LSP-600 - LABORATORY-SCALE ULTRASONIC LIQUID PROCESSOR

USER MANUAL

Notice of Liability:

The information contained in this manual is distributed on an "as is" basis, without warranty. While every precaution has been taken in the preparation of this manual, the manufacturer shall not have any liability to any person or entity with respect to any loss or damage caused or alleged to be caused directly or indirectly by the instructions contained in this manual or by the products described herein.

Patent Protection:

This ultrasonic equipment is manufactured under U.S. Patent No. 7,156,201, International Patent Application No. PCT/US2008/068697 and U.S. Patent No. 8,651,230.

Table of Contents

Section I

Introduction

General User Information

Read This Manual First

Before operating your ultrasonic processor, read this User Manual to become familiar with the equipment: this will ensure correct and safe operation.

NOTE

Note statements provide additional information or highlight procedures.

Notes, Cautions and Warnings

Throughout this manual we use NOTES (right, top) to provide information that is important for the successful application and understanding of the product. In addition, we use special notices (CAUTION and WARNING blocks, right) to make you aware of safety considerations. These blocks have important information that, if ignored, could have severe outcomes. The statements in the yellow and red blocks help you identify hazards, avoid them and recognize the consequences. One of three different symbols also accompany the CAUTION and WARNING blocks to indicate whether the notice pertains to a condition or practice, an electrical safety issue or an operator protection issue (right, bottom).

CAUTION

Caution statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING

Warning statements point out conditions or practices that could result in personal injury or loss of life.

Failure to follow any of the statements in the WARNING or CAUTION blocks will void this product's warranty.

System Overview

The LSP-600 laboratory-scale ultrasonic liquid processor is designed for small-scale experiments and process optimization. The processor can output up to 600 W of acoustic power into the processed liquids and operates at the frequency of approximately 20 kHz.

Regulatory Agency Compliance

FCC

The ***LSP-600 W generator*** complies with the following Federal Communications Commission regulations:

- The limits for FCC measurement procedure MP-5, "Methods of Measurement of Radio Noise Emissions from industrial scientific or medical Equipment", pursuant to FCC Title 47 Part 18 for Ultrasonic Equipment.

CE Marking

This mark on your equipment certifies that it meets the requirements of the EU (European Union) concerning interference causing equipment regulations. The ***LSP-600 W generator*** complies with the following CE requirements:

- The EMC Directive 2014/30/EU for Heavy Industrial Environment:
  - EN 61000-6-4, EN 55011, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6 EN 61000-4-8, EN 61000-4-11
- The Low Voltage Directive 2014/35/EU
- The Machinery Directive 2006/42/EC
  - EN 60204: Safety of Machinery – Electrical Equipment of Machines Part 1: General Requirements
- EN ISO 12100: Safety of Machinery – General principles of design, risk assessment, and risk reduction.

IP Rating

The ***LSP-600 W generator*** has an IP (International Protection) rating from the IEC (International Electrotechnical Commission):

- IEC: 61010-2012

UL & CSA

The ***LSP-600 W generator*** complies with these standards:

- Underwriters Laboratories (UL): 1012:2010
- National Standards of Canada (CSA): CAN/CSA C22.2 No. 61010-1-12 as verified by TÜV Rheinland.

CAUTION

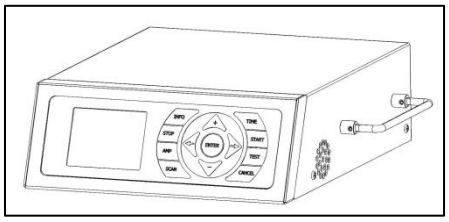
DO NOT make any modifications to the LSP-600 generator or associated cables. The changes may result in violating one or more regulations under which this equipment is manufactured.

Safe Working Conditions	
Operating Environment	Temperature: 40 – 100°F (5 – 38°C) Air Particulates: Keep the equipment dry. Minimize exposure to moisture, dust, dirt, smoke and mold. Relative Humidity: 5 – 95% (Non Condensing @ 5 – 30°C)
Shipping/Storage Environment	Temperature: -4 – 158°F (-20 – 70°C) Air Particulates: Keep the equipment dry. Minimize exposure to moisture, dust, dirt, smoke and mold Relative Humidity 5 – 95% (Non Condensing @ 0 – 30°C)
Other	For indoor use only

Main Components

Included with the LSP-600 processor are: 600 W **ultrasonic generator**, air-cooled **piezoelectric transducer**, **Full-wave Barbell Horn®** (FBH), optional **Conventional horn** (CH), and optional water-cooled **reactor chamber** (flow cell).

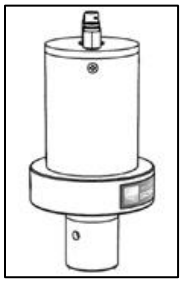
Generator



The 600 W LSP-600 **generator** is designed to supply a continuous resonant frequency lock and constant amplitude during operation. The generator's LCD display and *hot-key* buttons can be used to change the settings for the ultrasonic amplitude (20% - 100%) or the duration of the ultrasonic output. The generator supplies constant amplitude by automatically adjusting the power delivered to the transducer as a function of variable loading conditions (further explained below). The generator passes strict CE test specifications for global applications.

Generator AC Power Requirements		
Operating Frequency [kHz]	20 +/- 1	
Overload Power Rating [W]	600	
Input Voltage	100 VAC – 120 VAC, 50/60 Hz @ 9.0 Amps	200 VAC – 240 VAC, 50/60 Hz @ 4.5 Amps
North America/Japan AC Outlet Rating	15.0 Amps	
Weight	12 lbs. (5.44 Kg)	
Main Dimensions	11.6"W x 15.2"L x 3.9"H 295 mm x 387 mm x 99 mm	

Transducer



The LSP-600 processor includes an air-cooled **piezoelectric transducer**, ACT-22-LSP. This transducer has the power rating of 600 W, and is capable of supplying ultrasonic energy to both batch and continuous processes. It is necessary that the transducer be cooled with clean and dry compressed air if operating for more than 30 min. Even while cooled with air, the continuous operating time of this unit should not exceed 60 minutes.

ACT-22-LSP Transducer	
Weight	2.55 lbs. (1156 g)
Main Dimensions	6.5" L x 3.5" Dia. (165 mm x 88 mm)
Maximum Amplitude	22 microns

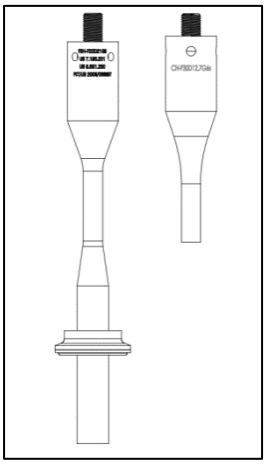
NOTE

If continuous operation for more than 60 min is desired, please contact ISM to inquire about an upgrade to our bench or industrial-scale ultrasonic processor.

CAUTION

The temperature of ACT-22-LSP transducer' front mass (the part that meets the horn) should never be allowed to exceed 45 ^{o}C. If this temperature is reached, the unit must be turned off and allowed to cool.

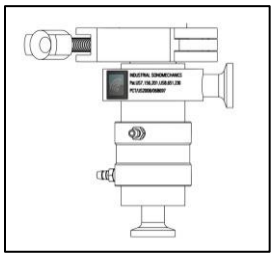
Ultrasonic Horns



Two types of ultrasonic horns may be utilized with the LSP-600 processor: **Conventional horn** (CH), generally employed for small batch (15 – 100 ml) processing and **Full-wave Barbell Horn®** (FBH), used for flow-through processing (Fig. 1 - 2) or for treating larger (100 – 500 ml) batches (Fig. 1 - 1, Fig. 4 - 8). A calibration sheet correlating horn tip vibration amplitude to the adjustable amplitude setting at the generator (20% - 100%) is provided with each horn.

	CH-type horn, 12.7 mm tip	**FBH-type Barbell horn®, 21 mm tip**
Weight	0.76 lbs. (350 g)	1.13 lbs. (514 g)
Dimensions	5.75” L x .5” tip Dia. (146 mm L x 12.7 mm tip Dia.)	11.25” L x .83” tip Dia. (286 mm L x 21 mm tip Dia.)
Materials	Titanium Alloy	Titanium Alloy
Maximum Amplitude	107 microns	115 microns

Reactor Chamber (Flow Cell)



The flow-through processing mode requires a **reactor chamber** (flow cell). This mode is recommended when a higher processing capacity (500 ml - 1 L), improved ultrasonic exposure uniformity and better temperature stability are required. During continuous flow-through ultrasonic processing, the use of the reactor chamber ensures that all of the treated liquid is directed through the active cavitation zone created by the incorporated FBH-type horn, resulting in homogeneous processing. The reactor chamber supplied with the LSP-600 processor includes a water-cooling jacket that helps maintain the temperature of the liquid at the desired level.

Reactor Chamber	
Weight	1.34 lbs. (606 g)
Dimensions	4.05" L x 2.86" Dia. (103 mm x 73 mm)
Materials	304 Stainless Steel
Internal volume (Reactor Chamber)	35 ml
Internal volume (Cooling Jacket)	10 ml

System Productivity

Productivity rates provided by the LSP-600 processor are highly dependent on the nature of each process and the horn type being used. With the CH-type horn, the productivity ranges from about 1 ml/min for challenging tasks (e.g., wet milling) to about 50 ml/min for fast processes (e.g., basic emulsification). With the FBH-type horn, the rates are approximately 3 times greater: about 3 ml/min for challenging tasks (e.g., wet milling) to about 150 ml/min for fast processes (e.g., basic emulsification).

NOTE

If your desired processing rate is higher, please speak to your ISM client representative about upgrading to a bench or industrial-scale system.

Principles of Operation

The 600 W ultrasonic generator transforms AC line power to a ~20 kHz signal that drives the piezoelectric transducer. For ultrasonic processing, the electrical energy coming from the generator is transformed to the mechanical vibration energy via the ACT-22-LSP transducer's reverse piezoelectric effect - the capability of a material to expand and contract (vibrate) when stimulated by an alternating current.

The transducer is coupled to a horn, which amplifies and transmits the vibration down its length to the processed liquid. The amplitude of the horn tip oscillation correlates to the intensity of cavitation and is set at the front panel of the generator by the operator (20% - 100%). The amplitude should be optimized for your particular process. Increasing the amplitude to its maximum setting does not always lead to superior processing quality - for many applications, optimal amplitude is found at a setting below 100%.

The vibration of the tip promotes acoustic cavitation in the liquid. This phenomenon can typically be seen as a cloud of bubbles forming in the vicinity of the tip and heard as an intense hissing noise. Cavitation is the formation of low-pressure voids (a.k.a., vacuum bubbles or cavities) in the liquid, which grow, briefly oscillate and then asymmetrically implode with great intensity. This generates extreme local temperatures, heating/cooling rates and pressures, giving rise to many chemical (sonochemical) reactions (sterilization, transesterification, desulfurization, etc.). At the same time, streaming currents, extremely fast micro-jets and enormous shear forces are generated in the cavitation filed, promoting a wide range of physical (mechanical) effects (nano-emulsification, particle fragmentation, cell disruption, homogenization, dispersing, deagglomeration, degassing, etc.). Under the right conditions, cavitation events can even create light - this effect is called sonoluminescense.

The horn tip diameter dictates the amount of sample that can be effectively processed per unit of time. The choice of horn is matched to the sample volume, viscosity and other parameters of your particular application.

NOTE

Please consult with your ISM client representative for assistance with selecting the right horn for your application.

Sonication Amplitude and Power

Amplitude is a measurement of the excursion of the horn tip, and is measured in microns (peak-to-peak). The generator's AMP hot-key allows setting the amplitude to any desired level between 20% and 100%. Each horn comes with a calibration certificate that correlates this % setting to the horn tip amplitude in microns.

The LSP-600 ultrasonic processor has a power display, showing the sonication power in watts. During operation, the wattage displayed is the power required to drive the radiating face of a horn at that specific amplitude setting against that specific load. For example, the unit experiences a higher load when processing higher-viscosity samples than lower-viscosity ones or when using a horn with a larger tip diameter.

The processor is designed to deliver constant amplitude to your liquid sample, regardless of any changes in the load. The speed/cruise control on an automobile is a good analogy: it is used to ensure that the vehicle maintains a constant rate of travel independently of the "load". As the terrain elevations change, so do the power requirements. The cruise control senses these requirements, and automatically adjusts the amount of power delivered by the engine in order to compensate for these changing conditions. The greater the terrain's upward incline and the resulting resistance to the movement of the vehicle, the greater the amount of power that will be delivered by the engine to overcome that resistance and maintain a constant speed. The LSP-600 ultrasonic processor's constant amplitude control operates on a similar principle. As a liquid is processed, the load on the horn may vary due to changes in the liquid sample (i.e. viscosity, pressure). If the resistance to the movement of the horn increases, additional power will be delivered by the generator to ensure that the excursion at the horn tip remains constant. The displayed wattage readings will vary as the load changes; however, the amplitude will remain the same.

