SAI MODEL 5

Helium Bubble Generator

DESCRIPTION AND OPERATING INSTRUCTIONS

WARNING: ***This equipment uses gases under high pressure. Please Read ALL of the following instructions completely before operating and follow them carefully.***

sai™ *HELIUM BUBBLE GENERATOR SYSTEMS FOR AIRFLOW VISUALIZATION*

What Is a Helium Bubble Generator?

Airflow visualization is an extremely powerful tool for gaining insight into complex aerodynamic phenomena. It can also save valuable time in the design of various configurations and provide considerable assistance in subsequent interpretation of test data. Flow velocities can be measured, too, if the visualization technique used allows the motion of discrete particles, or groups of particles which do not diffuse, to be recorded.

The SAI™ HELIUM BUBBLE GENERATOR is a compact and unique tool that produces helium-filled, neutrally buoyant bubbles of controlled size for such airflow visualization. The bubbles have been shown to trace airflow patterns at speeds as high as 200 fps. Since they follow the flow streamlines, the bubbles rarely collide with objects in the airstream and are extremely durable. For example, they will pass through fans and blowers quite readily.

The motion of the bubbles in low-speed flows can be photographed or videotaped with conventional lighting. For better results and higher speeds, a special SAI™ Basic Light is available. A SAI™ Modulated Arc Lamp is also available as light source for measuring velocity.

Key Features:

Superior Tracing of Air Motions - The helium-filled bubbles will follow complex laminar and turbulent airflows which cannot be traced by any other technique.

Ease of Operation - The SAI™ HELIUM BUBBLE GENERATOR has been designed for ease and simplicity of operation in practically any location. Fine controls are provided to adjust bubble size, specific weight and rate of generation.

Safe Operation - Non-toxic and non-corrosive constituents may be used at room temperature for clean and safe operation.

Quality of Construction - Quality components assure high reliability and durability.

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DESCRIPTION & COMPONENTS

The SAI™ Model 5 Bubble Generator provides a compact and unique tool for visualizing complex airflow patterns. Helium-filled, neutrally-buoyant bubbles of uniform size, adjustable from 1/32" to 3/16" in diameter, can be generated simultaneously from one or two outputs. These bubbles are capable of tracing intricate air motions without bursting or impacting on objects within the airflow.

The Model 5 Bubble Generator operates up to two Plug-In Heads, each driving a device that is called a "Mini-Vortex Filter". The Plug-In Head and Mini-Vortex Filter combination represents the most advanced means for high generation rates of "good" bubbles within a compact space.

The control Console accurately meters the flow of the Helium, Air and BFS to the Plug-In Heads. Helium and Air are supplied by external supplies while the BFS, though, is stored in an internal PVC cylinder. This solution is driven from the tank to the Plug-In Heads by pressure tapped from the helium circuit.

The Plug-In Head consists principally of a concentric arrangement of two stainless steel hypodermic tubes, one inside the other, attached in a cantilever fashion to a cylindrical manifold base or body, see Figure 1, pg. 3. Within the Head, helium passes through the inner hypodermic tube and "Bubble Film Solution" (BFS) through the annulus between the inner tube and the outer tube to form the helium-filled bubbles at the tip. A much larger, concentric jet of air, in turn, blows the bubbles continuously off the tip.

Some of the bubbles generated are too heavy and some, too light. The Mini-Vortex Filter removes these “bad” bubbles. Basically, it is a clear, plastic cylinder which utilizes the jet of air from the Plug-In Head to set up a rotational or cyclonic motion inside. The resulting radial forces then cause the bubbles which are not neutrally-buoyant to separate out.

Within the case the Console is mounted to the left and the Mini-Vortex Filters with the Plug-In Heads attached, in the middle. To the right, space is provided for storage of outlet tubing for the Filters, the Variable Speed Wand Nozzles, beaker, funnel and other miscellaneous items. The top cover of the case provides storage for the four 18” long stainless tubes which can be configured with Wand Nozzles in a variety of ways to implant the bubbles into the flow.

The requirements for external sources of helium and compressed air are quite modest. A cylinder of compressed helium with a 0 to 20 psi pressure regulator is adequate. The helium flow rate is less than 200 ccm for each Head. Air may be from any source which is capable of delivering 1.2 cfm, per Head, at 40 psi.

