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Sonolator™ Homogenizing Systems

Operating & Instruction Manual

The Sonolator™
High-Pressure Ultrasonic Mixing and Homogenizing Systems

SONOLATOR SYSTEMS MANUAL

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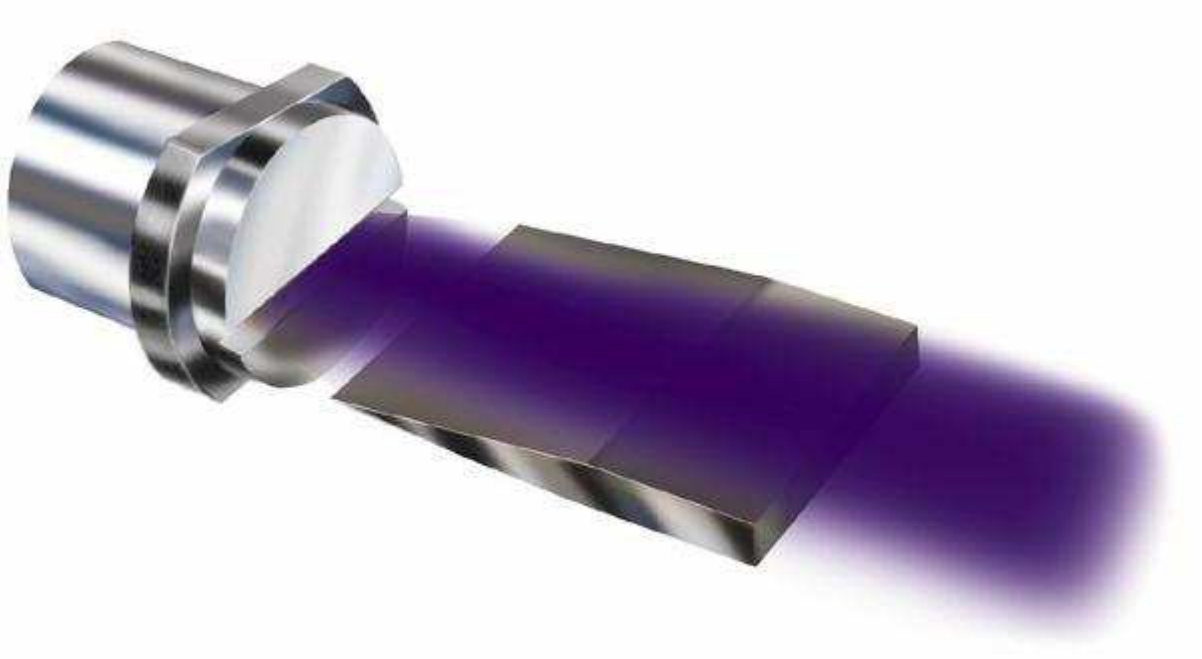
What Is A Sonolator?



The Sonolator™ is an in-line homogenizing device that employs ***high pressures*** and ***ultrasonic cavitational energy*** to create emulsions and dispersions. The ultrasonic conversion of energy within the liquid stream is accomplished by a physical phenomenon known as "jet-edge tone." The Sonolator™ is coupled to a positive displacement pump and is employed in a comprehensive system containing the motor, base, variable frequency drives, pressure and flow measuring devices and many other components as needed.

What happens to a stream of process liquid as it passes through the Sonolator's mixing chamber is illustrated above. A stream of process liquid is subjected to extreme pressure and shear when forced through our specially engineered **Orifice**, to the right. The process material is then projected at a velocity of 300 feet per second or more over the edge of our **Blade**, seen to the left. Between the Orifice and Blade, the jet of liquid sheds vortices perpendicular to the original flow vector. The alternating shedding patterns create a steady, ultrasonic oscillation within the liquid. The stresses set up within the fluid by these ultrasonic oscillations cause the fluid to cavitate.

The ***pressure*** and high level of ***cavitation***, shear, and turbulence within the Sonolator's mixing chamber are responsible for de-agglomerating product particles and emulsifying liquids.

