Heads through co-joined PVC tubing (paratubing). Each paratubing line connects to the inlet stems on the Plug-In Head — two lines are 2.4 mm I.D., and one is 25.4 mm I.D. The complete unit — control console, Plug-In Heads, Mini-Vortex Filters, and accessories — is packaged in a

durable, easy-to-carry case. The console is simple to operate wherever helium and compressed air are available, and disassembles easily for cleaning, maintenance, and repair.

Setup & Operation

1. Place the Suitcase Console bottom-side down on a flat surface, release the two front latches, and fully open the cover.
2. Use the provided beaker and funnel to fill the BFS tank with 250 mL of SAI 1035 Bubble Film Solution. Don't overfill the BFS cylinder — excess solution can leak into the helium line. See “Filling the BFS Cylinder” for detailed instructions.
3. Connect the external helium and air supplies. The Hook-up Kit included with the unit has 1/4" NPT male fittings on one end of each nylon tube and male quick-connect fittings on the other. Connect the NPT fittings to the outlet ports of the external supply regulators first, then insert and seat the quick-connect fittings into the matching female fittings at the top of the console panel. Insert an air filter if needed to keep dirt, oil, or water out of the air circuit. The green line is for air, and the black line is for helium. Note: If you're using the Auxiliary Air & Helium Supply, its supply lines are stored in its case.

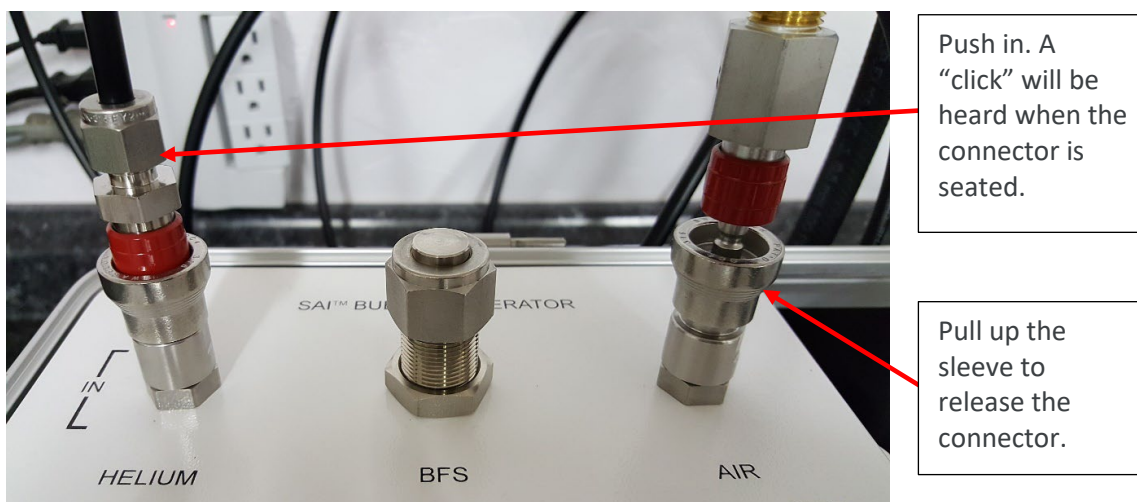


Figure 4 — HELIUM, BFS, and AIR inlet fittings on the console panel.

4. As shipped, the Plug-In Heads come in a compartmented plastic box. Press-fit each Plug-In Head into its boss on the corresponding Mini-Vortex Filter — the rear head/filter pair is OUT 1, and the front pair is OUT 2. Arrange the Plug-In Head inlet stems so they point upward. Route the console panel's paratubing lines ahead of each filter, looping them gently upward and back down to the inlet stems to avoid kinks.
5. Push each piece of paratubing onto the correct inlet stem of each Plug-In Head, about 6 mm. The inlet stems are the three parallel tubes perpendicular to the head body. Fit the larger-diameter air tubing onto the black stem first, then the BFS tubing onto the central stainless-steel stem, and finally the helium tubing onto the remaining stainless-steel stem. Note: store the BFS line plug in one of the holes on the Mini-Vortex Filter cover.

