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 be liable to any person or entity with respect to any liability, 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, U.S. Patent No. 8,651,230, U.S. Patent No. 9,142,751, U.S. Patent Application No. 16/667,411, U.S. Patent Application No. 17/502,229, and U.S. Patent No. 11,325,094.

Table of Contents

Section 1

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. The manual is organized to allow you to learn how to safely operate this processor. The examples given are chosen for their simplicity to illustrate basic operation concepts.

Notes, Cautions and Warnings

Throughout this manual, we use NOTES to provide information that is important for the successful application and understanding of the product.

In addition, we use special notices to make you aware of safety considerations. These are the CAUTION and WARNING blocks as shown here. They have important information that, if ignored, could have increasingly severe outcomes. These statements help you to identify and avoid hazards 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.

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

NOTE

Note statements provide additional information or highlight procedures.

CAUTION

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

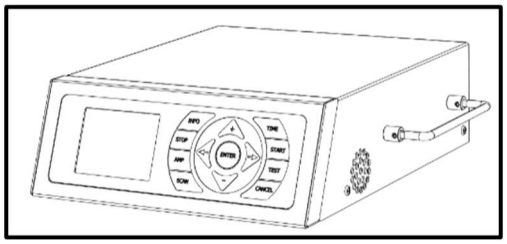
WARNING

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

System Overview

The LSP-600 laboratory-scale ultrasonic liquid processor is designed for small-scale experiments and process optimization. It outputs up to 600 W of acoustic power into the processed liquids and operates at the frequency of approximately 20 kHz. The processor is typically supplied with at least four primary ultrasonic components: **ultrasonic generator**, **air-cooled transducer**, **ultrasonic horn,** and **reactor chamber** (flow cell).

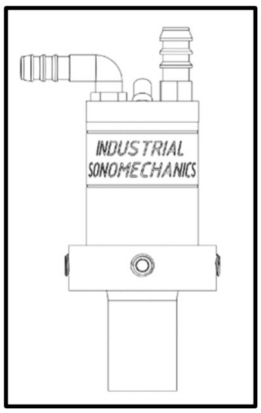
Ultrasonic Generator



The 600 W **ultrasonic generator** has rugged internal circuitry and ensures a continuous resonance frequency lock during operation. The LCD display and hot-key buttons can be used to change the settings for the ultrasonic amplitude, starting frequency, operation regime (pulsed or continuous), and duration of the ultrasonic output. Constant amplitude is provided, regardless of the power draw, which is automatically adjusted to compensate for variable loading conditions. The ultrasonic vibration amplitude level can be adjusted from 20 to 100 %. The generator passes strict CE test specifications for global applications (see Section 6).

Ultrasonic Generator		
Operating Frequency	20 (+/ - 1) kHz	
Overload Power Rating	600 W	
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	

Air-Cooled Transducer



The LSP-600 processor includes an **air-cooled piezoelectric transducer**, TR-ACT-600. This transducer has a power rating of 600 W and is capable of supplying ultrasonic energy for both batch and continuous processes. It is necessary that the transducer be cooled with clean and dry air (e.g., from an air blower) if operating continuously for more than 10 min. Even while cooled with air, the continuous operating time of this unit should not exceed 60 minutes.

TR-ACT-600 Transducer	
Weight	3.6 lbs. (1156 g)
Main Dimensions	6.5” L x 3.5” Dia. (165 mm x 88 mm)
Maximum Amplitude	19 microns

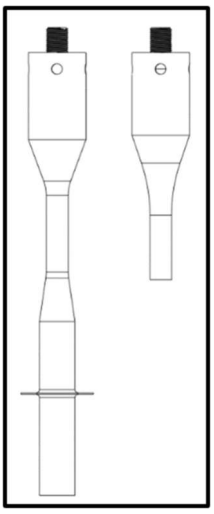
CAUTION

In no event may the transducer’s front mass (the area just above where the transducer meets the horn) be allowed to exceed 54 °C (129 °F). To extend its continuous operation time, the TR-ACT-600 transducer can be cooled with dry air.

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.

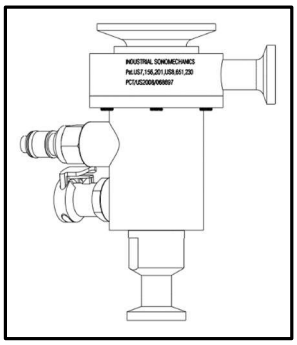
Ultrasonic Horn



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), which can be used to treat larger batches (100 – 500 ml, Fig. 1) or for flow-through processing (up to 2000 ml, Fig. 2). A calibration sheet correlating the horn tip vibration amplitude to the adjustable amplitude setting at the generator (20 – 100 %) is provided with each unit.

