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**SAI™ BUBBLE GENERATOR
MODEL 5 CONSOLE**

DESCRIPTION AND OPERATING INSTRUCTIONS
Serial No. 04008

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

Revised April 2002

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DESCRIPTION

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 "Heads". These bubbles are capable of tracing intricate air motions without bursting or impacting on objects within the airflow. The whole unit, including the control "Console", Heads 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.

The Model 5 Bubble Generator operates with one or 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 "heart" of the Head, itself, consists 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. 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.

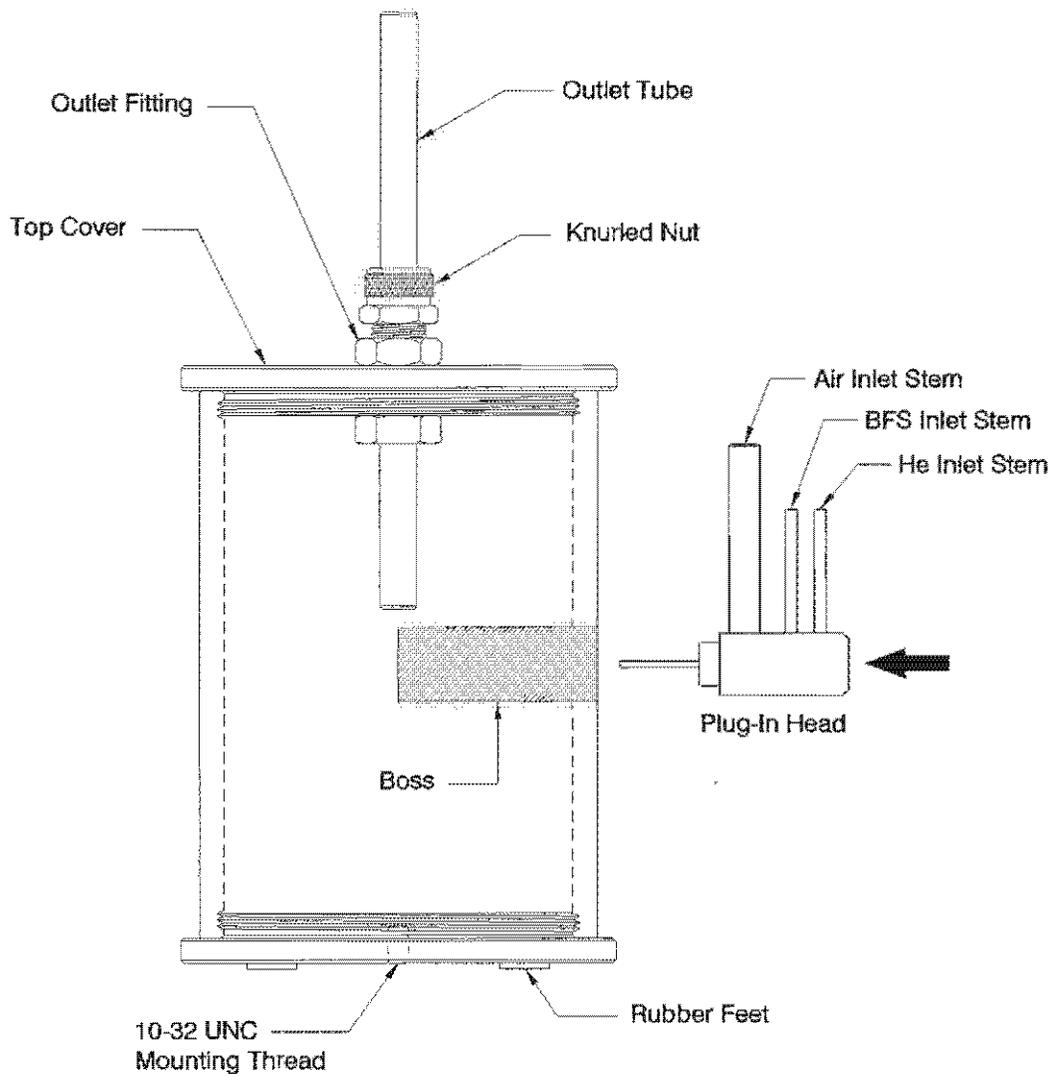
Some of the bubbles generated are too heavy and some, too light. The Mini-Vortex Filter removes these "bad" bubbles. Basically, it is a clear, plastic cylinder which utilizes the jet of air from the Head to set up a rotational or cyclonic motion inside. The resulting radial forces then cause the bubbles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