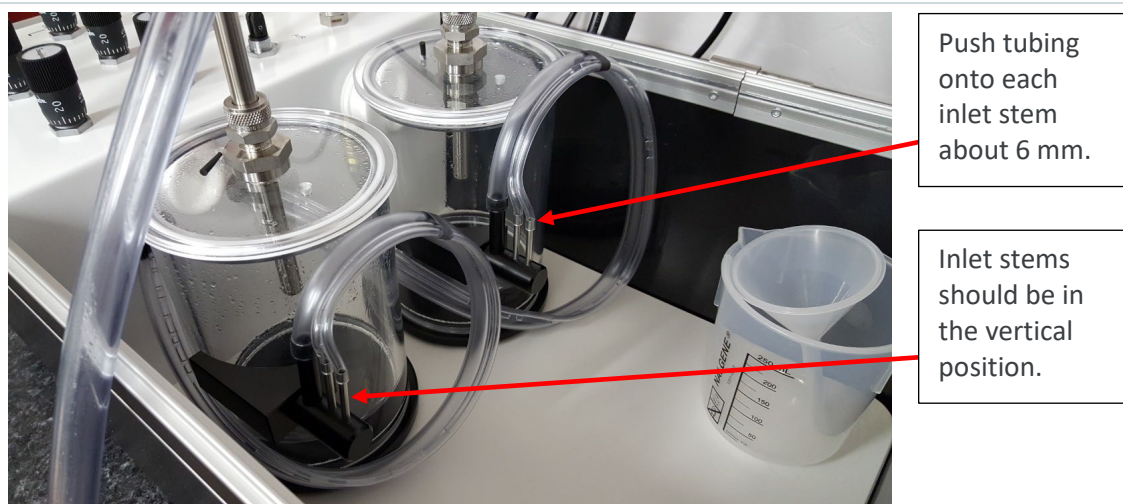


Figure 5 — Mini-Vortex Filters connected with looped paratubing lines, ready for operation.

6. Set the height of each Mini-Vortex Filter's stainless steel outlet tube by loosening the knurled nut on the filter's top cover. For regular use, position the bottom of the outlet tube halfway down into the filter, then retighten the knurled nut finger-tight. See Figure 2.
7. The calibration sheet for one- or two-Plug-In-Head operation is in “Initial Calibration” at the end of this manual. Open the micro-metering valves to the settings for the number of heads in use. Each valve's micrometer handle measures needle-stem displacement; one full revolution opens the stem 0.025".

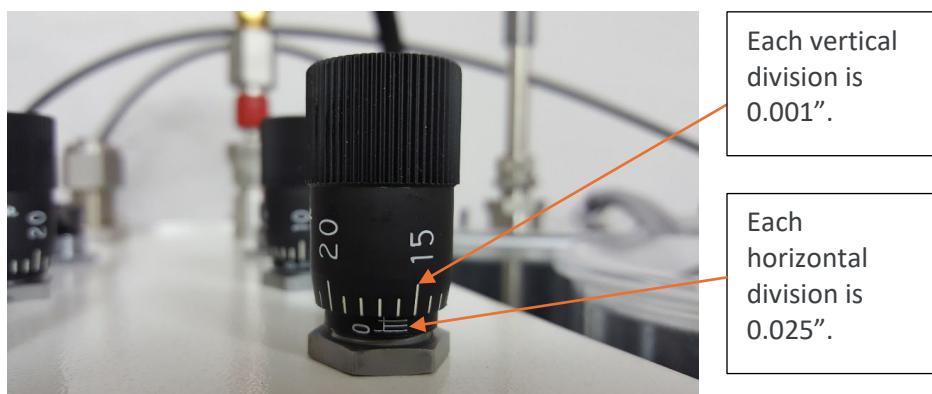


Figure 6 — Micro-metering valve with Vernier scale for precise, repeatable flow settings.