Introduction

The Sonolator is intended to emulsify, disperse and homogenize at flow rates between five (0.5) to twenty (100) gallons per minute at pressures ranging from 150 to 5000 psi. *Many of the Sonolator™ Systems fabricated by Sonic are restricted to certain flows and pressures due to the pump used; just because the Sonolator™ itself is rated to such pressures does not necessarily mean that the entire system is rated for such pressures!* There are several type Sonolators used depending on flow rates and applications. These include the Model A, Model BT, Model BTK400, Model EM, Model XS1500, and Model CIP, Model A-CIP2. Assembly Drawings and Parts Lists for each model Sonolator is available on our website.

There are three parameters which dictate the level of mixing energy, or homogenization, within the Sonolator™ at a given flow rate. The first, and the most important of these, is pump-to-orifice ***pressure***, which can be varied by either changing the size of the orifice or the flow of material through the orifice. When the area of the orifice is smaller or the flow is accelerated, the pressure increases. The second variable is the orifice-to-blade distance, which, with this model Sonolator, is externally adjustable. The third variable is the pressure within the mixing chamber itself, which is manipulated by a back pressure tuning valve. Both the blade-to-orifice adjustment and the back pressure tuning valve are used only to enhance the cavitation occurring within the Sonolator's mixing chamber. All products have differing pressures at which they can be effectively homogenized within the Sonolator, the back pressure tuning valve and blade adjustment knob allow the operator to enhance cavitation within the mixing chamber once an appropriate pressure has been discerned.

An acoustic "note," audible only in the sonic range, is generated by the cavitational forces and oscillations mentioned above. When this note is at its peak, maximum cavitation is then being achieved. An Acoustic Intensity Meter, connected by a coaxial cable to a liquid crystal probe mounted just above the Sonolator's mixing chamber, allows the operator to read that "note." The operator can then adjust the blade to orifice distance and the back pressure to locate the "note's" peak, thereby ensuring that maximum cavitation is being generated.

Operation

The operating procedures for a Sonic system will vary depending on whether the system is mono feed or dual feed, fixed speed or variable speed, or any combination of these. When operating any system, however, the operator must understand (1) the operation of the pump, (2) the relationship between orifice area, pressure, and flow, and (3) how to tune the Sonolator to generate optimum cavitation.

The Pump

A Sonic unit may possess any of a variety of positive displacement pumps. Our website contains customer specific manuals with pump manuals, drawings, etc. Each pump provided by Sonic Corporation has a definite pressure limitation as a function of its design. Specifications and data provided with the pump manual will indicate that pressure limitation. Any system utilizing a variable speed drive or mechanically variable speed motor possesses a pressure relief valve, rupture disk, or pressure limit switch to insure protection in case an operator unintentionally exceeds the pressure limitation of the pump.

Sonic Corporation is not able in all cases to determine the exact speed of a fixed speed system because the process liquid viscosity is an uncontrollable variable. Adjustments in the speed of the unit may be made in the field if a V-Belt drive arrangement has been provided.

THROUGHPUT ABOVE THAT SPECIFIED FOR THE UNIT SHOULD NOT BE CONSIDERED A BONUS, AND CONSTITUTES ABUSE OF EQUIPMENT. The unit should be slowed down in correlation with pump curves.

The Relationship between Orifice, Pressure and Flow

As touched upon earlier, the pump-to-orifice pressure is the dictating force when generating fine emulsions and dispersions and is determined by either the *flow rate* generated by the pump or the *size of the orifice* through which the material flows. The intensity of the mixing or dispersion that occurs within the Sonolator is a direct function of the pump-to-orifice pressure. The cavitation levels achieved will vary directly with the pressure; the blade-to-orifice adjustment and the back pressure tuning valve are used to enhance cavitation. A low pump-to-orifice pressure will thus generate low cavitation levels, and a high pump-to-orifice pressure will create higher levels. Every product has a specific pressure at which it is most effectively homogenized, and once that pressure is determined, efforts should be made to insure that that specific pressure is maintained while generating product. For production units, that pressure is pre-determined either through lab tests conducted at Sonic or from research performed on a Sonic rental unit at the customer's plant. Given the desired production rates and the predetermined pressure, Sonic calculates the orifice area which yields the desired pressure at the desired flow rate.