Since the resistance to the movement of the horn determines how much power will be delivered to maintain the amplitude, horns operating in liquids draw more power than when they operate in air. For example, at the 100% amplitude setting, the supplied FBH horn will vibrate at the amplitude of 115 microns and require approximately 50 watts to operate in air. Insert the horn in water down to its flange and the power reading will increase to approximately 435 watts. Insert it deeper, and the power reading will increase further. The amplitude will, however, always remain the same.

Although the degree of cavitation/ultrasonic energy required to process a sample can sometimes be determined by visual observation, the amount of power required cannot be predetermined. A sensing network continuously monitors the output requirements and automatically adjusts the power to maintain the amplitude at the preselected level. The greater the resistance to the movement of the horn due to higher viscosity, deeper immersion, larger horn diameter or higher pressure, the greater the amount of power that will be delivered to the horn. *Setting the AMP control to its maximum will not cause the maximum power rating of the unit to be delivered to the sample. The maximum power (600 W) that the Ultrasonic Processor is capable of providing will only be delivered when the resistance to the movement of the horn is high enough to draw the maximum wattage.*

Processing Configurations

Batch Mode

Batch-mode processing does not require the reactor chamber. In this mode, the processed liquid is placed in a batch container. Batch mode is commonly used for small-scale process investigations.

CAUTION

Use only the provided support arm to mount the transducer on the support stand.

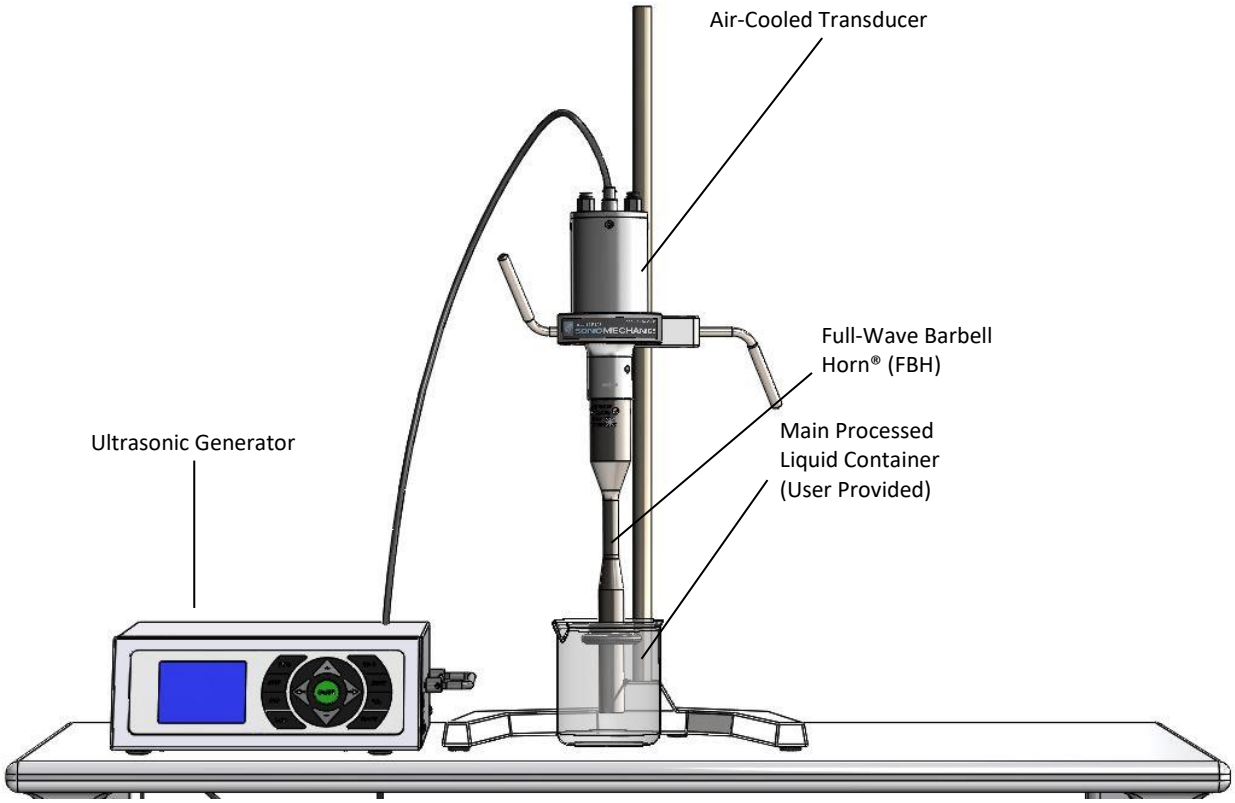


Figure 1 - 1. LSP-600 ultrasonic processor in the FBH-type horn-based batch-mode configuration. The 600 W ultrasonic generator excites vibration in the piezoelectric transducer. The vibrational amplitude is amplified by the Full wave Barbell Horn® (FBH), and the ultrasonic energy is delivered to the liquid in the batch container. Batch sizes of up to about 500 ml can commonly be processed using this setup directly.

Flow-Through Mode

Recirculating and **single-pass** configurations are possible in the **flow-through** processing mode. In the recirculating configuration (Fig. 1 – 2), the material passes through the reactor chamber multiple times, which increases the cumulative ultrasonic exposure time. This configuration is recommended for challenging processes, such as nano-crystallization, nano-emulsification, deagglomeration, etc. A single-pass configuration is commonly used as part of a continuous multistep process. In this configuration, the working liquid, coming from a previous processing step, passes through the reactor chamber and is then either collected as a finished product or continues down the line for further treatment.

CAUTION

Use only the provided support arms to mount the transducer and reactor chamber on the support stand. Always make sure to support both the transducer and the reactor chamber.

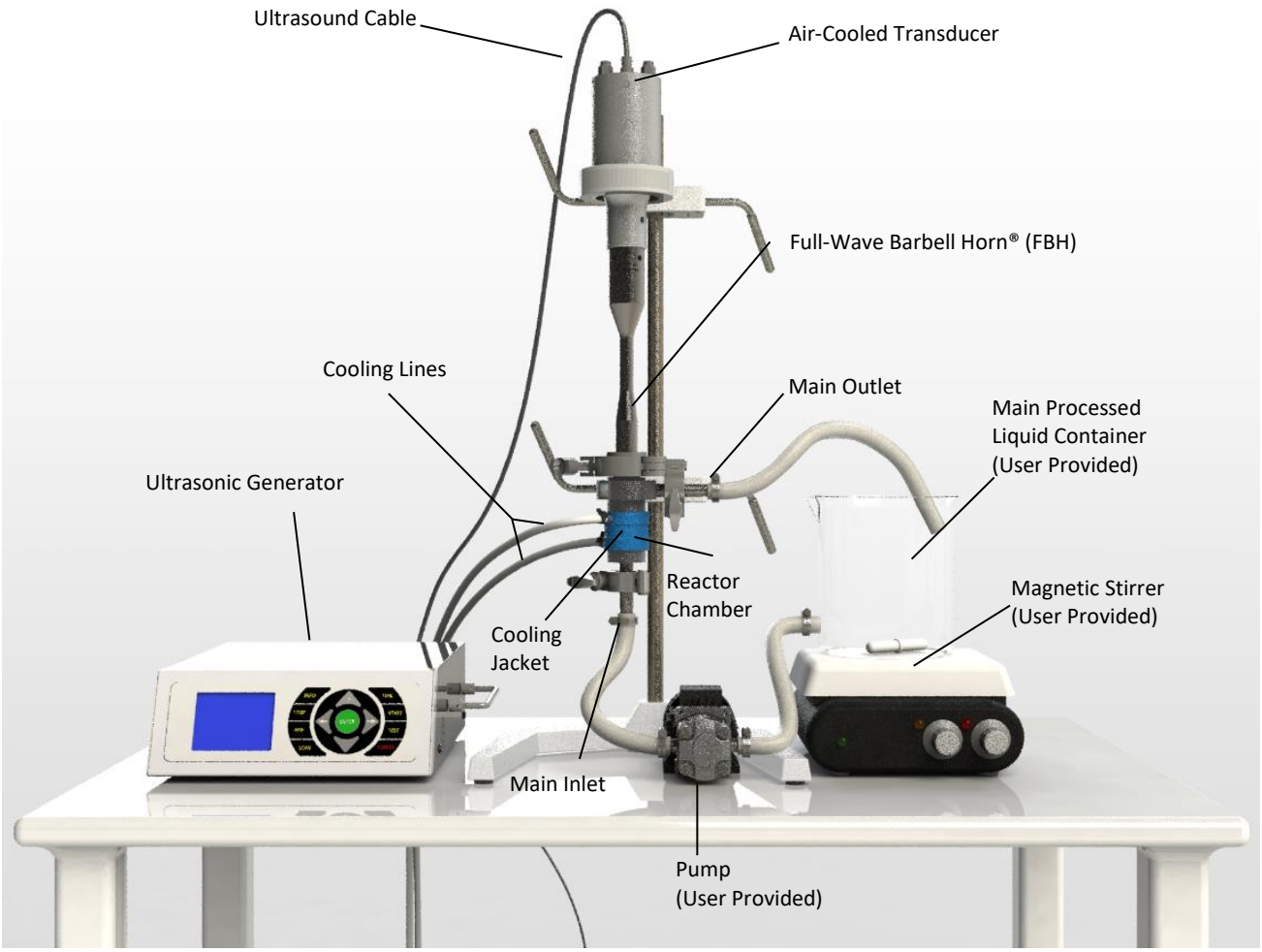


Figure 1 - 2. LSP-600 ultrasonic processor in the recirculating flow-through configuration. The 600 W ultrasonic generator excites vibration in the piezoelectric transducer. The vibration amplitude is then amplified by the FBH-type Barbell Horn®, and the ultrasonic energy is delivered to the liquid flowing through the reactor chamber. A cooling water jacket surrounds the chamber to allows for temperature control of the processed fluid.

Section II

Health and Safety

General Considerations

Please observe these health and safety recommendations for safe, efficient, and injury-free operation of your equipment.

CAUTION

Proper Installation – Operate system components only after they are properly installed and checked.

Comply with Regulations – You may be required to add accessories to bring the system into compliance with applicable OSHA regulations for machine guarding and noise exposure.

Avoid physical damage - Do not drop, hit or strain any component of the ultrasonic processor.

WARNING

No Unauthorized Modifications – Do not modify your system in any way unless authorized to do so by the manufacturer. Unauthorized modifications may cause injury to the operator and/or equipment.

Keep the Cover On – Do not remove any equipment cover unless specially directed to do so by the manufacturer. The generator produces hazardous electrical voltages, which could cause injury.

Grounded Electrical Power – Operate this equipment only with a properly grounded electrical connection. (See *Electrical Safety* and the grounding instructions below).

WARNING

Wear ear protection to reduce the noise emitted during ultrasonic processing. In addition, sound absorbing materials, enclosures or sound deflectors may be installed to reduce the noise level.

Electrical Safety

Domestic and International Power Grounding

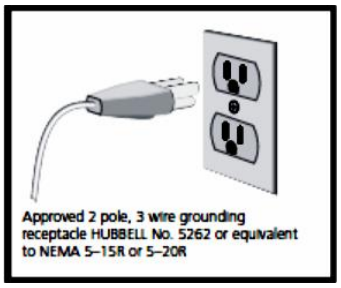


Figure 2 - 1. Example of 120 Volt, Grounded, 3-Prong Receptacle.

For safety, this product has a three-wire, grounding-type power cord. Fig. 2 - 1 illustrates the appropriate electrical outlet to use with the power cord that is included with the 120 V rated generators shipped to North America.

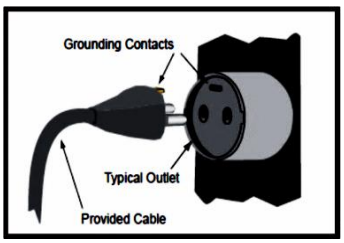


Figure 2 - 2. International 220/240V Grounding.

The power cable normally provided for international use is compatible with the power outlet used in many European countries (Fig. 2 - 2).

WARNING

If you have a two-prong electrical receptacle, replace it with a properly grounded three-pong type. Have a qualified electrician replace it following the National Electric Code and any local codes and ordinances that apply. If there is any question about the grounding of your receptacle, have it checked by a qualified electrician. Do not cut off the power cord grounding prong or alter the plug in any way. If an extension cord is needed, use a three-wire cord that is in good condition. The cord should have an adequate power rating to do the job safely. It must be plunged into a grounded receptacle. Do not use a two-wire extension cord with this product.

SECTION III

Generator Installation, Connections and Control

System Overview

The LSP-600 W generator's rugged internal circuitry ensures a continuous resonant frequency lock and constant amplitude while operating. The brightly lit display is easy to read. The menu structure makes programming simple, and the one-touch hot-keys give the operator additional flexibility. The generator also includes an RFI line filter that passes strict CE test specifications for global applications.