Within the case, the Console is mounted to the left and the Mini-Vortex Filters with the Heads attached, in the middle. To the right, space is provided for storage of outlet tubes and tubing for the Filters, as well as



sai[™] MODEL 5 CONSOLE WITH TWO BANKS

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



other miscellaneous items. The whole unit may be readily disassembled for maintenance and repair.

The Console accurately meters the flow of the helium, air and BFS to the Heads. The helium and air are connected to external supplies. The BFS, though, is stored in an internal PVC cylinder. This solution is driven by pressure tapped from the helium circuit through a check valve.

The requirements for external sources of helium and compressed air are quite modest. A cylinder of compressed helium with a 0 to 30 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 30 to 60 psi.

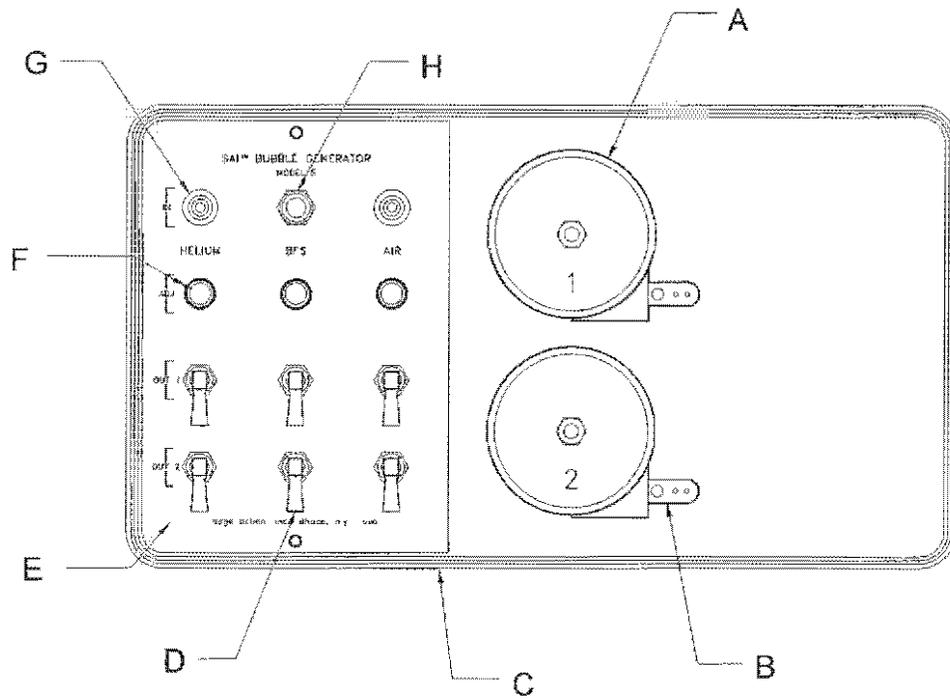
The Console panel is laid out for easy identification of the fittings and valves. From the left, the columns are labeled "HELIUM", "BFS", and "AIR". Starting at the top of the panel, the fittings designated by "IN" are the inlets to the Console. The helium and air supplies are to be connected to their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

Below each inlet is a micro-metering valve to regulate the flow of the corresponding constituent to the 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. This row of valves is designated by "ADJ".

The two rows of toggle valves below the micro-metering valves are designated by "OUT 1" and "OUT 2". These toggle valves allow quick shut-down of any constituent to either Head. The valves are open when the handles are perpendicular to the panel and closed, when they are parallel to the panel.