8. Set the external air supply to 690 kPa and the helium supply to 140 kPa. **Note:** If using the SAI Auxiliary Air & Helium Supply, the compressor sets air pressure automatically, so no separate regulator is needed.
9. Open the BFS toggle valve and wait for the solution to reach the Plug-In Head(s) — momentarily opening the BFS micro-metering valve further will speed this up. Then open the helium toggle valve; a “white beard” of connected bubbles, about 6 mm across, will form on the filter's inner wall below the head opening.
10. Open the air toggle valve to start bubble generation. The bubbles will spin rapidly inside the filter, following a complex path to the filter's center before exiting through the outlet tube. BFS will accumulate inside the filter over time, but this doesn't affect operation until the solution reaches about 25 mm deep — see “Shutdown” to empty the excess solution.

11. Hold your hand about 100 mm above the filter outlet tube to check bubble size, quality, and quantity under direct light. Once satisfied, slide the 13 mm O.D. clear, flexible PVC tubing over the outlet tube(s).
12. Place the other end of the flexible tubing wherever you want to implant bubbles in the flow — either directly from the tubing end or using the Variable-Speed Wand(s). The Diffusing Nozzle outlet is 60 mm in diameter, and the Bubble Outlet is 12 mm; positioning the bubble outlet farther into the diffusing nozzle slows the bubbles' exit velocity.

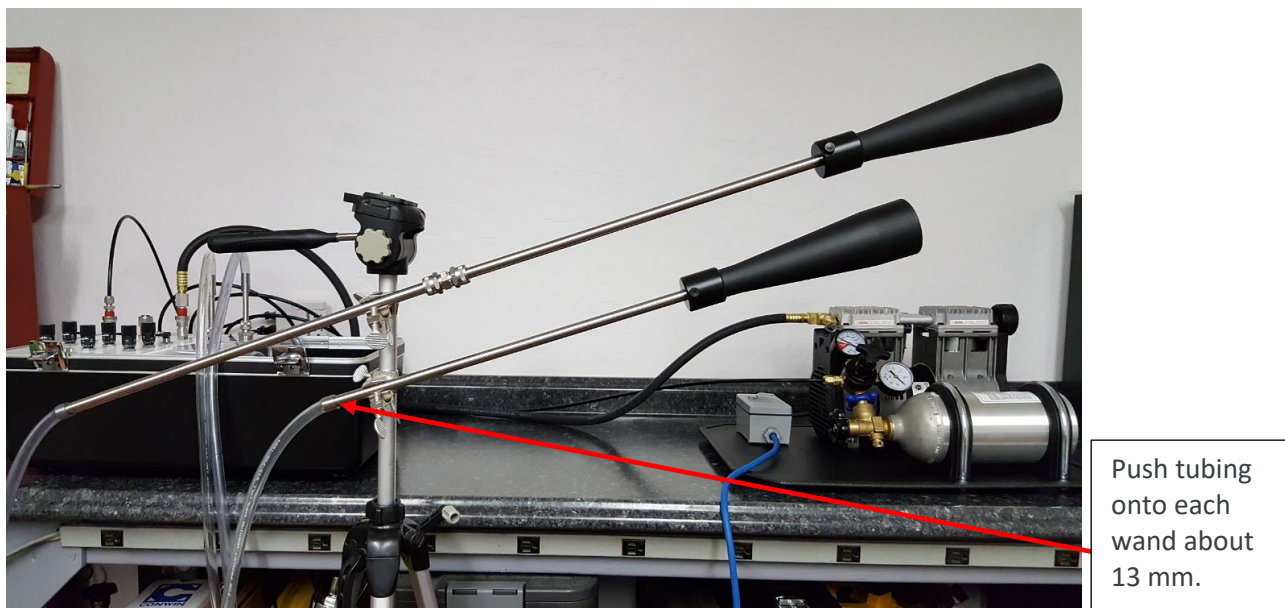


Figure 7 — Variable-Speed Wands mounted and connected for use.



Figure 8 — Variable-Speed Wand: Adjustment Knob, Diffusing Nozzle, and Bubble Outlet.

13. Experiment with where and how you introduce the bubbles into the flow. This minimizes any spurious effect from the wand's air jet and ensures a complete picture of the airflow pattern you're studying.

Welcome to the exciting world of airflow visualization with SAI™ neutrally-buoyant bubbles!