The Console panel is laid out for easy identification of the proper fittings and valves, see Figure 2, pg. 5. From the left, the columns are labeled "HELIUM", "BFS", and "AIR". Starting at the top of the panel, the fittings designated by "IN" are the inlets to the Console. The helium and air supplies are to be connected to their respective inlets in this row. The inlets are 1/4" female quick-connect fittings. The large fitting in the center of the inlet row is the fill port for the Bubble Film Solution.

Below each inlet is a toggle valve. The toggle valves allow quick shutdown of any constituent to the Plug-In Heads. The valves are open when the handles are perpendicular to the panel and closed, when they are parallel to the panel.

Below the toggle valves there are two rows of micro-metering valves designated by "OUT 1" and "OUT 2". The micro-metering valves regulate the flow of the corresponding constituent to the Plug-In Head. Micrometer Vernier scales are incorporated in the handles of the metering valves to enable the user to reproduce the desired flow rates very precisely.

SAI™ MINI-VORTEX FILTER AND ASSEMBLY
WITH PLUG-IN HEAD

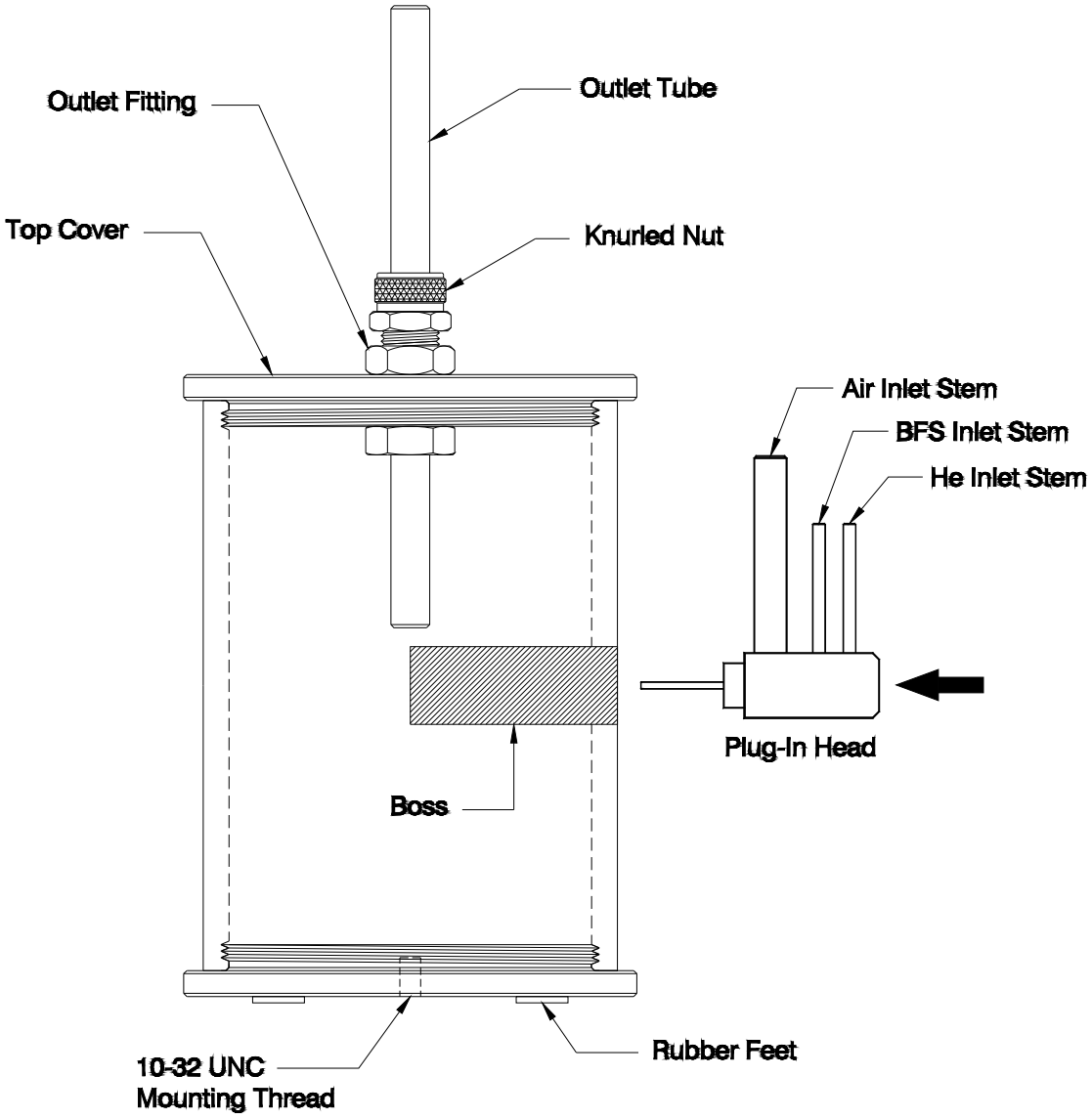
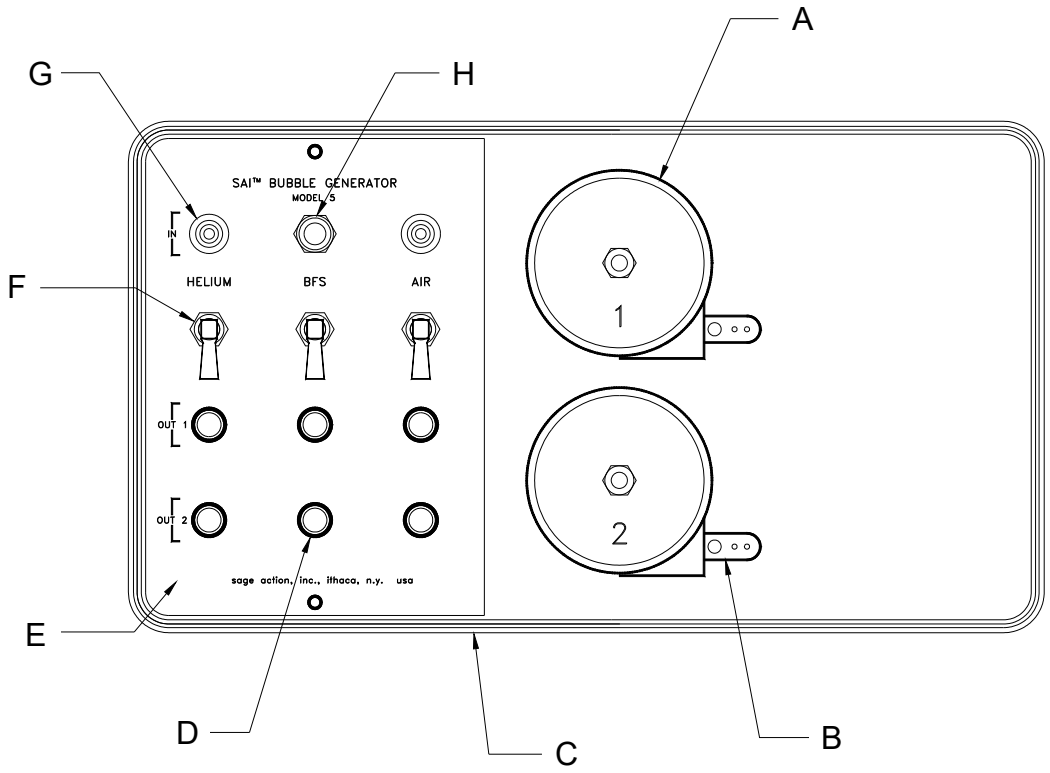


FIGURE 1

The constituents from the Console are fed to the Plug-In Heads by means of paratubing, two 3/32" I.D. and one 1/4" I.D. plastic tubes side by side. There are two holes on the side of the Console panel. The paratubing comes through these holes from the Console and connects to the three inlet stems on the Plug-In Head(s). The whole unit, including the control Console, Plug-In Heads, Mini-Vortex Filters and associated equipment, is packaged within a convenient, durable case. It is designed for simplicity of operation in any location where helium and compressed air are available. Easy disassembly facilitates cleaning of the Mini-Vortex Filters and Plug-In Heads as well as maintenance and repair.