The constituents from the Console are fed to the Heads by means of 2 to 1 paratubing, two 3/32" I.D. and one 1/4" I.D. plastic tubes side by side.

GENERAL LAYOUT OF THE SAI™ MODEL 5 COMPONENTS



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

There are two holes on the side of the Console panel. The paratubing comes through these holes from the Console and connects to the Plug-In Head(s).

FILLING THE BFS CYLINDER

SAI™ 1035 Bubble Film Solution (BFS) has been developed over a period of many years. Extensive tests have shown a dramatic improvement in bubble characteristics with SAI™ 1035 over bubbles made from other commercial bubble-blowing solutions. Bubbles generated from this solution have a longer life, form more readily and will not stain surfaces or clothing. SAI™ 1035 bubbles have an average lifetime of 2 minutes and generation rates as high as 400 bubbles per second per Head may be achieved. If two 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 soap cylinder through the refill port with fresh BFS. This cylinder holds 250 cc and one full beaker of BFS will fill it up.
4. Replace the refill cap, making sure that it is screwed on snug enough to prevent helium leakage.
5. Re-seat the Helium Quick-Connect and verify the helium pressure is set to 20 psi.

SETUP & OPERATION

1. Place the Suitcase Console on its bottom side and open the cover so the inside panel is horizontal.
2. 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 disconnect fittings at the other end. Connect the NPT fittings first to the outlet ports of the regulators for external supplies, then simply insert and seat the male quick disconnect fittings into the appropriate female disconnect fittings at the top of the Console panel. Insert an air filter, if necessary, to prevent dirt particles, oil or water from entering the air circuit.
3. Attach the paratubing protruding from the 3/4" diameter holes on the side of the panel to the proper inlet stems on the Plug-In Heads. As shipped, the Heads are packaged inside the Filters. The Head inlet stems are the three parallel tubes perpendicular to the Head body. The larger plastic tube for the air fits onto the 5/16" black stem first. In turn, the middle plastic tube for the BFS fits onto the 1/8" stainless steel stem next to the air stem and the outer plastic tube for the helium, onto the second 1/8" stainless steel stem.
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 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.
5. Insert the stainless steel outlet tube, 6" x 3/8" O.D., for each Mini-Vortex Filter into the chrome fitting located on the top cover of the Filter. Tighten the knurled nut *only finger tight* to hold the outlet tube in

place. For normal use, it is recommended that the bottom of the outlet tube be set 1 1/2" to 2" below the top cover.

6. The unit was calibrated before shipment. Calibration Sheet(s) for operation with either one Plug-In Head or two Plug-In Heads are included at the end of these Instructions. Open the micro-metering valves to the settings given corresponding to the number of Heads to be run.
7. Turn on the external air supply. The air pressure should be constant and regulated within the limits of 30 to 60 psi. Turn on the external helium supply and allow the BFS cylinder to pressurize. The helium pressure should be constant and regulated at 20 psi.
8. Open the helium toggle valve(s) *slowly*. Next open the BFS toggle valve(s). Wait, then, for the BFS to reach the Head(s) and for any trapped air bubbles to pass through the paratubing so that the flow becomes steady. This may be accelerated by temporarily 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 diameter should form on the inside wall of the Filter(s) below the tangential opening for the Head(s).
9. To complete the bubble generating process, open the air toggle valve(s). 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.
10. 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).

11. 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 from a rigid tube inserted as a wand. The bubbles will flow nicely along the center of the tubing regardless of how it is shaped so long as any kinks are avoided. If required, a much longer length of flexible tubing than provided may be substituted.
12. 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 !*

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. This way 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 and the BFS sputters instead. 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(s), 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. Store the BFS at normal room temperature of 68 - 70°F. If subjected to much higher temperature, it will deteriorate sooner.