Key Generator Features

- **Compact Generator** is light and easily moved, allowing your work-space to accommodate more of the items needed for your process.
- **Pulse Width Modulation** incorporates patented circuitry giving the generator the ability to efficiently change the output amplitude.
- **Linear Ramp Soft-Start** circuitry allows the ultrasonic stack (transducer/horn assembly) to be brought to operating amplitude smoothly, minimizing start-up surges and abnormal stress to the ultrasonic stack and generator.
- **Digi-Trac Tuning** tracks the resonant frequency of the acoustic stack and adjusts the generator output frequency to match it. This eliminates the need to manually tune the generator.
- **Line Voltage Regulation** automatically maintains constant amplitude regardless of line voltage deviation. The available output power is maintained with any voltage input within the specified range. This provides consistent system performance regardless of line voltage fluctuations. It also eliminates the need for bulky, external constant-voltage transformers.
- **Load Regulation** provides constant ultrasonic amplitude automatically, regardless of power draw. The ultrasonic output amplitude level is held to within ±1%.
- **Industrial Line-Power Source** means that systems will operate worldwide at the local high line voltage level. There are no internal transformer taps to change for world-wide operation.
- **Multiple Electronic Overload** protection circuits prevent instantaneous component failure in the event of extreme output overload conditions, and rated overload power limit is based on the actual true RMS power output level.
- **CE Certification** means that the system meets the required European standards to be sold and used in Europe.
- **ISO 9001 : 2008 Certification** means that this system has been manufactured to high quality standards and assures you of manufacturing excellence.
- **TUV Certification** - TÜV Rheinland certifies this generator with applicable UL (Underwriters Laboratories) and CSA (Canadian Standards Association) requirements.

Inspection

Perform a visual inspection to detect any evidence of damage that might have occurred during shipment. Before disposing of any packaging material, check for small items. The ultrasonic processor was carefully packed and thoroughly inspected before leaving our factory. The carrier, upon acceptance of the shipment, assumed responsibility for its safe delivery. Claims for loss or damage sustained in transit must be submitted to the carrier. If damage has occurred, contact your carrier within 48 hours of the delivery date. DO NOT OPERATE DAMAGED EQUIPMENT. Retain all packing materials for future shipment.

Electrical Requirements

The ultrasonic generator requires a fused, single-phase 3-terminal grounded electrical outlet. For power requirements, check the label on the back of the unit.

WARNING

For your personal safety, DO NOT, under any circumstances, defeat the grounding feature of the power cord by removing the grounding prong.

Installation

The ultrasonic generator should be installed in an area that is free from dust, dirt, explosive and corrosive fumes, and extremes of temperature and humidity. If processing flammable liquids, use an approved fume hood and do not place the generator inside the fume hood. When positioning the unit, be sure to leave adequate space so that all connections can be easily accessed.

Unpacking

Carefully open your shipping container and make sure it contains all items shown on the shipping documents. Inspect the items and report any damage immediately.

Placing

Make certain the generator placement and cable routing allow for easy access and do not interfere with normal operation. The operator should have unobstructed access to all control switches and a clear view of the LCD panel. If the generator is installed inside an enclosure with a front door, be sure to allow at least 3 inches (8 cm) clearance behind the door for the cables.

WARNING

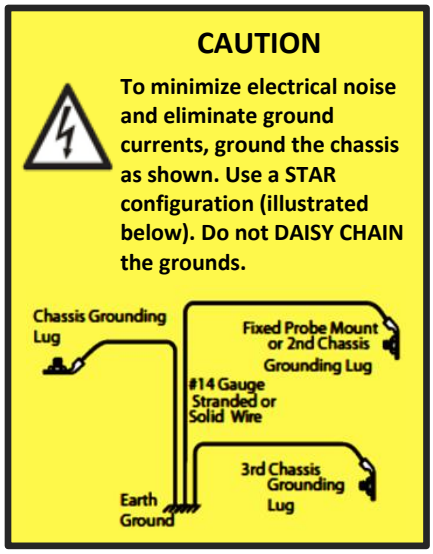
Do not allow any liquid or mist to enter the internal area of the generator in any way, for example, through its air inlet or outlet. This may cause an electrical short.

CAUTION

Place the generator on a hard, flat, horizontal surface with at least 3” of free space on all sides to be sure that air can properly ventilate the generator and there is sufficient space for wiring.

RFI Grounding

In addition to the safety considerations previously mentioned, proper grounding at the generator power cord is essential for the effective suppression of electrical noise or RFI (Radio Frequency Interference). The ultrasonic generator contains an RFI filter which blocks noise on the AC power line from entering the system control circuitry. This filter also prevents ultrasonic frequency noise from being fed back into the AC power line. In order for the RFI filter to operate properly, it is necessary to correctly ground the system. Run a grounding wire from the ground stud connection (see Fig. 3 - 5) to the nearest grounded metal pipe or equivalent earth ground, and secure it with a ground clamp.



Connecting Cables (Quick Start Guide)

Complete the basic connections as shown below:

Step 1
Connect the supplied AC power cord to the generator's Power Cable Input, **A** (Fig. 3 - 5). Do not plug the cord into the power outlet yet.

Step 2
Ground the generator chassis with the supplied 14-gauge wire. Attach one end of the wire to the grounding stud, **C** (Fig. 3 - 5) and its other end to the nearest grounded metal pipe or equal earth ground.

Step 3
Plug the AC power cord into a suitable power outlet.

ACT-22-LSP Air-Cooled Ultrasonic Transducer

Ultrasonic transducers are devices used to convert electric energy coming from an ultrasonic generator into mechanical energy in the form of ultrasonic vibrations.

The ACT-22-LSP transducer (Fig. 3 – 1) comprises the **transducer** itself, an **ultrasound input connector**, a **support arm**, and optional **air-cooling fittings**. It is compatible with both the FBH and CH-type horns.

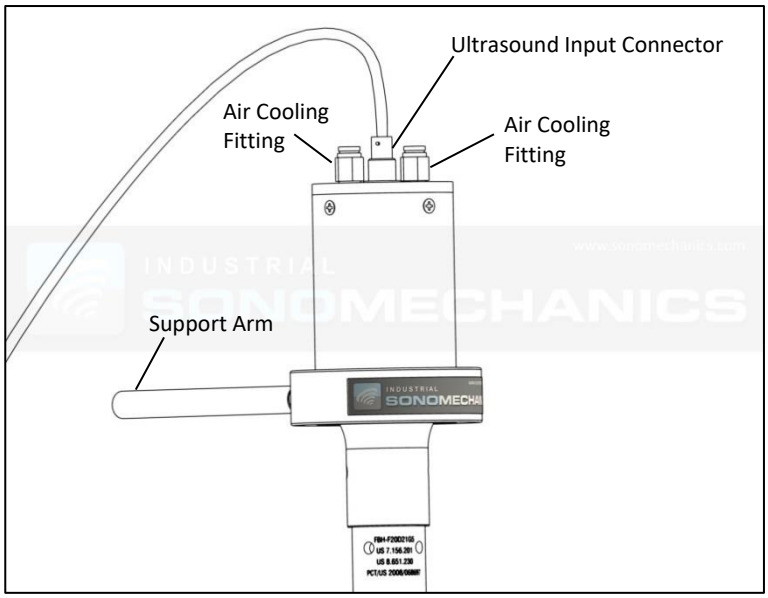


Figure 3 - 1. Schematic of Air-Cooled Piezoelectric Transducer, ACT-22-LSP.

CAUTION

The temperature of ACT-22-LSP transducer's front mass (the part that meets the horn) should never be allowed to exceed 45 ˚C. If this temperature is reached, the unit must be turned off and allowed to cool.

Air Fittings

If you have an application that requires greater than 30 minutes of continuous processing, there is potential for the transducer to heat up.

The general rule is that if the transducer clearly feels warmer than body temperature to the touch it should be cooled. Each transducer has 2 threaded ports for air cooling. Dry and clean compressed air is required. One port is attached to the air source and the other port remains open as a vent. Note that the ports provided on your transducer may require additional adapters to connect a line of compressed air.

Figure 3 - 2. Air Cooling of the ACT-22-LSP Transducer.

WARNING

Do not allow any liquid or mist to enter the internal area of the transducer in any way, for example though its air ports. This may cause an electrical short. When cooling the transducer, always use DRY air.

Support Arm

The support arm (Fig. 3 – 3) is screwed into the transducer collar and used for positioning the transducer in a clamp holder on a support stand. The support arm consists of a threaded metal rod, a counter-nut and a washer. Place the counter-nut onto the thread, followed by the washer. Insert the threaded side of the rod into the threaded hole located on the collar of the transducer. When the rod has fully penetrated the thread, tighten the connection with the counter-nut. Always use the provided support arm to secure your ultrasonic processor. **NEVER** support the transducer with a clamp on either the orange or red-shaded regions shown in Fig. 3 – 3.

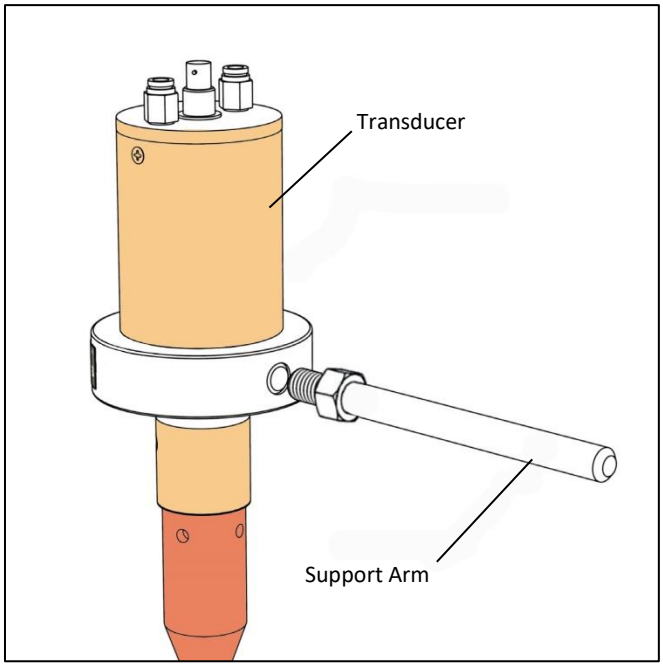


Figure 3 – 3. ACT-22-LSP Support Arm Attachment.

CAUTION

NEVER clamp the transducer to the areas indicated in orange or red in Fig. 3 – 3.

WARNING

Do not remove any labels or stickers from the transducer, detach its cooling connectors or open the transducer housing lid. This may allow a liquid to enter the internal area of the transducer and cause an electrical short.

Ultrasound Input Connector

The ultrasound input connector is a high-voltage coaxial style SHV-BNC connector. This connector provides superior shielding of electrical noise. The ultrasound input connector mates with a fully shielded coaxial ultrasound cable that is secured with a simple and reliable quarter-turn bayonet style attachment mechanism.

WARNING

Make sure to always connect the ultrasound cable to both the transducer and generator. Do not activate ultrasound if the cable is not connected to both devices.

CAUTION

The cable assembly should not be used to carry the transducer or pull it toward the user. Make certain the cable always has slack and is never tensioned. If necessary, move the generator or transducer closer to one another to accomplish this. If this is not possible, contact your ISM client representative to obtain a longer cable.

WARNING

The input into the ultrasound input connector has a very high AC voltage and can exceed 2 amperes of current. It must be securely terminated via the ultrasound cable for safe operation. Use original equipment ultrasound cables for safe and reliable system operation. Improperly assembled ultrasound cables can result in high voltage arcing and will destroy the ultrasound connectors.

Do not use your transducer if there is any evidence of arcing (black carbon deposits) on any connector.

Ultrasonic Horns

In order to produce high cavitation intensities, the ultrasonic transducer is equipped with a high-gain acoustic horn, which amplifies the vibration amplitude provided by the transducer and delivers the ultrasonic energy to the processed liquids. The LSP-600 ultrasonic processor is supplied with an FBH or CH-type ultrasonic horn. These options are shown in Figure 3 – 4.

CAUTION

Do not allow any vibrating surface of a horn or transducer to come in direct contact with any solid object (e.g. batch container, support clamp, reactor chamber) during system operation.

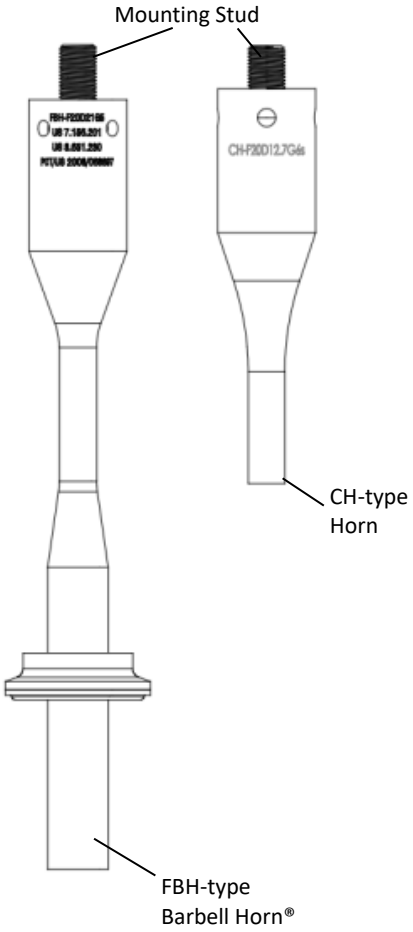


Figure 3 - 4. Horns Compatible with the LSP-600 Ultrasonic Processor.