Orifice Calculation:

The relationship between orifice area, pressure, and flow is expressed with the formula:

$$Q = 30A\sqrt{P}$$

where:

Q = Gallons per minute throughput of a water-like material, at the desired pressure (PSI) as approximated from pump curves.

A = The area of the orifice, in square inches, as marked on the face of the orifice.

P = Desired pump-to-orifice pressure, in PSI.

30 or K = Viscosity and pump slip constant

Converting this equation allows one to calculate the required orifice area given the flow and the pressure:

$$A = Q / 30\sqrt{P}$$

Generally, the pressure at which a production system operates does not need to be altered. If, however, a company needs to change the operating pressure, uses a Sonic lab unit, or is running various products that are emulsified or dispersed at different pressures,

The Pump-to-Orifice Pressure May Be Varied Two Ways:

(A) The speed of the pump may be adjusted on some units which utilize the variable speed drive arrangement. Accelerating the pump speed will increase the pressure.

(B) A new orifice with a different area may be installed. The area of the orifice directly determines pump-to-orifice pressure when the speed of the pump and the viscosity of the liquid are maintained constant. Orifices with smaller areas will generate higher pressures.

Warning!: *Do not alter the pressure by toggling either the back pressure tuning valve or the blade-to-orifice distance. When the pump speed or orifice is changed, the Sonolator may need to be re-tuned.*

Troubleshooting Pressure Problems

Because pressure is the dictating force and should be maintained constant throughout production runs, if at any time during production the pressure falters or fluctuates dramatically, check the following:

1. The pump to insure that piston cups, plunger seals, stators or gears are not worn or damaged.

2. The Sonolator orifice to insure nothing is clogging it, or that it is not worn.

3. The gauge seal assembly to insure it is not damaged. Sonic seal assemblies possess a diaphragm seal that must be full with water.

4. The back pressure valve to insure it is not closed and generating higher pressures.

5. Check any strainers upstream of the pump for clogs; such clogs will create pump starvation.

Tuning

As mentioned, the blade-to-orifice adjustment knob and the back pressure tuning valve are used to enhance or fine tune the cavitation occurring within the Sonolator's mixing chamber. BEFORE STARTING THE SYSTEM, observe the method of adjusting the orifice-to-blade distance and the back pressure as detailed in the section entitled **Start-Up Procedures** in this manual. The orifice-to-blade distance is adjusted by rotating any large Calibrator handle clock-wise to move the blade closer to the orifice and counter clock-wise to move the blade back. The back pressure tuning valve is adjusted by turning the valve handle to increase cavitation. The Acoustic Intensity Meter is used to assist in locating the optimum level of cavitation.

As mentioned earlier, cavitation is created when the process material encounters the restriction created by the orifice and then flows over the blade at high velocity; the two tuning adjustments described here will optimize the amount of material that flows over the blade. As material exits the orifice at high velocity, the process streams twists, much like water discharging from a pinched garden hose. The Back-pressure Tuning Valve, when closed slowly, will flatten that stream, thereby optimizing how much material flows over the blade. Material exiting an orifice at high speeds also tends to spray as it moves further downstream away from the orifice. The blade-to-orifice adjustment allows the operator to position the blade within the flat liquid stream just before the material begins break up and spray, again increasing the amount of material impinging upon the blade and escalating cavitation levels within the Sonolator™.

Variations in the Process Liquid

Changes in the process liquid will necessitate re-tuning of the Sonolator. Variations in temperature, viscosity, and flow rates will also occasion re-tuning of the Sonolator. Barring any variations in process liquid or process controls, the Sonolator should require little attention aside from routine maintenance checks.

Orifice and Blade Wear

Orifice wear is first noticed when pressure within the system decreases. As the orifice becomes larger, it offers less resistance to flow. Wear is observed as a rounding of the inside "lips" of the orifice, and the formerly sharp corners of the "cat's eye" will take on a definite radius.

Abrasive liquids will cause the leading edge of the blade to wear in a "U" shaped pattern in front of the orifice. The blade need only be replaced when the acoustic intensity drops by more than 15-20%, or the "U" shaped wear pattern is visibly 1/16 to 1/8" in depth.

Non-abrasive liquids will cause the blade to show cavitational erosion slightly behind the leading edge. This rate of erosion is very slow and is not to be considered a source of contamination.