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 a 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 red 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 soft cloth or paper towel.
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 cover. The black base is screwed on, too, but it is sealed with silicone to prevent leakage. *DO NOT* unscrew the base or its seal will be broken.
4. If BFS has accumulated on the Console or other surfaces, it can be cleaned off with warm water as well. Most commercial glass cleaners, however, are more effective and reduce foaming during the cleaning process. If there is any question about possible damage to the surfaces by the cleaner, test it at some inconspicuous spot.
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 gasses.
2. Do not *exceed* a maximum operating pressure of 30 psi for the external helium supply and 100 psi for the external air supply.
3. Maintain an adequate supply of BFS during operation of the unit. Helium can be trapped in the BFS line if the BFS cylinder is allowed to empty completely before refilling.
4. Do not recycle the BFS unless it is absolutely necessary.
5. 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.
6. Keep all toggle valves closed when the unit is not in service.
7. Do not close the micro-metering valves 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.
8. 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.
9. Turn off the helium supply to avoid loss of helium due to leakage when shutting down for long periods of time.

SAI™ MODEL 5 BUBBLE GENERATOR SPECIFICATIONS

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 @ 30 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. Black Flexible Nylon Lines, Each With A 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 With Epoxy Lettering

Console Panel Fittings: Stainless Steel & Chrome Plated Brass

Console Case: Rugged Black A.B.S. Case With 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

Materials: Black Anodized Aluminum & Stainless Steel

Weight: 21 Gms

Head Body: 0.63" Dia x 1.50" L

Helium & BFS Inlet Stems: 11 Ga Tube

Air Inlet Stem: 5/16" O.D. x 9/32" I.D. Tube

Helium Outlet Stem: 22 Ga Tube

BFS Outlet Stem: 16 Ga Tube

SAI™ MINI-VORTEX FILTER DETAILS

Materials: Acrylic, Delrin, Stainless Steel

Weight: 649 Gms

Overall Dimensions: 4 3/8" Dia x 7 3/8" H

Mounting: Threaded 10-32 UNC Insert In Base

Outlet Fitting: 3/8" I.D. With Knurled Nut

Output Tube(s): 6 3/4" L x 3/8" O.D.

Output Tubing: 15' L x 3/8" I.D. Clear Flexible Vinyl Tubing

INITIAL CALIBRATION FOR

MINNESOTA STATE UNIVERSITY

Serial No. 04008

This SAI™ Modified Model 5 Console has been calibrated for you in our Laboratory prior to shipment. Listed below are the settings to which the vernier micro-metering valve controls for helium, bubble film solution and air were adjusted to achieve neutrally-buoyant bubbles about 1/8" in diameter. The calibration was performed with SAI™ 1035 Solution at a helium supply pressure of 20 psi and an air supply pressure of 40 psi. Changes from these conditions may require re-adjustments from the listed settings.

METERING VALVE SETTINGS

	OUT 1	OUT 1 & 2
Helium valve setting:	0.016"	N/A
BFS valve setting:	0.025"	N/A
Air valve setting:	0.010"	N/A

Date: 6 Aug 2004

MATERIAL SAFETY DATA SHEET

SAI™ 1035 BFS

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Reissue Date: January 1, 2004

SECTION 1 NAME & HAZARD SUMMARY

Material Name: SAI 1035 Bubble Film Solution

Hazard Summary (as defined by OSHA Hazard Comm. Std., 29 CFR 1910.1200):

Physical hazards: NONE

Health hazards: Irritant (skin, eye, respiratory passages)

Read the entire MSDS for a more thorough evaluation of the hazards.

SECTION 2 INGREDIENTS

OSHA PEL

Sodium diethyl sulfosuccinate (CAS 922-80-5)	Not Listed
Glycerin (CAS 56-81-5)	Not Listed
Water	Not Listed

Ingredients not precisely identified are proprietary or nonhazardous. Values are not product specifications.

SECTION 3 PHYSICAL DATA

Appearance and odor: Liquid
Boiling point: No data
Vapor pressure (mm Hg at 20 deg C): No data
Vapor density (air = 1): No data
Solubility in water: Soluble
pH: No data
Specific gravity: No data
% Volatile by volume: No data

SECTION 4 FIRE AND EXPLOSION HAZARD DATA

Flash point: Does not flash
Autoignition temperature: No data
Flammable limits (STP): Not applicable
Extinguishing media: Not applicable. Use media suitable for surrounding fire.
Special fire fighting protective equipment: Self-contained breathing apparatus with full facepiece and protective clothing if involved in a fire of other materials.