Generator Layout

Rear Panel

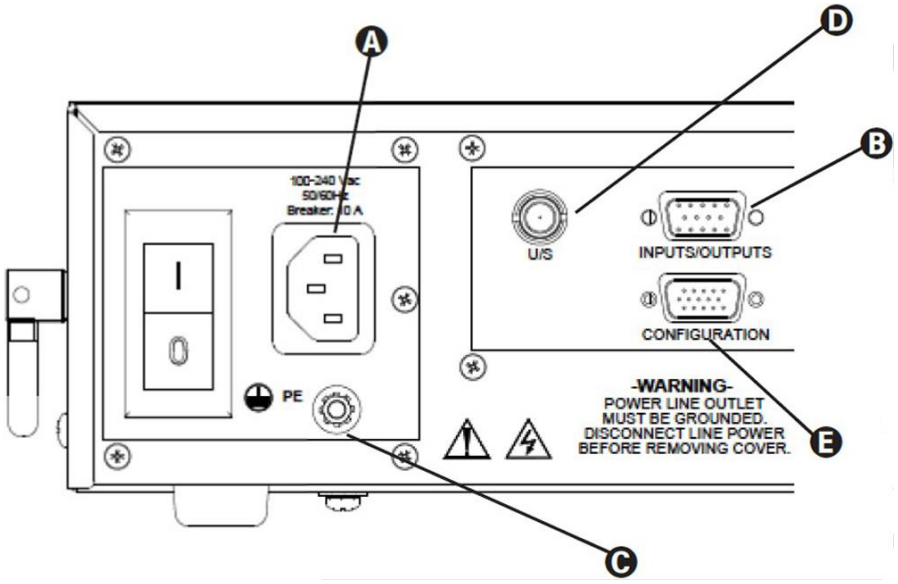


Figure 3 - 5. Rear Panel of the LSP-600 Generator.

REAR PANEL	
A	Power Cable Input.
B - **INPUTS/OUTPUTS**	Connects to a standard HD-15 connector (male) for auxiliary control (e.g., remote button switch).
C	Grounding lug.
D - **U/S**	Coaxial ultrasound cable connector (SHV-BNC, bayonetted-type).
E - **CONFIGURATIONS**	Unavailable or ISM use only. Connects to a standard HD-15 connector (female) for system data retrieval and software updates.

Front Panel

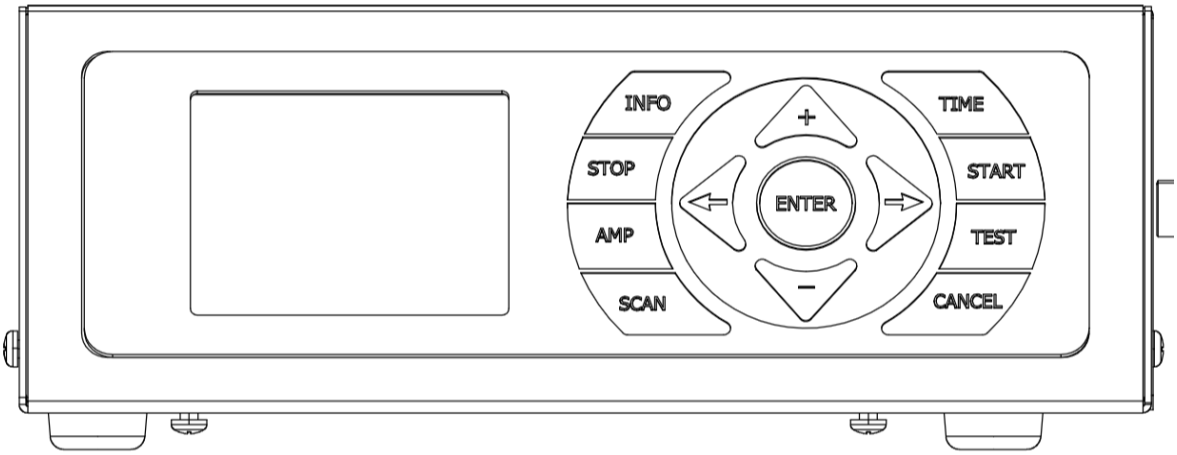


Figure 3 - 6. Front Panel of the LSP-600 Generator.

FRONT PANEL	
LCD display	Display
ENTER key	Confirm/Accept Menu Options
+ / - keys	Increase or Decrease Values
←/→ keys	Navigate Menus
INFO key	Additional Settings
TIME key	Set Timed Ultrasonic Processing
STOP key	Stop Ultrasonic Processing
START key	Start Ultrasonic Processing
AMP key	Select and Set Ultrasonic Amplitude %
TEST key	Test Ultrasonic Stack (HOLD to initiate ultrasound)
SCAN key	Perform Scan Stack Procedure
CANCEL key	Return to Previous Menu

Ultrasound Cable Connector

The ultrasound cable connector used with all standard generators is a high-voltage (5,000 V) coaxial style SHV-BNC connector. This connector provides superior shielding of electrical noise, compared to other types of connectors. The ultrasound cable connector mates with a fully shielded coaxial ultrasound cable. This connection is secured with a simple and reliable quarter-turn bayonet style attachment mechanism.

WARNING

Make sure to always connect the ultrasound cable to both the transducer and generator. Do not activate ultrasound if the cable is not connected to both devices.

WARNING

The output from the ultrasound cable connector has a very high AC voltage and can exceed 2 amperes of current. It must be securely terminated via the ultrasound cable for safe operation. Use original equipment ultrasound cables for safe and reliable system operation. Improperly assembled ultrasound cables can result in high voltage arcing and will destroy the ultrasound connectors.

Do not use your generator if there is any evidence of arcing (black carbon deposits) on any connector.

Figure 3 – 7. Ultrasound Cable Connector.

LCD Display

The LCD display gives the operator a basic interface for generator monitoring and control. Fig. 3 - 8 illustrates a typical view of the display just after the generator has been powered up.

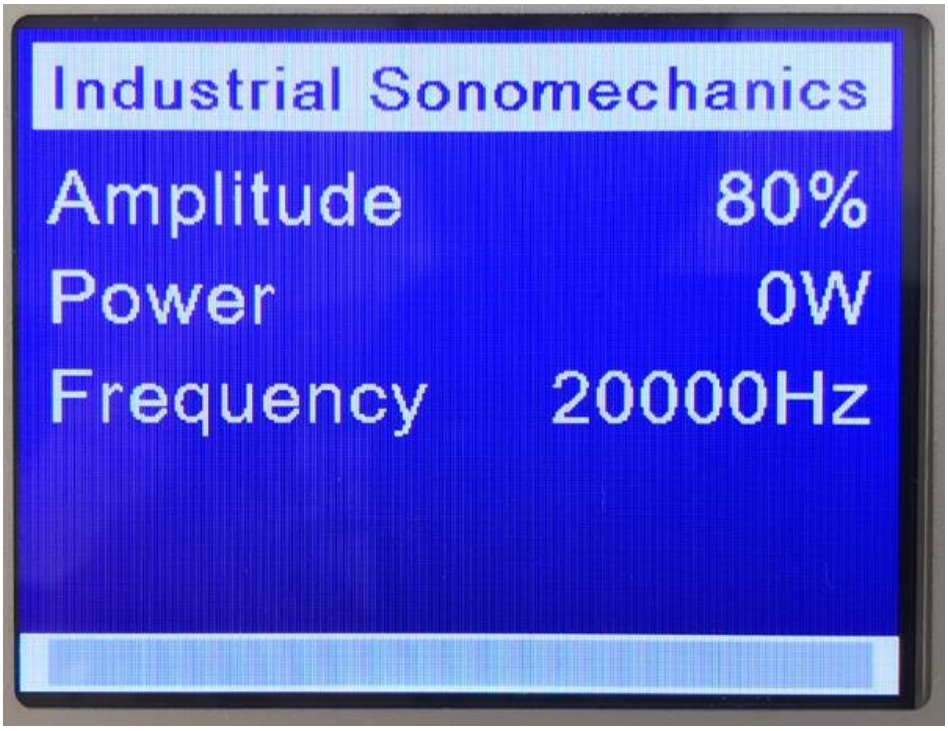


Figure 3 – 8. The LSP-600 generator's LCD display.

SECTION IV

Transducer, Horn and Reactor Chamber Assembly

Attaching a Horn to the Transducer

1. Inspect the Mylar acoustic washer (provided) for damage, making sure it has no scratches or particles, and place it over the connecting stud of the horn (CH or FBH). If the washer's condition is in doubt, replace it with a new one.
2. Thread the components together by hand (Step 1, Fig. 4 – 1) and then tighten using the supplied spanner wrenches (Step 2, Fig. 4 – 2).

CAUTION

Do not rely on the transducer's support arm for attaching or detaching a horn. Always remove the transducer's support arm before attaching or detaching a horn.

CAUTION

Always use a Mylar washer (one) during this procedure, otherwise mating surfaces may permanently bond. Make sure the washer is in good condition, without scratches or rips. Using a damaged washer may cause the assembly to operate incorrectly.

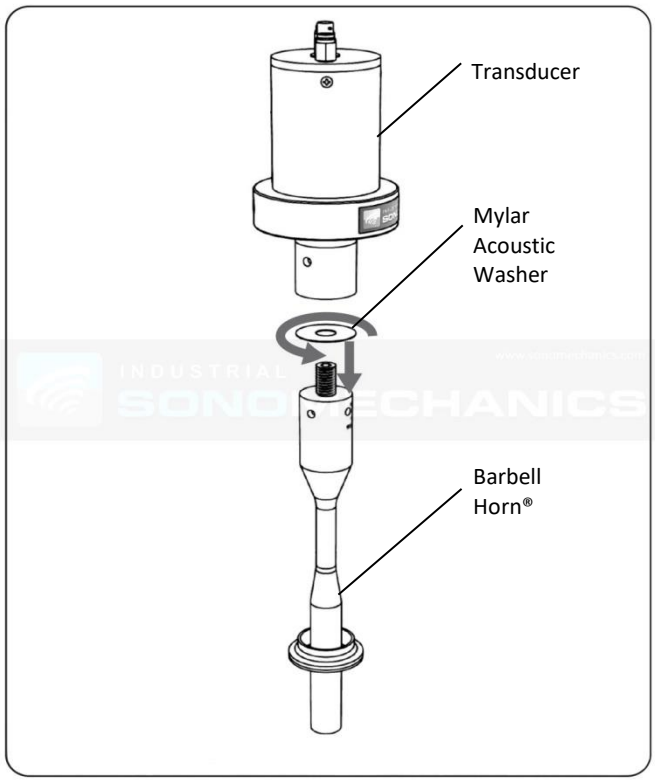


Figure 4 - 1. Attaching a Horn to the Transducer, Step 1.

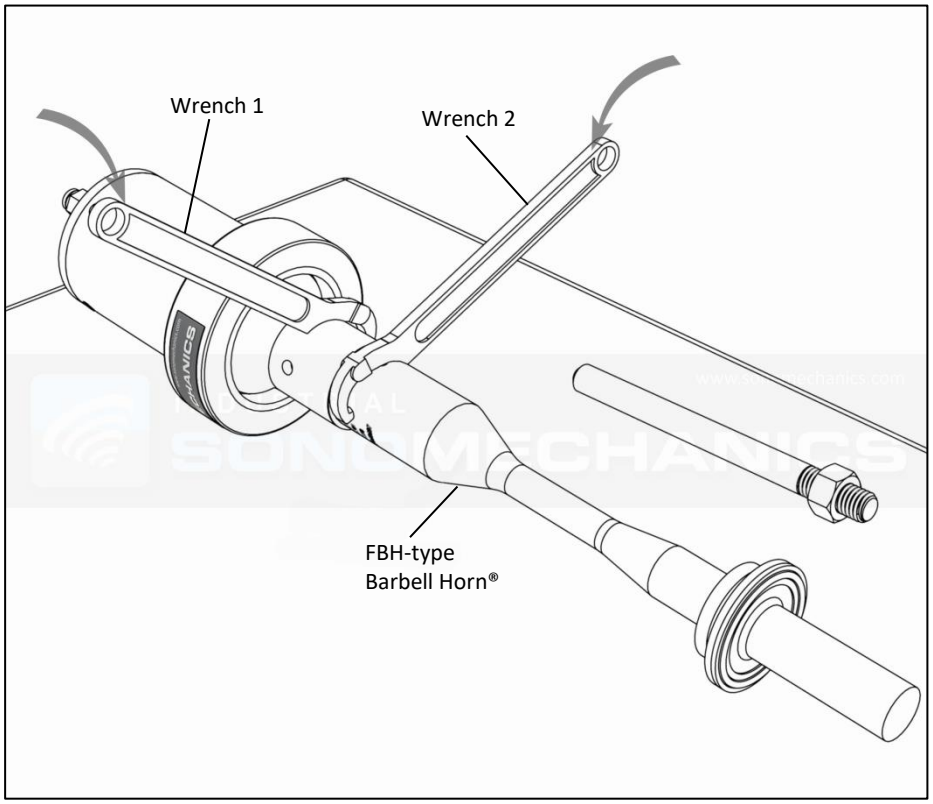


Figure 4 - 2. Attaching a Horn to the Transducer, Step 2.

i. **Insert the pin of the first spanner wrench into a hole in the transducer's front mass. Set it up to provide counterclockwise torque.**
ii. **Insert the pin of the second spanner wrench into a hole in the horn's input end. Set it up to provide clockwise torque.**
iii. **Firmly press down with your palms on the wrenches, using the weight of your body to generate counterclockwise (wrench 1) and clockwise (wrench 2) torques.**

CAUTION

Do not substitute the provided spanner wrenches with any other tools. Never rely on the transducer's support arm instead of the provided spanner wrench during the horn attachment or detachment procedure as it may permanently damage the transducer.