GENERAL LAYOUT OF THE SAI™ MODEL 5 COMPONENTS



A Mini-Vortex Filter
B Plug-In Head
C Case
D Metering Valve
E Console Panel
F Toggle Valve
G Quick-Connect
H BFS Fill Port

FIGURE 2

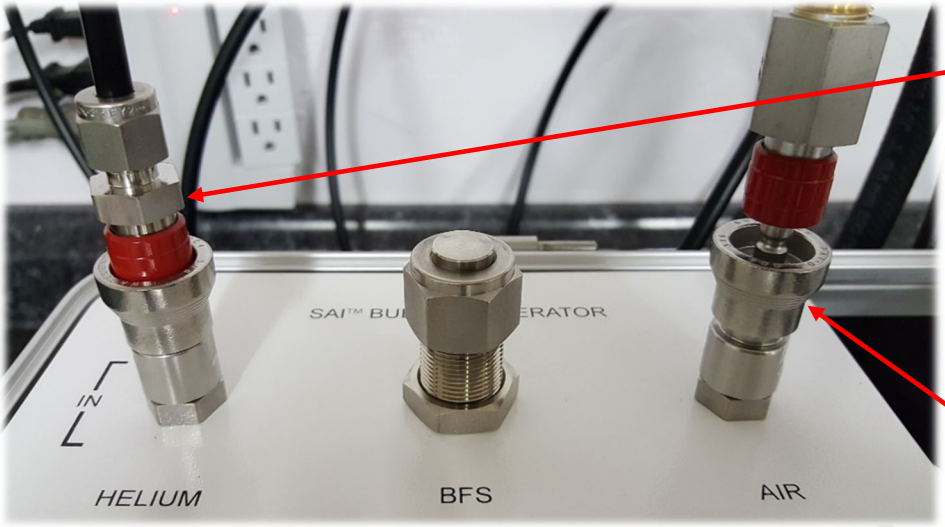
SETUP & OPERATION

1. Place the Suitcase Console, bottom side down, on a flat surface, release the two front latches and open the cover fully. If desired, unbutton the strap on the right and slide the cover to the right to detach it from the unit.

2. Fill the BFS tank with 250 ml of SAI 1035 Bubble Film Solution using the beaker and funnel provided. Be sure NOT to overfill the BFS cylinder, otherwise the solution can leak into the helium line. See page 11 for detailed instructions.

3. Connect the external helium and air supplies. The Hook-up Kit provided with the unit has 1/4" NPT *(National Pipe Thread)* male fittings at one end of each nylon tube and male quick-connect fittings at the other end. Connect the NPT fittings first to the outlet ports of the regulators for the external supplies, and then simply insert and seat the male quick-connect fittings into the appropriate female fittings at the top of the Console panel.

   Insert an air filter, if needed, to prevent dirt particles, oil or water from entering the air