Unusual fire and explosion hazards: None known.

SECTION 5 REACTIVITY DATA

Stability: Stable under normal conditions.

Incompatibility: Oxidizing agents.

Hazardous decomposition products: Combustion products of dry material - Carbon dioxide, carbon monoxide. Nitrogen oxides, ammonia. Sulfur oxides.

Hazardous polymerization: Will not occur.

SECTION 6 HEALTH HAZARD ASSESSMENT

General: No toxicity information is available on this specific preparation; this health hazard assessment is based on information available on the properties of its components.

Ingestion: The acute oral LD50 in rat is probably above 5,000 mg/kg. Relative to other materials, this material is classified as "practically nontoxic" by ingestion.

Eye contact: This material will probably irritate human eyes following contact.

Skin contact: Short contact periods with human skin are not usually associated with skin irritation; repeated and/or prolonged contact can result in skin irritation.

Skin absorption: This product will probably not be absorbed through human skin.

Inhalation: Inhalation data are not available on this material. Vapors and aerosols will probably irritate respiratory passages.

Other effects of overexposure: No other adverse clinical effects have been associated with exposures to this material.

First Aid Procedures:

Ingestion: Give 1 or 2 glasses of water to drink. If gastrointestinal symptoms develop, consult medical personnel. (Never give anything by mouth to an unconscious person.)

Eyes: Immediately flush with plenty of water for at least 15 minutes. If redness, itching, or a burning sensation develops, have eyes examined and treated by medical personnel.

Skin: Wash material off of the skin with plenty of soap and water. If redness, itching, or a burning sensation develops, get medical attention. Wash contaminated clothing and decontaminate footwear before reuse.

Inhalation: Remove victim to fresh air. If a cough or other respiratory symptoms develop, consult medical personnel.

SECTION 7 SPILL OR LEAK PROCEDURES

Steps to be taken in case material is released or spilled: Wear skin, eye, and respiratory protection during cleanup. Soak up material with absorbent and shovel into chemical

waste container. Wash residue from spill area with water and flush to a sewer serviced by a wastewater treatment facility.

Disposal method: Discarded product is not a hazardous waste under RCRA, 40 CFR 261.

Container disposal: Empty container retains product residue. Observe all hazard precautions. Do not distribute, make available, furnish or reuse empty container except for storage or shipment of original product. Remove all product residue from container and puncture or otherwise destroy empty container before disposal.

SECTION 8 SPECIAL PROTECTION INFORMATION

TLV or suggested control value: No ACGIH TLV or OSHA PEL is assigned to this mixture. Minimize exposure in accordance with good hygiene practice.

Ventilation: Use ventilation adequate to maintain safe levels.

Respiratory protection: Use MSHA-NIOSH approved respirator for organic vapors, dusts and mists whose TLV is greater than 0.05 mg/m³.

Protective clothing: Impervious gloves and apron.

Eye protection: Chemical tight goggles; full faceshield in addition if splashing is possible.

Other protective equipment: Eyewash station and safety shower in work area.

SECTION 9 SPECIAL PRECAUTIONS OR OTHER COMMENTS

Special precautions or other comments: Prevent skin and eye contact. Avoid breathing vapors or aerosols.

SECTION 10 REGULATORY INFORMATION

TSCA (Toxic Substances Control Act) Regulations, 40CFR 710: All ingredients are on the TSCA Chemical Substance Inventory.

CERCLA and SARA Regulations (40 CFR 355, 370, and 372): This product does not contain any chemicals subject to the reporting requirements of SARA Section 313.

Other Determined Regulations: None.

THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH BUT NO WARRANTY, EXPRESSED OR IMPLIED, IS MADE.