Filling the BFS Cylinder

Extensive testing has shown that SAI™ 1035 Bubble Film Solution produces superior bubbles compared to other commercial bubble solutions. Bubbles made with SAI 1035 BFS last longer, form more readily, and won't stain surfaces or clothing. Average bubble lifetime is about 2 minutes, with generation rates up to 300 bubbles per second per output. Using two outputs, a full 250 cc cylinder should last 2 to 3 hours.

1. Close the toggle valves and disconnect the helium quick-connect fitting at the top left of the console panel.
2. Using a 7/8" wrench, loosen the nut on the BFS "IN" port and let any excess helium pressure bleed out, then remove the nut.
3. Using the provided beaker and funnel, fill the BFS cylinder through the fill port with fresh BFS — the cylinder holds 250 ml, or one full beaker.
4. Replace the fill cap finger-tight, then tighten the nut another 1/8 turn with a wrench.
5. Verify the helium pressure is set to 138 kPa and re-seat the helium quick-connect fitting.
6. Open the toggle valves to resume testing, allowing time for the new solution to travel through the line and bleed out any air pockets.

Operating Suggestions

1. Adjust the micro-metering valves while introducing bubbles into still air or a low-velocity flow — this makes bubble size and neutral buoyancy easier to see. Once calibrated, only minor changes should be needed during testing.
2. To shut down temporarily, slowly close the AIR, BFS, and HELIUM toggle valves, in that order. To restart, reopen the valves in reverse order and readjust the micro-metering valves if necessary.
3. Neutrally buoyant bubbles are typically generated at the "maximum" helium flow. To find this setting, increase helium flow until bubbles stop forming, then slowly reduce it until you reach the maximum bubble generation. Note any changes from the calibrated setting on the Calibration Sheet.
4. Adjust the BFS flow rate to maintain steady bubble production — if bubbles form in spurts, increase the BFS flow rate. Generally, the lowest BFS flow rate that produces steady bubble production is best.
5. If BFS backflows into the helium lines, open the helium toggle valve, then open the corresponding micro-metering valve to 0.275" to flush out the excess BFS. Return the valve to its calibrated setting when finished.
6. Airflow setting has a strong effect on bubble release rate and diameter: lower airflow produces fewer, larger bubbles, while higher airflow produces more, smaller bubbles.
7. If bubbles collect at the tip of the head, first confirm the air supply is on and regulated, then check that the AIR column's micro-metering and toggle valves on the console panel are open and set correctly. If air still isn't reaching the head, check the paratubing lines under the console panel for kinks or disconnections.

8. If the Plug-In Head produces no bubbles, double-check that the air and helium lines are connected correctly and the pressure regulators are on and properly set. Check the BFS — a strong odor means it has deteriorated and should be replaced. Empty the BFS tank, fill it with warm water, and open the valves to flush the old solution through the Mini-Vortex Filters; then empty the filters and refill the tank with fresh SAI™ 1035 BFS.

If the head still produces no bubbles, unplug it from the Mini-Vortex Filter boss and check for dried BFS clogging the tubes. Flush the parts with warm water to clear any obstructions, and confirm the passages are clear by blowing air through the inlet tubes. Do not clean the Plug-In Head in an ultrasonic bath.

If flushing doesn't clear the passages, try a 0.014" diameter wire — sized by comparing it to the distance from the end of the BFS outlet tube to the axial location of the helium inlet tube. Carefully insert the wire into the helium outlet tube and gently work it until it reaches the base of the passage, then flush with water and blow air through as above.

Shutdown

1. Slowly close each toggle valve, turn off the external helium and air supplies, and disconnect the lines from the console panel.
2. When storing the unit, disconnect the paratubing lines from the Plug-In Heads and insert the small plastic stoppers into the BFS lines. Remove the Plug-In Heads from the Mini-Vortex Filters and flush them with warm water to prevent residual BFS from drying inside. Dry everything with a clean microfiber cloth.
3. Clean and dry the Mini-Vortex Filters. To remove them, lift out the white mounting base — it comes out easiest if you lift and tip the upper-right corner first. Thumbscrews under the base hold the filters in place; unscrew them to remove each filter, then unscrew the top and bottom covers to disassemble the base.
4. Clean any BFS residue from the console or other surfaces with warm water and a damp microfiber cloth. Don't use commercial cleaners — they can damage the surfaces.
5. Reassemble the unit carefully, making sure everything is back in its proper place.
6. Close the cover and store.