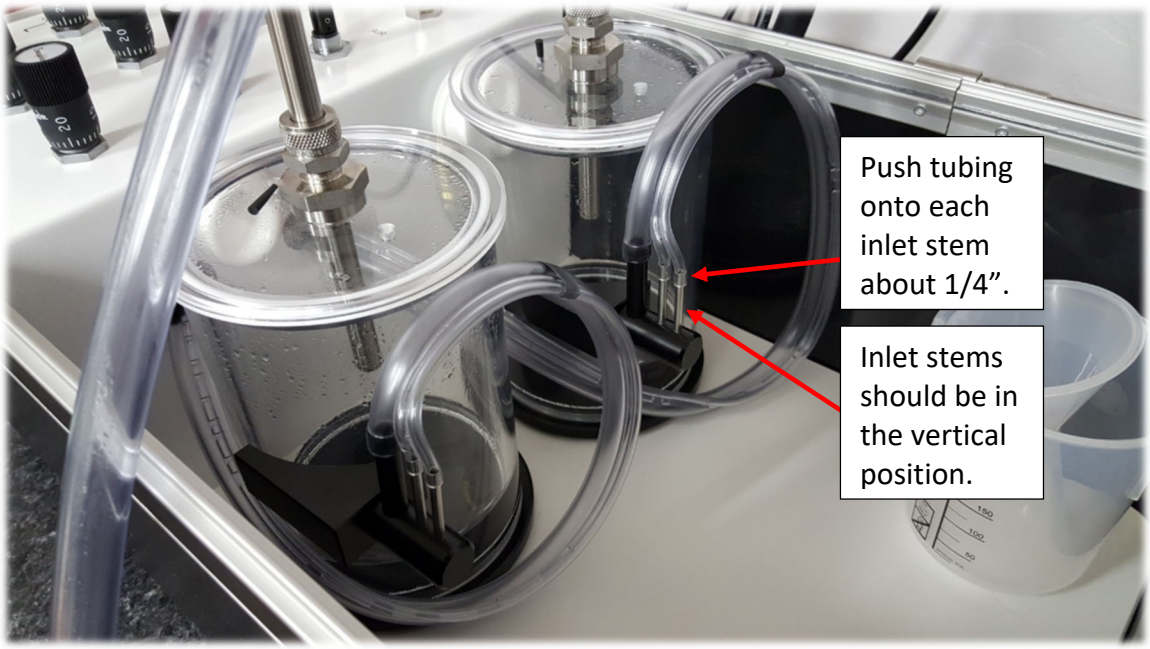


   circuit. The Green Line is for "Air" and the Black for "Helium". ***Note: If the Auxiliary Air & Helium Supply is being used, the supply lines will be contained in its case.***

4. Plug the Heads into the respective bosses of the Mini-Vortex Filters, the "rear" Head controlled by OUT 1 going to the rear Filter and the "front" Head controlled by OUT 2 going to the front Filter. The inlet stems for both Heads should be pointed upward.

Arrange the paratubing lines protruding from the 3/4" diameter holes on the side of the panel so that they pass ahead of each Filter and gently loop upward and around back downward to the inlet stems to avoid any kinks in the lines. As shipped, the Heads are packaged inside plastic compartmented box which is also used for storing them.

5. Push each piece of paratubing onto the proper inlet stem of each Plug-In Head about 1/4", see photo below. The inlet stems are the three parallel tubes perpendicular to the Head body. The larger plastic tube for the air fits onto the 5/16" diameter black stem first. In turn, the middle plastic tube for the BFS fits onto the 1/8" diameter stainless steel stem



next to the air stem and the outer plastic tube for the helium, onto the second 1/8" stainless steel stem. *Note: The plastic BFS tube should have a stopper in it which can be removed and stored in one of the holes on the Mini-Vortex Filter Cover*.

6. Set the height of the stainless steel outlet tube, 7" L x 3/8" O.D., for each Mini-Vortex Filter. For normal use, it is recommended that the bottom of the outlet tube be set half-way down into the filter. Tighten the knurled nut ***only finger tight*** to hold the outlet tube in place. See Figure 1, page 2.

7. The unit was calibrated before shipment. Calibration Sheet(s) for operation with either one Plug-In Head or two Plug-In Heads are included with these Instructions. Open the micro-metering valves to the settings given corresponding to the number of Heads to be run. The valve handle actually measures the displacement of the needle inside the valve like a micrometer. One full revolution of the handle corresponds to 0.025".