NOTES

Date: _____

Re: _____

***sai*TM Helium Bubble Generator**

**“QUICK START” INSTRUCTIONS FOR THE -
SAI™ MODEL 5 CONSOLE**

Serial No. 04008

1. Check the connections for the helium and air supplies. The two nylon hook-up lines provided have 1/4" pipe fittings at one end and quick-connect fittings at the other end. Connect the pipe fittings first to the regulator outlets for the external supplies, then insert and seat the quick-connect fittings into their mating connections at the top of the Console panel.
2. Check the attachment of the plastic paratubing protruding from the 3/4" diameter holes on the side of the panel, making sure they are connected to the proper inlet stems on the Plug-In Heads. The larger tubing for the air fits onto the black stem, the middle piece of tubing for the BFS fits onto the adjacent stainless steel stem and the last piece of tubing for the helium onto the remaining stainless steel stem.
3. Plug the Heads into the respective bosses of the Mini-Vortex Filters. The inlet stems for both Heads should be pointed upward. Arrange the paratubing lines so they loop ahead of each Filter up and down into the inlet stems without any kinks in the lines.
4. Adjust the outlet tube for each Mini-Vortex Filter by loosening the knurled nut. For normal use, it is recommended that the bottom of the outlet tube be set 1-1/2" to 2" below the top cover.
5. Open the vernier micro-metering valves to the calibrated settings given below.
6. Turn on the external air and helium supplies. The air pressure should be set between 30 to 60 psi. The helium pressure should be set at 20 psi.
7. Open the helium toggle valves slowly, then the BFS toggle valves. Wait for the BFS to reach each Head. This may be accelerated by opening the BFS micro-metering valve somewhat further temporarily. Once a steady BFS flow is established, a "white beard" of bubbles about 1/4" in diameter should form on the inside wall of each Filter below the Head opening.
8. Open the air toggle valves. The bubbles should develop a rapid spinning motion inside the Filters, "working" their way to the center of the Filters and up the outlet tubes.
9. Hold your hand 4" to 5" directly above each outlet tube and examine the size, quality and quantity of the bubbles produced. If satisfactory, slide a piece of flexible outlet tubing over each outlet tube.
10. Place the other end of each flexible tubing wherever you wish to implant the bubbles in the flow, either directly from the end of the tubing or from a rigid tube inserted as a wand. Experiment with the point where you introduce the bubbles and how you direct them. With a little effort, this will minimize any unwanted effect of the jet of air from the Filter. It will also assure that you get a complete picture of what you want to see.

CALIBRATION

This SAI™ Bubble Generator has been calibrated in our Laboratory prior to shipment. Listed below are the settings to which the vernier micro-metering valves for the helium, bubble film solution, and air were adjusted to achieve neutrally-buoyant bubbles, approximately 1/8" in diameter. The calibration was performed with SAI™ 1035 Solution.

	He @ 20 psi	BFS	Air @ 40 psi
Out 1	0.016"	0.025"	0.010"
Out 1 & 2	N/A	N/A	N/A

FILLING THE BFS CYLINDER

SAI™ 1035 Bubble Film Solution is particularly recommended for use in the unit. Bubbles generated from this solution leave minimal residue and last about 2 minutes. Of most importance, generation rates as high as 400 bubbles per second per Head can be achieved. A full 250 cc cylinder should last 2 to 3 hours when both Heads are run.

1. DISCONNECT the Helium quick-connect at the top left hand side of the Console Panel.
2. SLOWLY loosen and remove the nut on the BFS "IN" port with a 7/8" open end wrench or a crescent wrench, taking care not to let the nut pop off.
3. Fill the soap cylinder with fresh 1035 BFS with the beaker and funnel provided. The cylinder under the console panel is a 250 cc cylinder. One full beaker of soap will fill the cylinder.
4. Replace the BFS nut, tightening it just snug enough to prevent helium leakage.
5. Reseat the Helium quick-connect and verify the helium pressure is set to 20 psi.