CAUTION

Be sure that the transducer support arm is removed before attaching or detaching a horn.

Batch Processing Mode Assembly

When processing less than about 500 ml of liquid, the batch-mode arrangement is preferable because of its simplicity. Batch sample volumes in the range of 15 - 100 ml can be treated with the CH-type horn. Volumes in the range of 100 - 500 ml require the FBH-type horn (Fig. 4 – 3). Larger samples can be treated in the flow-through mode (Fig. 4 – 8).

CAUTION

If the equipment produces a loud piercing or squealing sound, disassemble the horn from the transducer and repeat the horn attachment procedure following all instructions. Failure to do so may damage the equipment.

1. Secure the transducer/horn assembly on a support stand by the support arm.
2. Place the batch container under the assembly. Lower the assembly (or raise the container), immersing the horn in the liquid down to its flange (by about 6 cm).
3. Connect the ultrasound cable to the back of the generator and the top of the transducer. Push the connectors in and turn the chrome rings clockwise ¼ turn to secure the bayonet-type connection.

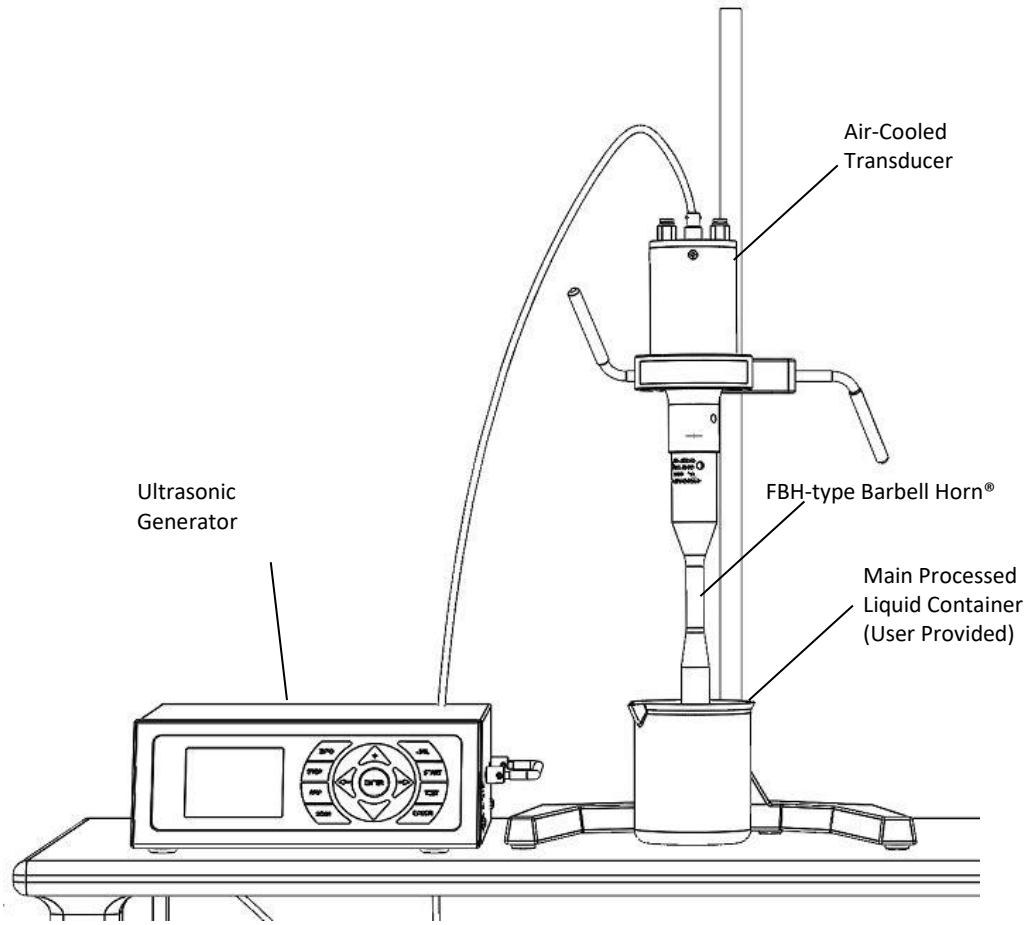


Figure 4 - 3. LSP-600 ultrasonic processor in the FBH-type horn-based batch mode configuration. Batch sizes of 100 - 500 ml can be processed using this setup directly. Smaller batches require the use of the CH-type horn. Larger volumes can be processed in the flow-through mode (Fig. 4 – 8).

Reactor Chamber (Flow Cell)

With the use of the reactor chamber (flow cell), the LSP-600 ultrasonic processor can be configured in the flow-through mode. When processing more than about 500 ml of liquid (up to about 1 L), this arrangement is preferable to the batch mode because it results in a higher processing capacity, improved ultrasonic exposure uniformity and better temperature stability. During continuous ultrasonic processing, the use of the reactor chamber ensures that all working liquid is directed through the active cavitation zone created by the incorporated FBH-type horn, resulting in homogeneous ultrasonic exposure. The reactor chamber includes a water-cooling jacket to help maintain the temperature of the working liquid at a desired level.

Fig. 4 – 4 shows the reactor chamber assembled with the FBH-type horn. The horn is secured and sealed to the reactor chamber by the Buna-N Gasket, Chamber Attachment Fitting and 1.5” Sanitary Clamp surrounding the horn’s non-vibrating flange.

The processed liquid is supplied through the "Main Inlet" and collected through the "Main Outlet" sanitary-flanged connections. Depending on the required process temperature, chilled water or ethylene glycol/water mixture may be supplied through the Coolant hose barb connections at the reactor chamber’s cooling jacket for temperature control.

CAUTION

Make sure to use the supplied gasket around the horn’s flange when using the reactor chamber. Failure to do so may result in a leak, incorrect equipment operation and permanent damage.

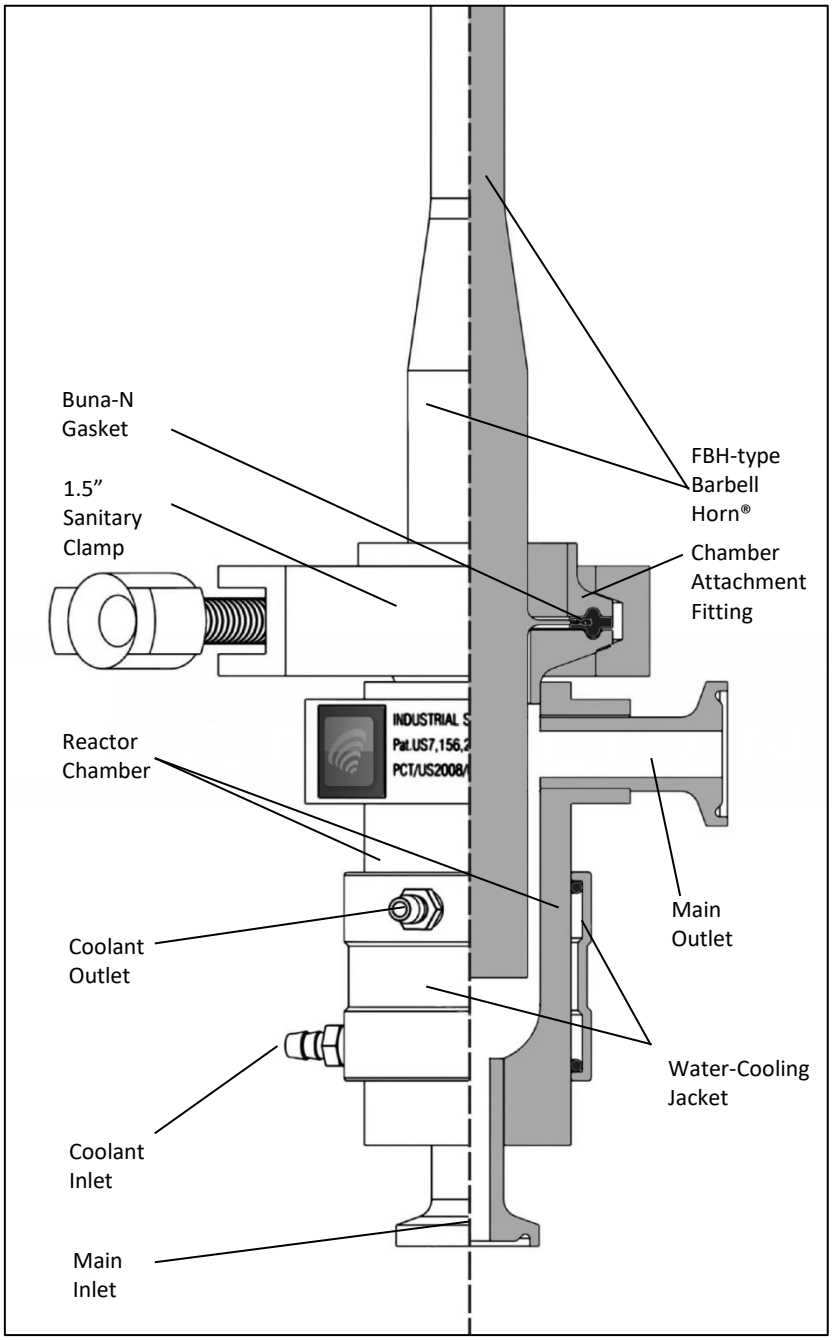


Figure 4 - 4. Cut-out view of Reactor Chamber assembled with a Full-Wave Barbell Horn®.

Flow-Through Processing Mode Assembly

1. Assemble the transducer and the FBH-type horn as described above, making sure that the Buna-N Gasket surrounds the flange of the horn and the Chamber Attachment Fitting is placed above the flange.
2. Attach Support Arms to the Transducer and Reactor Chamber.
3. Insert the Horn into the Chamber, ensuring that the support arms are parallel to each other.

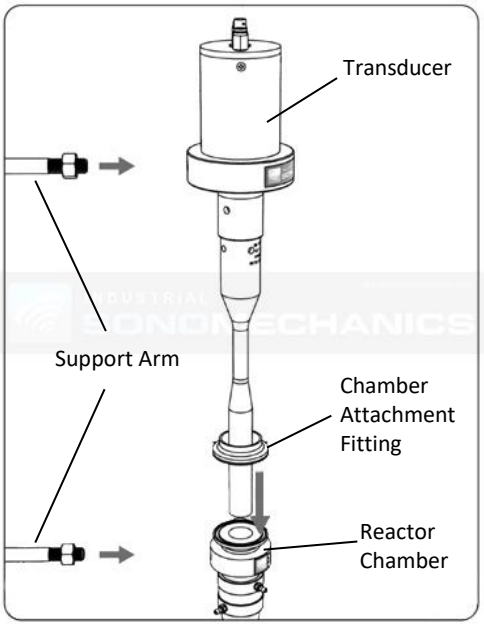


Figure 4 - 5. Orienting the Support Arms, Transducer/Horn Assembly and Reactor Chamber.

4. Use the provided 1.5” Sanitary Clamp to seal the Horn in the Reactor Chamber.

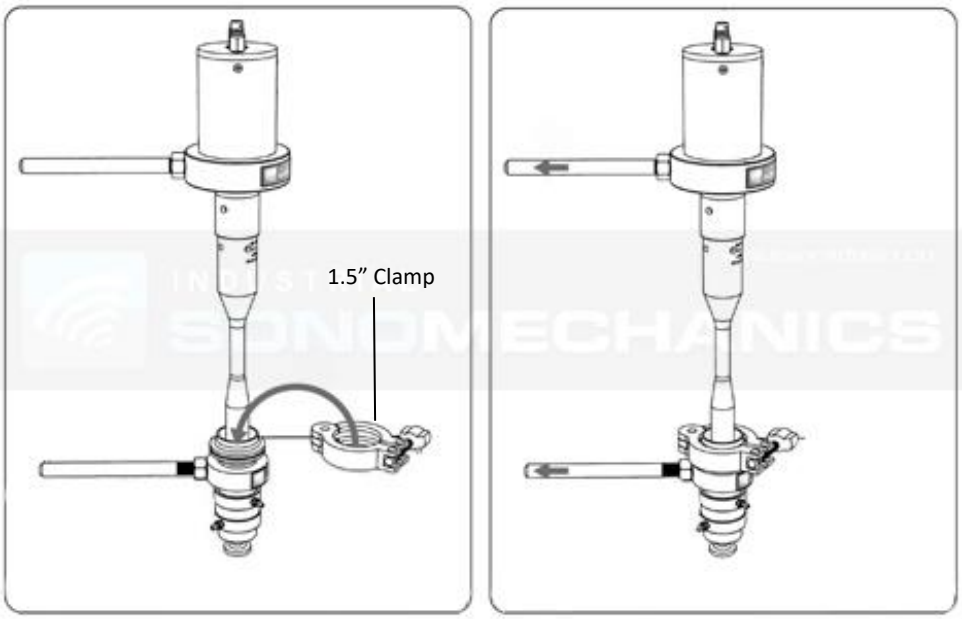


Figure 4 - 6. Sealing the FBH-Type Barbell Horn® in the Reactor Chamber.