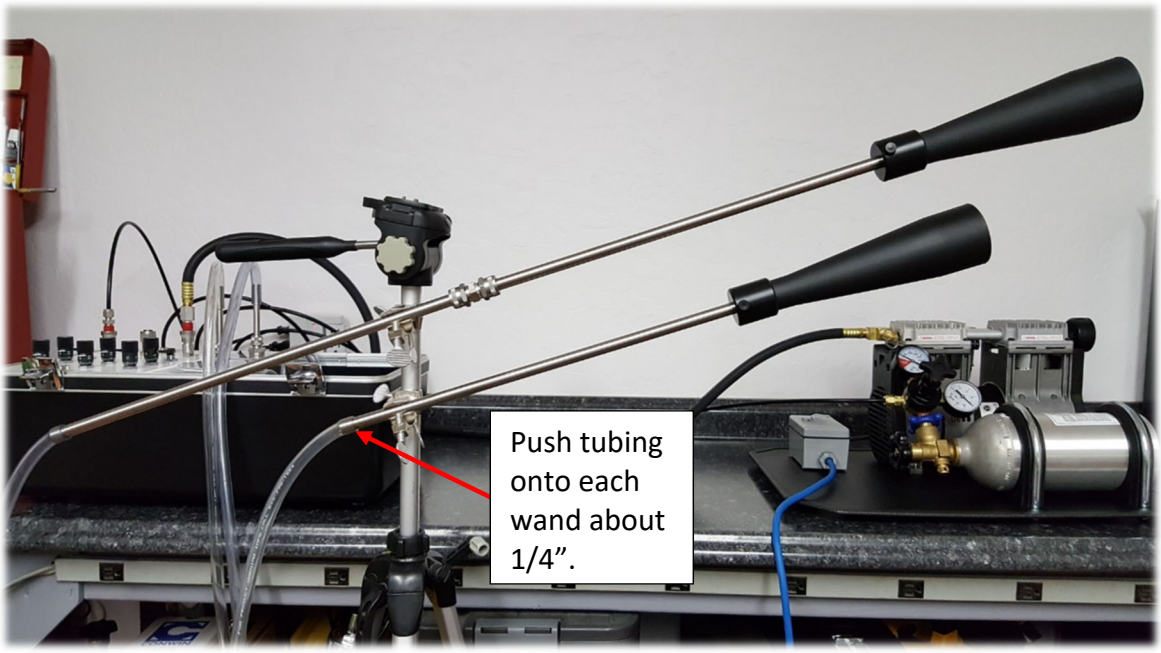
8. Set the external air supply. The air pressure should be constant and regulated to 60 psi. ***Note: If using the SAI Auxiliary Air & Helium Supply the air pressure is determined by the compressor, so no regulator is needed.*** Also set the helium supply. The helium pressure should be constant and regulated at 20 psi.

9. Now open the helium toggle valve(s) *slowly.* Next open the BFS toggle valve(s). Wait, then, for the BFS to reach the Plug-In Head(s) and for any trapped air bubbles to pass through the paratubing so that the flow becomes steady. This may be accelerated by momentarily opening the BFS micro-metering valve somewhat further. Once a steady BFS flow is established, a "white beard" of connected bubbles about 1/4" in size will form on the inside wall of the Filter(s) below the tangential opening for the Head(s).

10. To complete the bubble generating process, open the air toggle valve(s) and turn on the air compressor if one is being used. The bubbles will begin a rapid spinning motion inside the Filter(s) as the air flow increases. Their path is fairly complex, but the bubbles will "work" their way to the center and up the outlet tube(s). Over a period of time, some BFS may accumulate inside the outlet tube(s). However, this does not impair the operation.

11. By holding your hand 4” to 5” above the end of the outlet tube(s), the size, quality and quantity of the bubbles produced can be easily seen under direct light. If satisfied with the production, slide the 1/2” O.D. flexible outlet tubing over the outlet tube(s).

12. Place the other end of the flexible outlet tubing wherever you wish to implant the bubbles in the flow, either directly from the end of the tubing or using the Variable Speed Wand(s) provided.



The diameter at the outlet of the Diffusing Nozzle is 60mm and the diameter of the Bubble Outlet is 12mm. The further the Bubble Outlet is pulled into the nozzle the slower the exit velocity is of the bubbles. This allows for the adjustment in bubble exit velocity from about 0.1m/s all the way to 4m/s.

13. Experiment with the implantation of the bubbles, both where you introduce them and how you direct them. With a little effort, this will minimize any spurious effect of the jet of air from the Filter(s). It will also assure that you get a complete picture of the airflow patterns you want to see.

WELCOME TO THE EXCITING WORLD OF

AIR FLOW VISUALIZATION

WITH SAI™ NEUTRALLY-BUOYANT BUBBLES!

FILLING THE BFS CYLINDER

SAI™ 1035 Bubble Film Solution (BFS) has been developed over a period of many years. Extensive tests have demonstrated a substantial superiority in bubble characteristics with SAI™ 1035 over bubbles made from other commercial bubble-blowing solutions. Bubbles generated from the SAI™ 1035 solution have a longer life, form more readily and will not stain surfaces or clothing. The bubbles have an average lifetime of 2 minutes and generation rates as high as 300 bubbles per second per Plug-In Head may be achieved. If both Plug-In Heads are used, a full 250 cc cylinder should last 2 to 3 hours.