Particle Size Control

If the particle sizes produced by the Sonolator are too small or the mixing intensity is too great for the product, control should be achieved only by adjusting the orifice pressure. This can be done either by changing the orifice size or changing the flow rate. Control should not be attempted by de-tuning the Sonolator, for the results will be erratic and are usually not reproducible. The Sonolator should always be tuned to produce a maximum of acoustic intensity at a given pressure.

It will usually be advisable to retune the Sonolator when product temperature or viscosity change, or when orifice pressure or flow rates are changed or when the solids content of the fluid is changed.

Safety

A suitable pressure relief device located between pump and Sonolator must always be installed and kept in good operating condition. Adjustable spring-loaded valves are commonly used, but rupture discs may also be used if proper sanitation is a concern.

If the pressure relief device becomes clogged or otherwise fails, excessive pressure caused by orifice blockage will usually blow out one of the "O" rings on the sleeve (#5). This is messy, to say the least, and can be hazardous.

It is strongly urged that the operator check the pressure relief device before use and check it frequently during use.

Safety glasses should be worn by the operator and any persons in attendance as a precaution.

If fluids other than water are used, observe proper fire, explosion, and ventilation precaution.

Sound Hazards

Although the "whistle" or high pitched squeal developed by a properly tuned Sonolator seldom exceeds 85 dB 3 feet from the equipment, some persons may find the sound irritating and uncomfortable, particularly if the Sonolator is located in a confined space or a small room. In such cases, the operator should wear sound dampening ear plugs or "ear muffs."

If sound deadening of the equipment is desired, acoustic absorbing enclosures can be designed around the Sonolator and flexible connections installed to reduce sound transmission in the fluid itself. Consult the factory for further information.

Instrumentation

FOR COMPLETE INSTRUCTIONS REGARDING OPERATION OF INSTRUMENTATION, REFER TO ACOUSTIC INTENSITY METER OPERATING INSTRUCTIONS.

Sonolator Systems supplied prior to January 1973 include the Model IN-1000 Acoustic Intensity Meter; those supplied between 1973 and 1979 include the Model IN-2000 Acoustic Intensity Meter; and current systems from 1979 to the present include the In-3000 meter.

The instrumentation, consisting of an Acoustic Intensity Meter, probe, and transducing connecting cable is explained in an accompanying instruction booklet. The Acoustic Meter is usually battery operated and should be turned OFF when not in use. AC powered intensity meters are also available. If cable is disconnected from probe, it is suggested that the plastic cap provided be inserted atop the probe to protect threads.

Care of the O-rings

The Sonolator is largely fitted with 'O' ring seals. These seals are normally compression fit between two metal members. After the Sonolator has been operated for long periods of time, the original grease used to assemble the Sonolator may have been washed out. During disassembly this lack of grease may cause a high degree of friction between the 'O' ring and the member compressing it. A rotating motion should be used whenever parts sealed by an 'O' ring are separated.

Upon re-assembly, the 'O' rings should be carefully inspected for nicks, cuts, and swelling caused by solvent attack and should be replaced whenever necessary. 'O' ring grease or a suitable lubricant should be used liberally, but not in excess.

Pre Start-Up Check List

_____ 1. Unit is level and locked in position.

_____ 2. Pump suction flooded, with short run to feed tank. NO vacuum lift or pump starvation.

_____ 3. Discharge piping diameter large enough to accept full flow with minimum back pressure. NO RESTRICTIONS!

_____ 4. Pressure gauge is fitted with a diaphragm seal....Put Wrench On Bottom Only to tighten. DO NOT TURN GAUGE!

_____ 5. Sonolator connected properly, fittings tightened using ALUMINUM wrenches provided.

_____ 6. Voltage and overload relays matched to motor. All wiring installed properly and safely.

_____ 7. For continuous cavity pumps, pump motor rotation checks with "arrows" on pump drive end. Note: electrician may "jog" unit when dry.

_____ 8. Variable speed control handle on pump/motor set to LOW speed - VARIABLE SPEED CONTROL HANDLE MUST NOT BE TURNED UNLESS MOTOR IS RUNNING.