5. Secure the final assembly on a support stand using both support arms.
6. Attach the provided ½" hose-barb adapters to the Reactor Chamber's Main Inlet and Main Outlet sanitary-flanged connections using the provided Teflon gaskets and clamps.
7. Use ½" ID hoses to connect the outlet of your Batch Container to a pump, and further to the Main Inlet, as well as to return the liquid from the Main Outlet to your Batch Container.
8. Attach cooling water hoses (optional) to the cooling jacket fittings on the Reactor Chamber.
9. Connect the ultrasound cable to the back of the generator and the top of the transducer. Push the connectors in and turn the chrome rings clockwise ¼ turn to secure the bayonet-type connection.

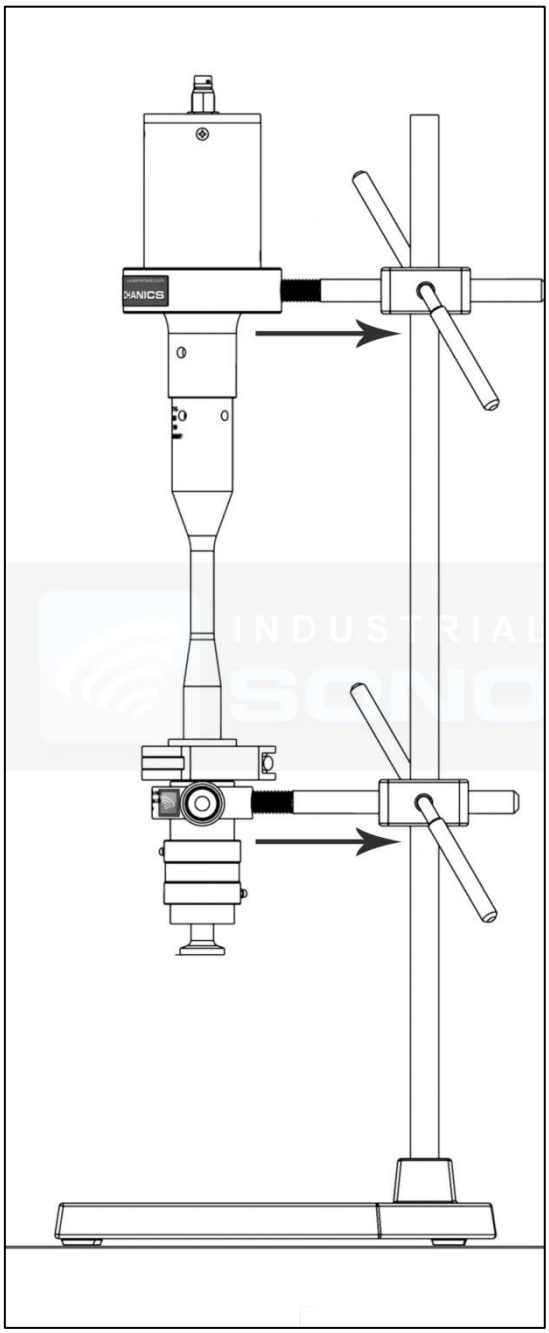


Figure 4 - 7. Securing the Transducer/Horn/Reactor Chamber Assembly on a support stand.

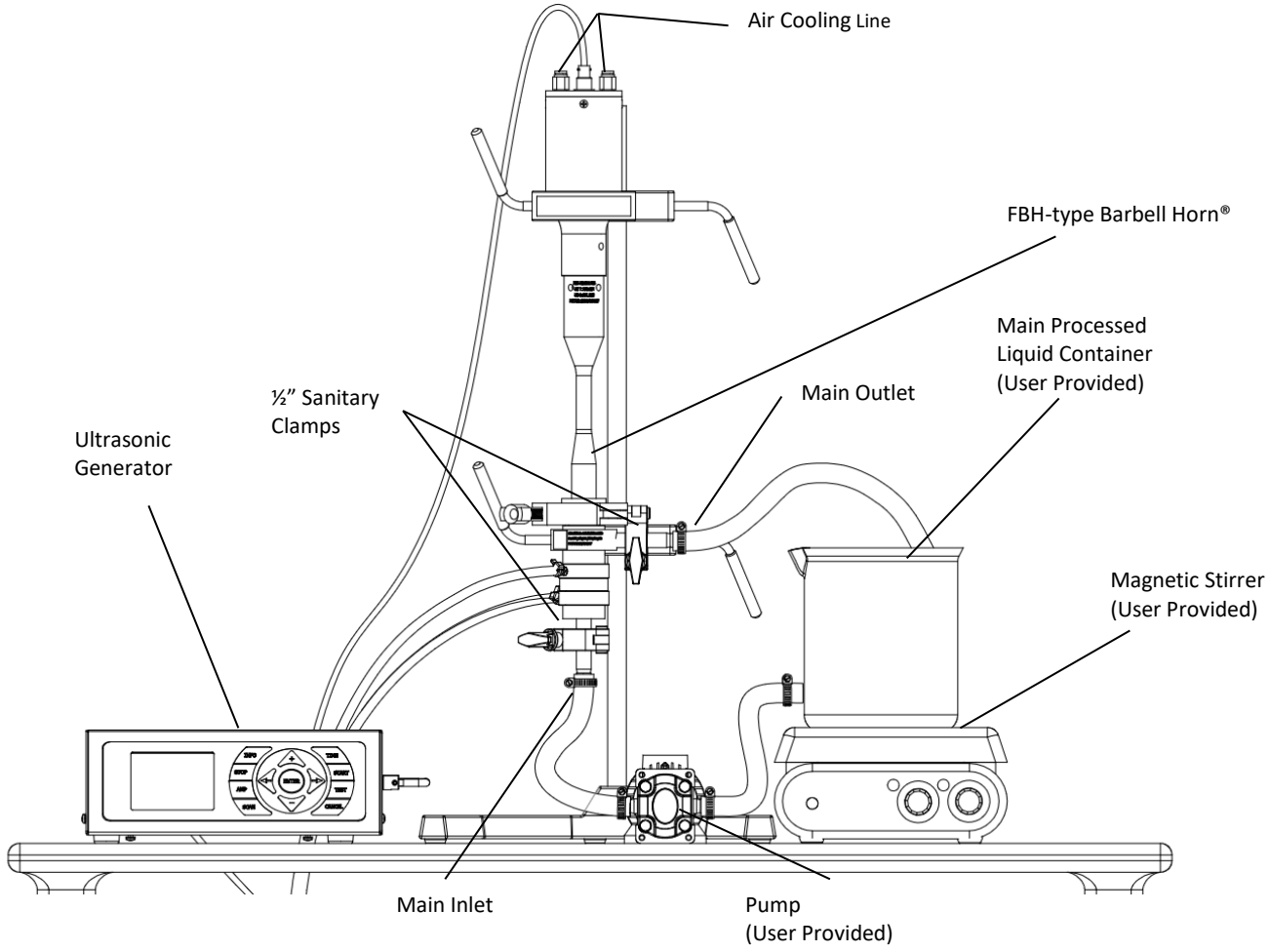


Figure 4 - 8. LSP-600 Ultrasonic Processor assembled in the Recirculating Flow-Through Mode.

SECTION V

Processor Testing and Operation

CAUTION Statements

CAUTION


Do not operate the generator unless it is connected to the transducer.


Never allow any liquid to spill on or into the transducer.


When switching horns see the Scan Stack protocol in the appendix of this manual.


Always place the Mylar acoustic washer (provided) between a horn and the transducer.


Should it become necessary to remove a horn, use the supplied spanner wrenches and follow the instructions detailed in Section IV.


Never attempt to remove the horn by twisting the transducer housing or holding it in a vice, as this may damage the electrical connections within the housing.

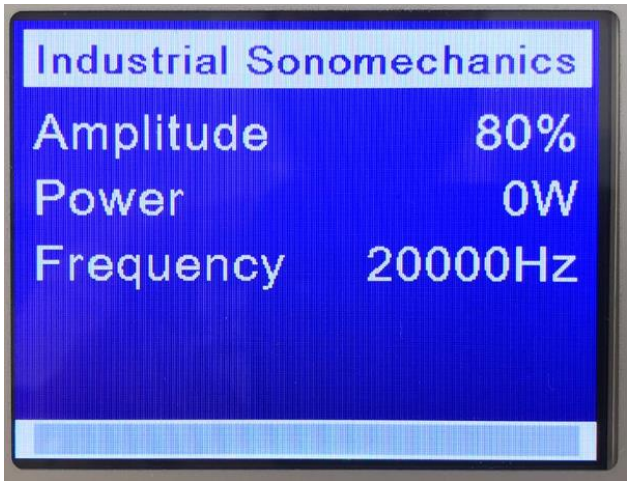

A loose horn may show a fluctuation in power readings and can cause damage to the generator circuitry or parts of the transducer and horn.


Never allow the transducer to become warmer than 45 °C. It is recommended that the transducer be cooled with clean and dry compressed air if continuously operating for more than 30 min.

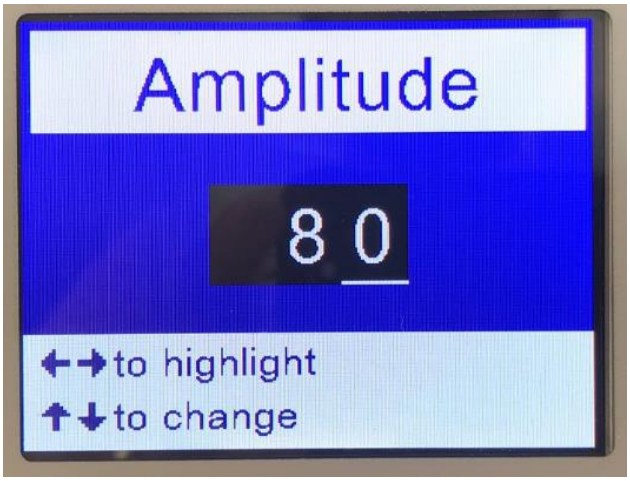
Operating Instructions and Testing

Main Functions – ON, OFF, SCAN, AMP, TIME, START, STOP

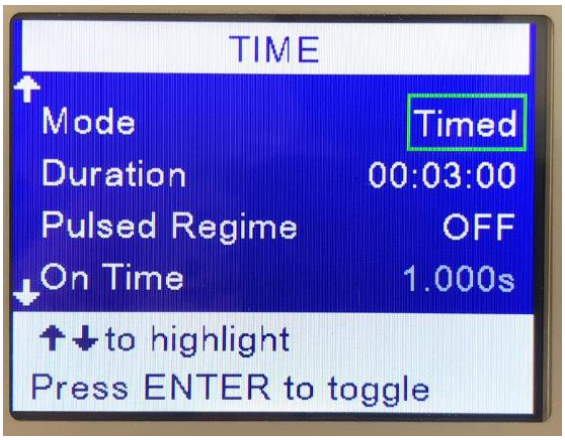
1. Connect the power cord to the rear of the generator (see Fig. 3 – 5) and plug it into a grounded electrical outlet.
2. Flip the switch on the rear of the generator to the ON position (|). The screen will display the following by default:



3. Press **AMP**, then use the **+ / -**, **←/→** and **ENTER** keys to change the amplitude on the LSP-600 generator:

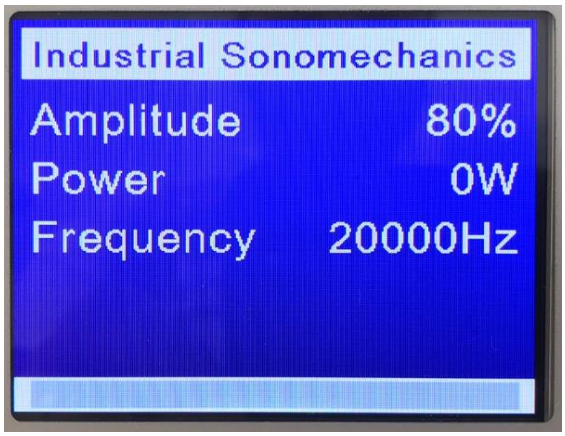


4. Press **TIME**, then use the **+ / -** and **ENTER** keys to select and set the sonication *Mode, Duration, Regime and On Time*:



5. Start ultrasound by holding the **TEST** button:

6. Release the **TEST** button to turn off ultrasound:



Testing: FBH-based configurations only

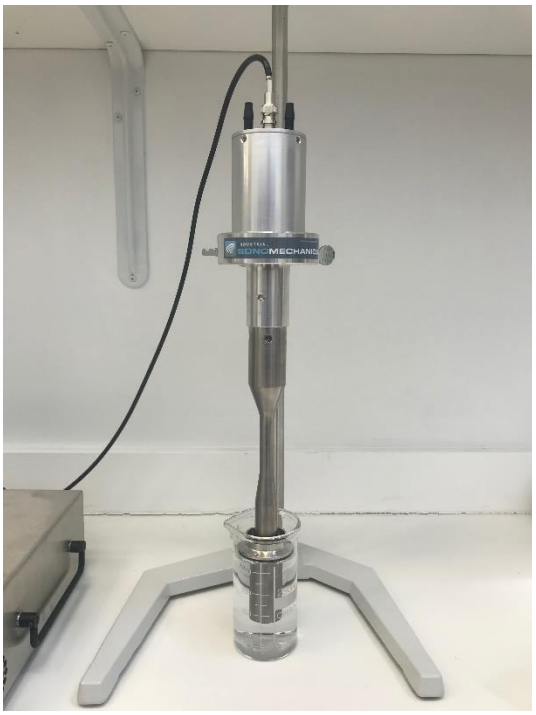
Use the following steps to make sure your LSP-600 is running to specifications. These tests should be performed in water at approximately 25°C (77°C).