Precautions

IMPORTANT SAFETY PRECAUTIONS

- Observe all industry safety measures when working with compressed gases.
- Do not exceed a maximum operating pressure of 138 kPa for helium or 415 kPa for air.
- Limit BFS recycling to three times — beyond that, bubble production suffers.
- Maintain 25 mm of clearance between the Mini-Vortex Filter outlet tube and the liquid solution at the bottom of the filter.
- Keep all toggle valves closed when the unit isn't in service, to avoid wasting pressurized gas or BFS.
- Never turn a micro-metering valve handle past zero — doing so damages the internal valve seat, alters calibration, and affects operation.
- Always flush the Plug-In Heads with warm water if they won't be used again the next day to prevent residual BFS from drying and clogging the hypodermic tubing.
- At the end of each testing day, turn off the helium and air supplies to prevent gas loss from leakage.

Specifications

SAI™ MODEL 5 BUBBLE GENERATOR	
Bubble Generation Rate	300–400 bps/head
Bubble Diameter	1 mm – 4 mm
Bubble Life	1–2 min
Minimum Spatial Resolution	1 mm
Helium Operating Pressure	138 kPa
Air Operating Pressure	276 kPa
BFS Cylinder Capacity	250 cc
Bubble Film Solution	SAI 1035 BFS
Helium Flow Rate	200 ccm/output
Nominal Air Flow Rate	0.034 cmm/output
Nominal BFS Consumption Rate	0.85 ccm/output

Input Lines	Two 3 m L × 6 mm O.D. nylon lines (1 black, 1 green), each with a male 1/4" NPT fitting on one end for the Helium/Air regulators and a 1/4" quick-connect fitting on the other for the console panel
Console Panel	Powder-coated 1/16" thick aluminum with epoxy lettering
Console Panel Fittings	Stainless steel
Console Case	Pelican Air Case, Model 1557
Dimensions	48.7 cm L × 40.1 cm W × 26.7 cm H
Overall Weight	9 kg

SAI™ PLUG-IN HEAD DETAILS

Head Body	16 mm dia × 38 mm L, black anodized aluminum
Helium & BFS Inlet Stems	11 Ga stainless steel tube
Air Inlet Stem	8 mm O.D. × 7.1 mm I.D. black anodized aluminum tube
Helium Outlet Stem	22 Ga stainless steel tube
BFS Outlet Stem	16 Ga stainless steel tube
Weight	23 g

SAI™ MINI-VORTEX FILTER DETAILS

Mounting	Threaded ¼-20 UNC hole in base
Outlet Tubes	178 mm × 9.52 mm O.D. stainless steel
Outlet Tubing	3.8 m L × 9.52 mm I.D. clear vinyl tubing
Materials	Acrylic, Delrin, stainless steel
Overall Dimensions	115 mm dia × 178 mm H
Weight	664 g

SAI™ VARIABLE SPEED WAND DETAILS

Main Tube	4 pieces, 381 mm L × 12.7 mm O.D., two with stainless steel connector
Wand Diffuser	203 mm L with 60 mm outlet diameter
Weight	453 g / wand

Initial Calibration

This SAI Model 5 console was calibrated in our laboratory before shipment. The tables below list the Vernier micrometer valve settings that produce neutrally buoyant bubbles approximately 3 mm in diameter. Calibration was performed using SAI 1035 Bubble Film Solution with a helium supply pressure of 140 kPa and an air supply pressure of 690 kPa. Changes to these conditions may require readjustment of the listed settings.

Company: TSINGHUA UNIVERSITY

Serial No.: 26002

Date: 2 AUGUST 2026

Settings for Operating One Output

	HELIUM	BFS	AIR
OUT 1	0.007"	0.019"	0.200"
OUT 2	0.000"	0.000"	0.000"

Settings for Operating Two Outputs

	HELIUM	BFS	AIR
OUT 1	0.008"	0.019"	0.200"
OUT 2	0.008"	0.018"	0.200"