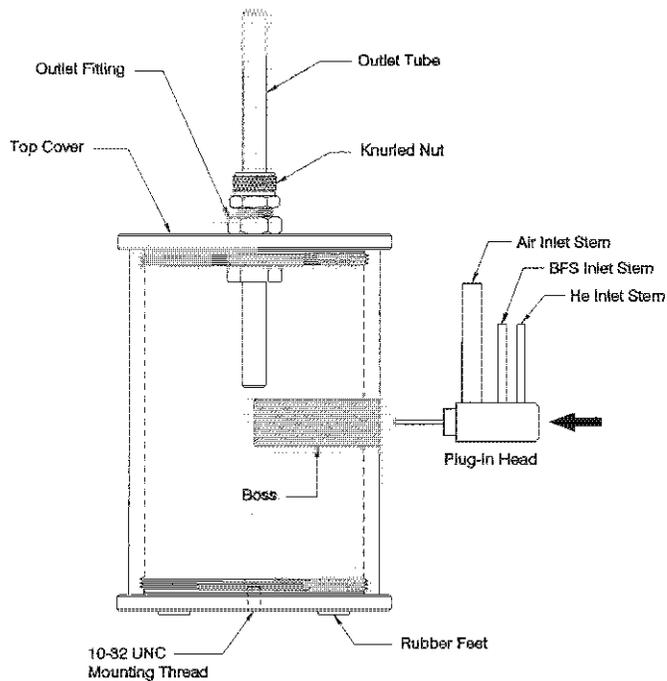
SPECIAL HINTS

- ☞ Neutrally-bouyant bubbles are usually generated at "maximum" helium flow rates. To operate at this condition, increase the helium flow until bubbles no longer form and the BFS sputters. Then reduce the helium flow rate slightly until bubbles again form properly.
- ☞ Adjust the BFS flow rate to vary the mean bubble specific weight. In general, the lowest BFS flow rate which produces a steady production of bubbles is best. If, however, the bubbles are released in spurts, the BFS flow rate should be increased.
- ☞ The airflow rate has a direct effect on the generation rate and the bubble diameter. Increasing the airflow rate increases the generation rate, but decreases the diameter. And vice-versa.
- ☞ Should the bubbles fail to form properly, proceed as follows:

The bad Head should be inspected by unplugging it from the boss and checking to see whether any dried BFS is clogging the passages. If so, soak it in warm water overnight to dissolve the obstruction. Then blow air through the inlet tubes to remove the debris.

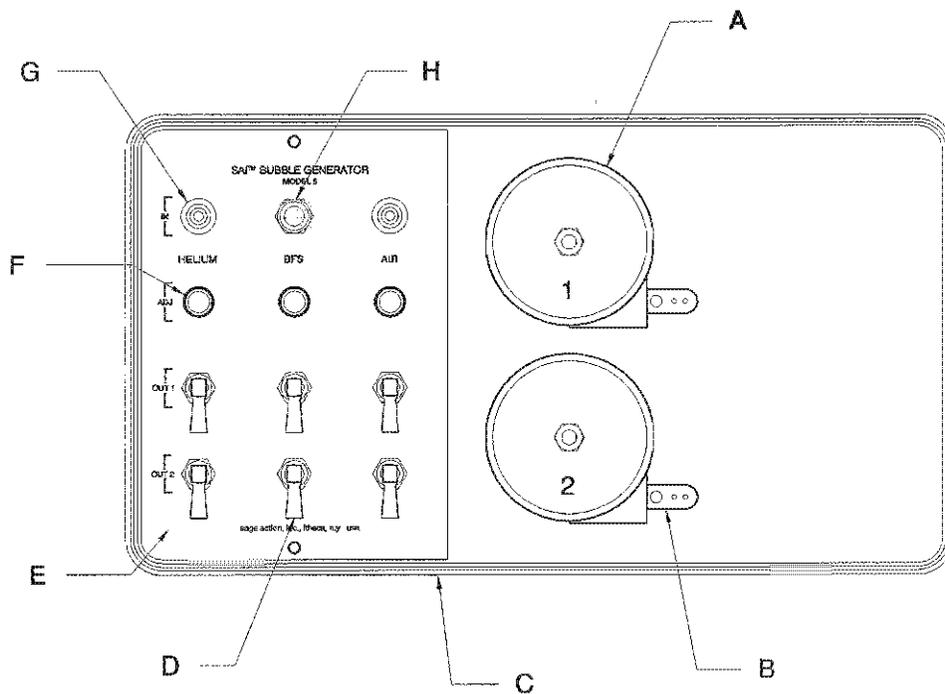
In the event that this does not clear the passages, a 0.014" diameter wire may be used instead. Carefully insert the wire into the helium outlet tube and gently push and pull until the end of the wire reaches the base of the passage. This can be roughly determined by comparing the length of inserted wire to the axial position of the helium inlet tube. Afterward, flush the Head with water and blow air through to remove any debris.
- ☞ If BFS gets in the helium line, disconnect the external helium and air supplies, temporarily LOWER the air supply to 20 psi and connect it to the helium inlet. Flush out the BFS in the line, then, by fully opening up *only* the helium metering valve and the two helium toggle valves.
- ☞ To shut down briefly, *slowly* close the air, BFS and helium toggles valves, respectively. To start up again, reopen these valves in the reverse order.
- ☞ For high-speed airflows, 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. Only minor changes, if any, will be needed when the bubbles are introduced into the test flow.