CAUTION

The following testing procedures should only be done when using the FBH-type Barbell Horn®.

System Test in Water (Batch Mode Configuration)

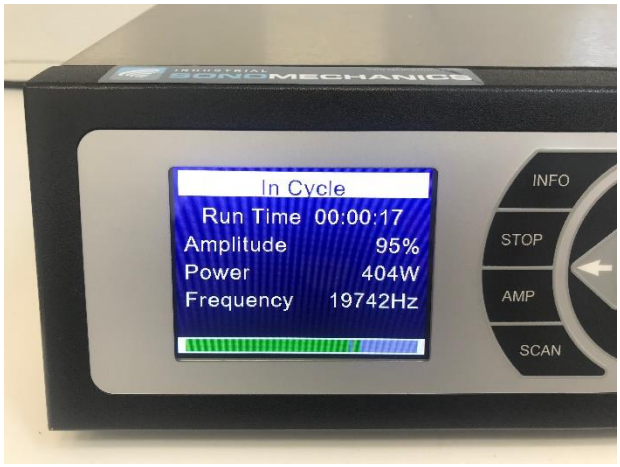
1. Assemble your LSP-600 in the batch-mode configuration (Fig. 1 – 1).
2. Fill a 200 - 500 mL beaker 3/4 full with water and place it under the ultrasonic stack.
3. Insert the horn into the water to its flange (about 6 cm insertion depth):



4. Place ear protection muffs over your ears and set the amplitude to 50%:

5. Press the **START** button to initiate ultrasound:
    a. You should hear a hissing sound and notice cavitation in the liquid. The generator power should display approximately 185 +/-25 W and the overall temperature of water should increase:

6. After about 1 minute, press the **STOP** button to turn off ultrasound.
7. Set the amplitude to 95%.
8. Press the **START** button to initiate ultrasound.
    a. You should now hear a louder hissing sound and notice greater-intensity cavitation in the liquid. The generator power should display approximately 430 +/-50 W and the water temperature should rise faster:



9. After about 1 minute, press the **STOP** button to turn off ultrasound.

SECTION VI

Transducer, Horn and Reactor Chamber Disassembly

Flow-Through Mode Configuration Disassembly

The following steps are provided for the Flow-Through Mode configuration (Fig. 4 -8) disassembly. The Batch Mode configuration can be disassembled in a similar fashion, skipping steps that do not apply.

1. Make sure that the generator and pump are turned off;
2. Detach the ultrasound cable from the Transducer;
3. Shut off the Reactor Chamber cooling line and detach the cooling line tubing;
4. Drain any liquid from the Reactor Chamber;
5. Detach the ½" Clamps from the Main Inlet and Main Outlet of the Reactor Chamber and collect the Teflon Gaskets;
6. Remove the Transducer/Horn/Chamber assembly from the support stand;
7. Remove the 1.5" Clamp holding the FBH-type Barbell Horn® in the Reactor Chamber and disconnect the Reactor Chamber (Fig. 6 – 1) from the Horn;
8. Detach the Support Arms from the Transducer/Horn Assembly and Reactor Chamber (Fig. 6 – 2);

Figure 6 - 1. Disconnecting the Reactor Chamber from the Transducer/Horn Assembly.

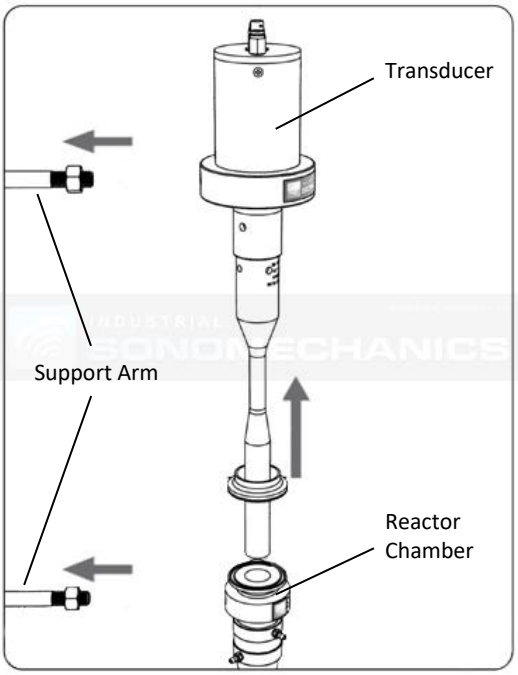
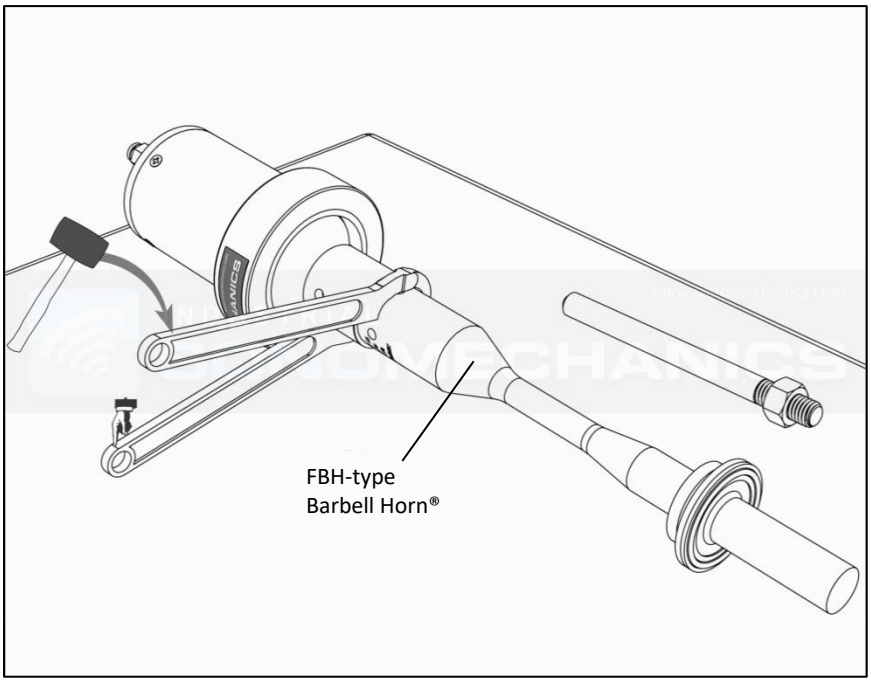


Figure 6 - 2. Detaching the Support Arms from the Transducer/Horn Assembly and Reactor Chamber.

9. Using the provided Spanner Wrenches and a rubber mallet, detach the FBH-type Barbell Horn® from the Transducer (Fig. 6 – 3).



i. **Insert the pin of the first spanner wrench into a hole in the transducer's front mass. Hold it against the workbench to prevent counterclockwise rotation.**
ii. **Insert the pin of the second spanner wrench into a hole in the horn's input end. Set it up to provide counterclockwise torque.**
iii. **Tap the second spanner wrench with a rubber mallet to generate counterclockwise torque. When the Barbell horn® turns with respect to the transducer, remove the wrenches and continue by hand.**

Figure 6 - 3. Disconnecting the FBH-type Barbell Horn® from the Transducer.

NOTE

Remember to account for the Mylar acoustic washer positioned in between the transducer and the horn.

CAUTION

Be sure that the reactor chamber and transducer support arm are removed before assembling or disassembling the horn.

CAUTION

Do not substitute the provided spanner wrenches with any other tools. Never rely on the transducer's support arm instead of the provided spanner wrench during the horn attachment or detachment procedure as it may permanently damage the transducer. Always remove the transducer's support arm before attaching or detaching a horn.

10. Once disassembled, examine the picture below and make sure that all parts are accounted for.

Figure 6 - 4. Individual Components of the LSP-600 Ultrasonic Processor.

SECTION VII

Maintenance & Troubleshooting

General Maintenance

It is recommended to periodically inspect the unit, both visually and physically, to ensure optimum and safe performance. This inspection should be scheduled as a routine maintenance procedure, done with the ultrasonic processor power OFF and with the unit unplugged from the AC power source.

Long exposure to acids or caustics results in corrosion of metal parts or components. Check the generator, transducer, and cables periodically for any signs of rust or discoloration. If discoloration is found, move the ultrasonic processor away from the source of the contaminant.

WARNING

Do not use any cable with broken end connections, exposed wires or frayed insulation. High voltage is present in the cable and will pose a shock hazard. Avoid touching the transducer assembly until the generator is powered off.

Examine the condition of the Ultrasound Cable. Inspect the wire insulation for damage, such as wear, burning from hot plate contact or breakage from extended use or rough handling. The cable assembly should not be used to carry the transducer or pull it toward the user. Make certain the cable always has slack and is never tensioned. If necessary, move the generator or transducer closer to one another to accomplish this. If this is not possible, contact your ISM client representative to obtain a longer cable.

Horn Maintenance

Ultrasonic processors create high-intensity vibration which puts stress on the transducer and horns. The sides and tip of a horn must **never** be allowed to come in contact with anything but the process fluid. Attempting to place a vibrating horn directly onto a solid surface will cause severe damage to the horn, and/or transducer.

WARNING

Make sure that a vibrating horn never comes in direct contact any solid object, as this can cause permanent damage to the horn, object and/or transducer.

Proper care of the horn is essential for dependable operation. The intense cavitation will, after usage for a period of time, cause the tip to erode.

It is recommended that a preventative maintenance schedule be adopted to examine the unit at regular intervals. The schedule should depend on the frequency of use. Weekly maintenance schedules are recommended for units used frequently or monthly for those used infrequently. When excessive wear (corrosion/pitting of the horn tip) is detected, contact your ISM client representative for further instructions.

NOTE

A loose horn will usually generate a loud piercing or squealing sound.

System Cleaning Instructions

Generator and Transducer

The generator and transducer may be cleaned with an acid-free cleaning solution (i.e. glass cleaner).

Horns, and Reactor Chamber

Horns and reactor chamber can be cleaned with water or isopropyl alcohol. Before and after using a horn in an experiment, be sure to briefly (< 30 sec) run it in either water or isopropyl alcohol to remove any remaining residue.

Troubleshooting

Your Ultrasonic Processor was designed to provide you with years of safe and dependable service. Nevertheless, because of component failure or improper usage, the possibility does exist that it might not perform as it should, shut down or stop working. The most probable causes for malfunction are listed below, along with suggested solutions.

Failure	Probable Causes	Suggested Solutions
Damaged Connector or Cable	• Tension applied across the ultrasound cable • Ultrasound connector not secured into bayonet-type connection • Electric shortage	Contact your ISM client representative about a new Ultrasound Cable or repair of your ultrasound connector.
Electric Short/ Malfunction	• Incorrect wiring of process hardware • Operating on an incorrect supply voltage	Check the rear of your Generator and Transducer to ensure proper connections. Test your outlet voltage.
Loud Screech While Ultrasonic Output is On	• Improper tightening of the Transducer/Horn assembly • Damaged Mylar washer or mounting stud • Extremely worn or damaged Horn	Disassemble the Horn from the Transducer and reassemble using a new Mylar acoustic washer. If the Horn is severely worn, contact your ISM client representative about ordering a replacement.
Physical Damage to the Transducer or Horn	• Transducer ran continuously for more than 30 mins without cooling (overheated) • System or component was dropped • Transducer was clamped improperly • Horn was allowed to touch a solid object	If the damage to any component has made it unusable, contact your ISM client representative about ordering a new one.
Rapid heating of the Transducer at the Horn junction**	• Improper tightening of the transducer/horn assembly • Damaged Mylar washer or mounting stud • Extremely worn or damaged Horn • Internal damage to the Transducer	Disassemble the Horn from the Transducer and reassemble using a new Mylar acoustic washer. If the problem persists, contact your ISM client representative for further assistance.