1. Make sure that the helium supply line to the Console is not pressurized. If it is, disconnect the helium quick-connect at the top left hand side of the Console panel.

2. Using a 7/8" open end wrench or a crescent wrench, loosen the nut on the BFS "IN" port and allow any excess helium pressure to bleed out. Then remove the nut.

3. With the beaker and funnel provided, fill the BFS cylinder through the fill port with fresh BFS. This cylinder holds 250 ml and one full beaker will fill it up.

4. Replace the fill cap finger tight, then with a wrench tighten the nut another 1/8th of a turn. This should be snug enough to prevent helium leakage.

5. Verify the helium pressure is set at 20 psi and re-seat the helium quick- connect fitting.

OPERATING SUGGESTIONS

1. The initial adjustment of the micro-metering valves should be done with the bubbles *introduced into still air*. This allows the size and buoyancy of the bubbles to be observed while the valves are adjusted and only minor changes, if any, will be needed when the bubbles are introduced into the test flow.

2. To shut down temporarily, *slowly* close the "AIR", "BFS" and "HELIUM" toggle valves, respectively. To start up again, reopen these valves in the reverse order and readjust the micro-metering valves, if necessary.

3. Neutrally-buoyant bubbles are usually generated at "maximum" helium flow rates. To operate at this condition, increase the helium flow until bubbles no longer form at the tip. Slowly reduce the helium flow rate until the bubbles again form properly. Note any change(s) from the calibrated setting on the Calibration Sheet(s).

4. Adjust the BFS flow rate to vary the mean bubble specific weight. If the bubbles are released in spurts, the BFS flow rate should be increased. In general, the lowest BFS flow rate which produces a steady production of bubbles is best.

5. If the BFS inadvertently gets into either or both of the helium lines, it can be easily cleared. Simply open the helium toggle valve, then the corresponding micro-metering valve to a setting of 0.275" to flush out the excess BFS. When finished, return this valve to its calibrated setting.

6. The airflow rate going to the Plug-In Head(s) has a pronounced effect on the rate-of-release of bubbles and the bubble diameter. At lower airflow rates, fewer bubbles are released and the bubble diameter increases. At higher airflow rates, more bubbles are released and the bubble diameter decreases.

7. If bubbles collect at the tip of the Head, first make sure the air supply is on and regulated. In turn, check the micro-metering and toggle valves in the "Air" column on the Console panel. They should be open and set correctly. In the event there is still no air going to the Head, check the paratubing lines under the Console panel to see whether they are kinked or disconnected.

8. If the Plug-In Head fails to produce bubbles, double check the supplies of air and helium to make sure the lines are connected correctly and the regulators are set to the recommended settings. Next check the supply of BFS. A strong odor indicates it has deteriorated and should be replaced with a fresh supply of SAI™ 1035 BFS only. Do not try to substitute another type of soap solution.

   If the Plug-In Head still fails to produce bubbles, unplug it from the boss of the Mini-Vortex Filter and check to see whether dried BFS from earlier operation is clogging any of the passages. Flush the parts with warm water to remove any obstructions found and verify that the passages are clear by blowing air through the inlet tubes. **DO NOT** try to clean the Plug-In Head in an ultrasonic bath. This can cause irreparable damage.

   Sometimes flushing does not clear the passages. In this case, try a 0.014" diameter wire instead. Carefully insert the wire into the helium outlet tube and gently push and pull until the end of the wire reaches the base of the passage. This can be roughly determined by comparing the length of the wire against the distance from the end of the BFS outlet tube to the axial location of the helium inlet tube. Afterward, flush with water and blow air through as above.

SHUTDOWN

1. Close each toggle valve slowly and, if desired, disconnect the external helium and air supplies. Make sure these supplies are turned off before disconnecting them.

2. If the unit will not be used again within the next couple of days, disconnect the paratubing from the Plug-In Head(s) and insert the small plastic stopper(s) provided to seal the BFS line(s). In turn, remove the Plug-In Head(s) from the Mini-Vortex Filter(s) and flush them with warm water to avoid "caking" of any residual BFS within the passages. Dry afterward with a micro fiber cloth.