SAI™ MINI-VORTEX FILTER AND PLUG-IN HEAD



SAI™ MODEL 5 CONSOLE

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



SHUTDOWN

1. Close each toggle valve slowly and disconnect the external supplies, if desired.
2. If the unit will not be used again within a day or two, disconnect the paratubing from the Heads and use the small red plastic stopper provided to seal the BFS line. In turn, remove the Heads from the Mini-Vortex Filters and flush them with warm water to avoid "caking" of any residual BFS within the passages. Dry afterward with a clean soft cloth or paper towel.
3. Similarly, clean and dry the Filters. The Filters may be removed by taking out the white plastic base to which they are fixed. This base is 5 mm thick and comes out best if the upper right corner is lifted and tipped out first. Under the base, there are two stainless steel thumbscrews to hold the Filters in place. These thumbscrews can be readily unscrewed to release the Filters. To disassemble the Filters, themselves, simply unscrew the top covers. The black Delrin bases are screwed on, too, but they are sealed with silicone to avoid leakage. *Do not* unscrew or the seals will be broken.
4. If BFS has accumulated on the Console or other surfaces, it should be cleaned off with warm water as well. However, most commercial glass cleaners are more effective and reduce foaming during the cleaning process. If there is any question about possible damage to the surfaces by the cleaner, try it at some inconspicuous spot.
5. Reassemble the unit carefully, making sure everything is back in its proper place.
6. Close cover and store.

PRECAUTIONS

- ⚠ Do not exceed a maximum operating pressure of 30 psi for the external helium supply and 100 psi, for the external air supply.
- ⚠ Observe the usual precautions advised when working with compressed gases.
- ⚠ Maintain an adequate supply of BFS during operation of the unit. Helium can be trapped in the BFS line if the BFS cylinder is allowed to empty completely before refilling.
- ⚠ Turn off the external helium supply to avoid loss of helium due to leakage when shutting down for long periods of time.
- ⚠ CLEAN THE HEADS, if you do not plan to use them immediately, with warm water, in order to flush out any residual BFS. You can wait somewhat longer to clean the Filters.
- ⚠ DO NOT CLOSE the micro-metering valves past "0". This may alter the calibration and affect the operation.
- ⚠ Exercise care when tightening the fittings on the panel so as not to scratch it. The epoxy finish on the panel can only withstand minor abrasion.
- ⚠ Keep all toggle valves closed when the unit is not being used.
- ⚠ DO NOT lower the outlet tubes below the surface level of the used BFS in the Mini-Vortex Filters! If you do, the BFS will blow forcefully up the outlet tubes when the air toggle valves are opened.