**Due to the high frequency vibration present during sonication, the junction will always feel hot (and also painful) if it is pressed against or grasped. This may be mistaken with “overheating”. To correctly judge whether the Transducer-Horn junction is overheating, initiate ultrasound for 1 minute, stop the ultrasonic output and only then feel the junction.

Overload Condition

The generator may stop working, either during or while initiating ultrasonic exposure, due to an overload condition, which can occur because the amount of power required by the process exceeds the generator rating of 600 W or because the generator was unable to establish a frequency lock. The Alarm Status message will be displayed as the result, which can be cleared by pressing Enter. Below are the various Alarm Status messages you may encounter and some ways to resolve them if the error message persists:

Pop-up Alarm Status Displayed	Alarm Description, Cause and Possible Resolutions
Alarm Status Alarm ID # U112 Frequency Overload Alarm 3	Generator was not able to find the resonant frequency of the ultrasonic stack (Horn and Transducer). Test the ultrasonic system in air (no liquid in contact with the Horn). If this Alarm Status persists perform the *Scan Stack Procedure (pg 53)*. If the SCAN fails or if the Alarm Status still persists, disassemble and reassemble the ultrasonic stack (pgs 28 and 42) and reattempt the above. If the problem persists, contact your ISM client representative for further assistance.
Alarm Status Alarm ID # U106 Peak Overload Alarm	Instantaneous current exceeds the rating of the internal generator components. Most often caused by a severe frequency mismatch or attempting to start the ultrasonic stack in a viscous liquid. Try to start the ultrasonic stack in air and if the error persists perform the *Scan Stack Procedure (pg 53)* and try again. If the problem persists, contact your ISM client representative for further assistance.
Alarm Status Alarm ID # U116 Ultrasound Voltage Exceeded	Ultrasound voltage exceeded input voltage. Most often caused by a severe frequency mismatch attempting to start the ultrasonic stack in a viscous liquid. Try and start the ultrasonic stack in air and if the error persists perform the *Scan Stack Procedure (pg 53)* and try again. If the problem persists, contact your ISM client representative for further assistance.
Alarm Status Alarm ID # U108 Average Overload Alarm	Output power exceeded the rated power of the generator. Most often occurs because the flow-rate is too high (and excessive pressure is building in the reactor chamber) or because the liquid is too viscous. For the former, reduce the flow rate on the pump. For the latter, try warming the liquid to reduce its viscosity. If the problem persists, contact your ISM client representative for further assistance.

Alarm Status Alarm ID # U111 Over Temperature Alarm	Temperature of the generator is too high. Make sure that the generator is properly placed to ensure good ventilation. Alarm will reset when the generator cools.
Alarm Status Alarm ID # U100 Configuration Alarm	Generator model number does not match internal generator configuration. Cycle power. If fault persists, contact ISM for Support.
Alarm Status Alarm ID # U110 Power not OK Alarm	AC line voltage is not within the specified limits. Check the AC line voltage to ensure it is within specifications. If the voltage is within specifications and the alarm persists, contact your ISM client representative for further assistance.

APPENDIX I

Main System Component Dimensions and Weights

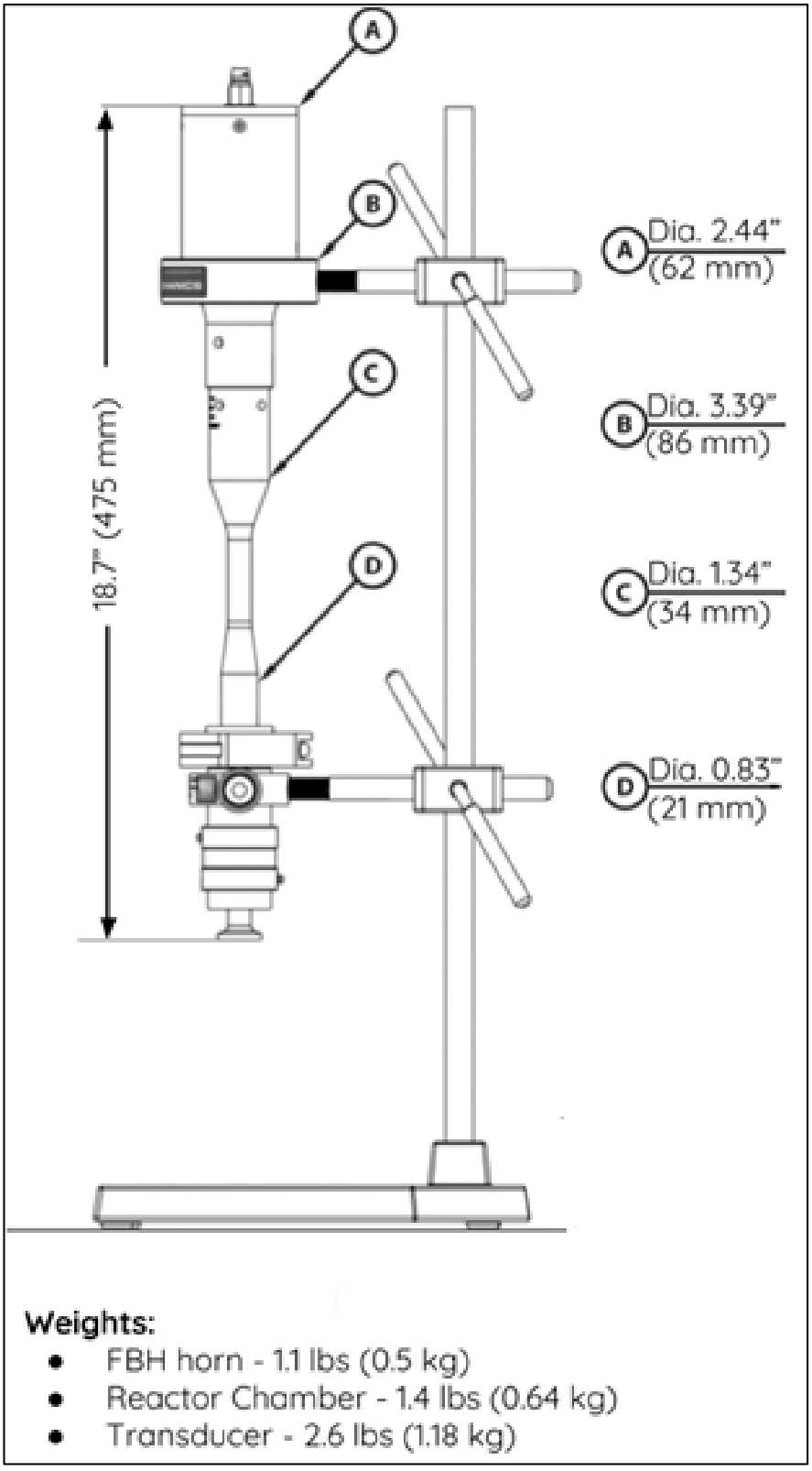


Figure A1 – 1. Ultrasonic Stack Dimensions and Weights.

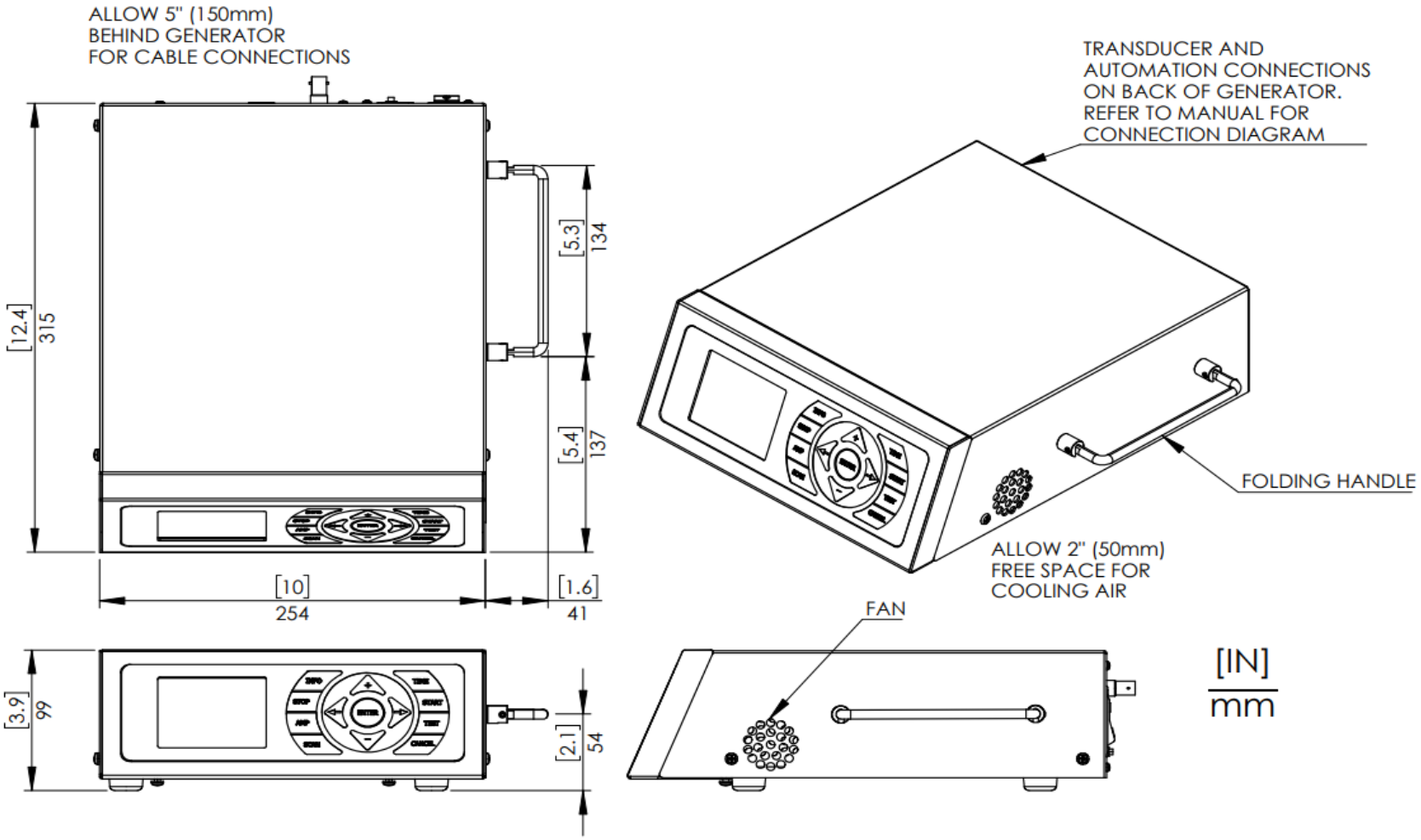


Figure A1 – 2. LSP-600 W Generator Dimensions.

APPENDIX II

Scan Stack Procedure

Each time you change an ultrasonic horn, you must determine and set the corresponding *Free Run Frequency*. The Free Run Frequency is the initial guess the generator makes when finding the horn's resonant frequency during operation. It can be determined by using the SCAN feature available on the ultrasonic generator's front panel. Follow the instructions below to scan your horn:

1. Attach the new horn to the ultrasonic transducer using the provided spanner wrenches (page 29) and connect the ultrasound cable from the generator to the top of the transducer.
2. If attached, unplug the remote button switch from the generator port and turn the generator on. The generator will display the *Amplitude* setting (%), the current *Power* (0 watts if the system is not running) and the current Free Run *Frequency*.
3. Press INFO, use the ↑ ↓ arrows to navigate to *Max Frequency* and use the ENTER key to turn this function ON.
4. Press CANCEL.
5. Press SCAN, and a warning message will appear. Confirm that the transducer is properly wired to the generator and that the tip of the horn is not in contact with any solid or liquid.
6. Press Enter and the *Scanning* screen will display for 5 seconds.
    a. If the SCAN was successful, the following *Scan Result* screen will display the *Optimal Frequency*. Press ENTER to update the Free Run Frequency.
    b. If the SCAN failed, the following *Scan Result* screen will display: *Optimal Frequency not found*. Press CANCEL and begin this procedure from 1. If the procedure continues to fail, contact your ISM client representative for further assistance.
7. Press INFO, and use the ↑ ↓ arrows to navigate to *Max Frequency* and use the ENTER key to turn this function OFF.
8. Press CANCEL.
9. Set the amplitude to 100 %. Hold the TEST button and read the *Power* displayed on the generator screen. Use the table below and verify that your horn is operating at the proper power (within 20 W of the value tabulated below). If the power displayed is outside of this range, contact ISM.

	Horn ID	Power (@100 %, in Air) [W] (+/-10 W)
LSP-600	FBH-F20D21G5s	50
	CH-F20D12.7G6s	30