3. Similarly, clean and dry the Mini-Vortex Filter(s). The Filter(s) may be removed by taking out the white plastic base to which they are fixed. This base comes out best if the upper right corner is lifted and tipped out first. There is a stainless steel thumbscrew under the base to hold each Filter in place. The thumbscrew can be readily unscrewed to release the Filter. To disassemble a Filter, simply unscrew the top and bottom covers.

4. If BFS has accumulated on the Console or other surfaces, it can be cleaned off with warm water as well. A damp micro fiber cloth will aid in the cleaning process. To prevent possible damage to the surfaces do not use any commercial cleaners.

5. Reassemble the unit carefully, making sure everything is back in its proper place.

6. Close cover and store.

PRECAUTIONS

1. Observe the precautions which are generally advised when working with compressed gases.
2. Do not *exceed* a maximum operating pressure of 25 psi for the external helium supply and 100 psi for the external air supply.
3. Do not recycle the BFS unless it is absolutely necessary.
4. Be sure there is at least 1/2" of clearance between the bottom end of the outlet tube inside each Mini-Vortex Filter and any residual BFS that has accumulated inside.
5. Keep all toggle valves closed when the unit is not in service.
6. Do not close the micro-metering valves past zero to try and stop the flow of a constituent to the Head(s). This may damage the valve seats, alter the calibration(s) and affect the operation.
7. Flush the Plug-In Heads with warm water if they are not going to be used again within the next couple of days to remove any residual BFS.
8. When finished testing for the day, turn off the helium supply to avoid possible loss of helium due to leakage.

SPECIFICATIONS

SAI™ MODEL 5 BUBBLE GENERATOR

Bubble Generation Rate: 300 - 400 bps / Head

Bubble Diameter: 0.050” - 0.150”

Bubble Life: 1 - 2 Mins

Minimal Spatial Resolution: 0.025” - 0.075”

Helium Operating Pressure: Regulated @ 20 psi

Air Operating Pressure: Regulated @ 40 psi - 60 psi

BFS Cylinder Capacity: 250 cc

Recommended Bubble Film Solution: SAI™ 1035 BFS

Helium Flow Rate: 200 ccm / Head

Nominal Air Flow Rate: 1.2 cfm / Head

Nominal BFS Consumption Rate: 50 cch / Head

Input Lines: Two 10’ x 1/4” O.D. Flexible Nylon Lines, 1 Black 1 Green, each w/ Male 1/4” NPT Fitting at one end for hook up to the respective Helium and Air Regulators, and 1/4” Quick- Connect Fitting, at the other, for connecting to the Console Panel

Console Panel: Painted 1/16” Thick Aluminum w/ Epoxy Lettering

Console Panel Fittings: Stainless Steel and Chrome Plated Brass

Console Case: Rugged Black A.B.S. Case w/ Heavy Wall Aluminum Valance and Take Apart Hinge for Cover Removal

Dimensions: 22” L x 13.5” W x 11” H

Overall Weight: 20 Lbs

SAI™ PLUG-IN HEAD DETAILS

Head Body: 0.63” Dia x 1.50” L Black Anodized Aluminum

Helium & BFS Inlet Stems: 11 Ga Stainless Steel Tube

Air Inlet Stem: 5/16” O.D. x 9/32” I.D. Black Anodized Aluminum Tube

Helium Outlet Stem: 22 Ga Stainless Steel Tube

BFS Outlet Stem: 16 Ga Stainless Steel Tube

Weight: 23 Gms

SAI™ MINI-VORTEX FILTER DETAILS

Mounting: Threaded ¼-20 UNC Hole In Base

Output Tube(s): 6” x 3/8” O.D. Stainless Steel

Output Tubing: 10’ x 3/8” I.D. Clear Flexible Vinyl Tubing

Materials: Acrylic, Delrin, Stainless Steel

Overall Dimensions: 4 1/2” Dia x 7” H

Weight: 664 Gms

SAI™ VARIABLE SPEED WAND DETAILS

Main Tubing: 2 Pieces, 18” L x 1/2” O.D. Stainless Steel w/ Connector

End Diffuser: 8” L w/ 1” Dia Inlet and 2 1/8” Dia Outlet

Weight: 1 Lb