_____ 9. Install Acoustic Intensity Meter with bracket provided. Connect cable between meter and Sonolator probe. Depress Acoustic Meter "Test" switch, making sure a reading is obtained. READ ACOUSTIC INTENSITY METER INSTRUCTION MANUAL.

_____ 10. Make sure proper filtration is installed prior to the Sonolator™ System to protect the pump and Sonolator™.

_____ 11. **STOP!** Read and follow carefully the Start-Up Procedures outlined on the following pages.

DO NOT RUN UNIT DRY!

IF THIS IS A DEMONSTRATOR UNIT YOU MUST RETURN IT CLEAN!

Start-Up Procedure

Note: Prior to Start-Up, carefully read the Check List on the preceding pages!
Note: Prior to start-up, the Acoustic Intensity Meter Operating Manual MUST be read.

1. Make sure power is OFF and that the unit is electrically grounded.

2. Check that the fluid to be processed is compatible with the "O" ring seals and pump.

3. Flush the unit with water or an acceptable solvent as follows:

- Remove the Orifice.
- Retract the Blade from the orifice by rotating the Calibrator Handle and fully open the Tuning Valve by turning the Tuning Valve Handle, (mounted at Sonolator OUTLET).
- Fill the funnel or feed Vessel/Tank with water or solvent.
- Start the pump and run the water or solvent out of the funnel or recycle it for a few minutes, if desired. Avoid running the pump dry for more than a second or two.

4. Select the proper Orifice to yield the desired pressure. Remember, it's usually better to start with a larger orifice (lower pressure) unless you are sure of the fluid characteristics and properties. Install the Orifice and its O-ring.

5. Pour a sufficient amount of premixed fluid into the funnel or open the feed line valve as appropriate.

6. Start the pump and observe the pressure gauge. If it is higher than it should be for a given orifice, check to make sure that:

a. The back pressure valve is completely open.
b. The blade is retracted from the orifice.
c. The filter is not clogged.
d. The orifice is not plugged.
e. The flow rate is correct and matches criteria given when Orifice was ordered and sized

Check the ***Troubleshooting Pressure Problems*** portion of this manual as well; found in the Procedures section

If all checks are in order, the orifice pressure can be lowered by using a larger orifice or reducing the pump revolutions, as appropriate.

7. When the desired pressure is established, the Acoustic Meter should be turned on and the unit tuned as follows:

- Move the blade into the jet stream until it is 2 or 3 turns of the adjusting wheel from the orifice.

- Increase the back pressure by closing the Back Pressure Valve slowly. An audible sound ranging from a rushing noise to a high pitched whistle should begin to develop. There will be a corresponding rise in the needle on the acoustic meter and it will probably be necessary to adjust the meter gain control to keep the needle "on scale." Continue turning the back pressure valve until the needle peaks or levels and begins to decline. Then return the valve to the highest meter reading. BE CAREFUL NOT TO CLOSE THE VALVE COMPLETELY.

Caution: Do not use the Back Pressure Valve to generate pressure. For the Sonolator™ to work efficiently, all the pressure must be generated solely by the Orifice. If the proper pressure is not generated by the Orifice provided with the Back Pressure Valve completely opened, contact Sonic Corporation.

- Adjust the blade-to-orifice distance by turning the wheel to move the blade further away from the orifice. If this increases the acoustic meter reading, continue moving the wheel in the same direction until the reading peaks on the meter. If the reading decreases, reverse the procedure until the reading is peaked.

- Return to the back pressure valve and adjust it slightly for the maximum meter reading.

- It is not necessary to reach and maintain the exact maximum meter reading, for the instrument is extremely sensitive and relatively minor changes are greatly amplified with the result that they appear more significant than they actually are. Fluctuations in the meter reading during operation are normal and do not require re-tuning of the Sonolator.

8. With the correct and desired pressure and a proper tune, you are ready to begin running product. Connect your inlet and outlet piping.

9. Open all valves both upstream and downstream of the Sonolator™ System.

10. Start unit.

11. If a feed pump is connected to force feed the pump provided with the Sonolator™ System, make sure to start the Sonolator™ System pump first, then slowly pump material with the feed pump carefully observing the inlet pressure created between the two pumps; this pressure should never exceed 50 to 60 psi.