	CH-type horn	**FBH-type Barbell Horn®**
Weight	0.76 lbs. (350 g)	1.13 lbs. (514 g)
Dimensions	5.75" x 0.5" (146 mm x 12.7 mm)	11.25" x 0.83" (286 mm x 21 mm)
Tip Diameter	12.7 mm	21 mm
Material	Titanium Alloy, Ti6Al4V	Titanium Alloy, Ti6Al4V
Maximum Amplitude	107 microns	115 microns

Reactor Chamber (Flow Cell)



The LSP-600 processor can operate in two processing modes: **batch** and **flow-through** (Figure 1 and Figure **2**, respectively). With the use of the **reactor chamber** (flow cell), the processor can be configured for continuous liquid processing in the flow-through mode. When a larger volume of liquid (500 ml – 2 L) needs to be processed, this arrangement is preferable to the batch mode, because it results in a much higher processing capacity, improved ultrasonic exposure uniformity and better temperature stability. During continuous ultrasonic processing, the use of the reactor chamber ensures that all processed liquid is directed through the active cavitation zones created by the incorporated Full-wave Barbell Horn®, resulting in homogeneous processing and high finished product quality.

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	1.83 lbs. (830 g)
Dimensions	4.05" L x 2.86" Dia. (103 mm x 73 mm)
Materials	316 Stainless Steel
Internal Volume (Process 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 faster: 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.

Batch Mode Configuration

Working in the **batch mode** (Figure 1) does not require the reactor chamber. In this configuration, the processed liquid is placed in a batch container. The batch mode is commonly used for process investigation or small-scale production (up to about 500 mL at a time). Transducer cooling with cool, dry air may be required. Please contact ISM for details on peripheral items offered with the LSP-600.

CAUTION

Always make sure to immerse the horn by 5 – 6 cm/2 – 2.5 in into the liquid, otherwise upward spraying may occur.

CAUTION

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

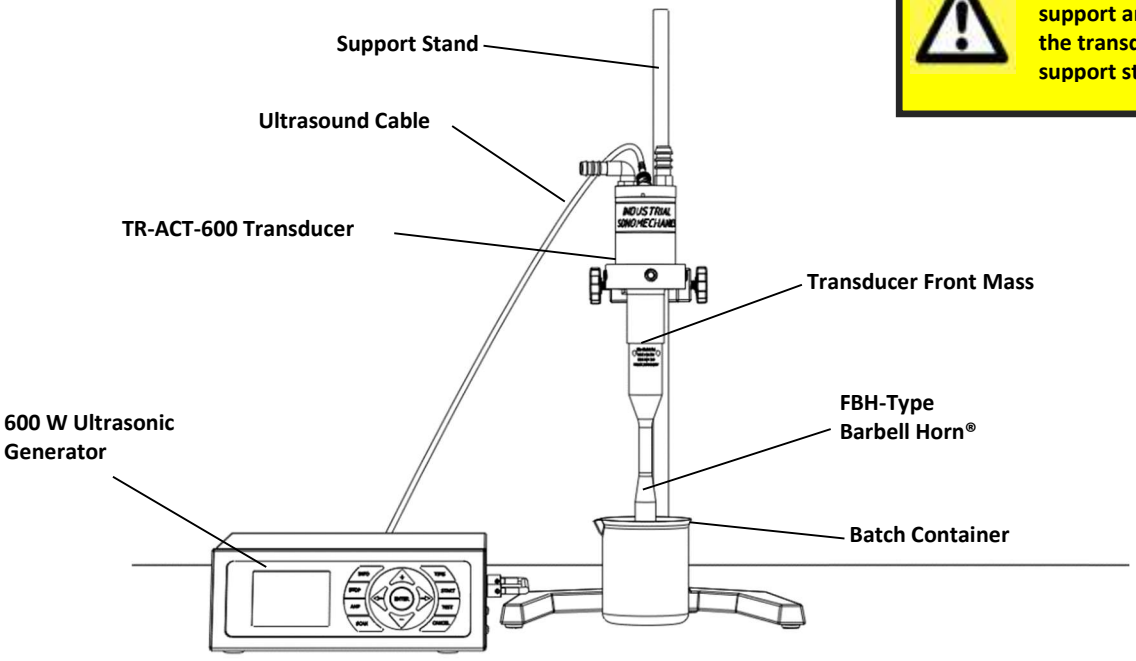


Figure 1. LSP-600 ultrasonic processor configured in the batch mode. The 600 W ultrasonic generator excites vibration in the TR-ACT-600 transducer. The vibration amplitude is amplified by the FBH-type Barbell Horn®, and the ultrasonic energy is delivered to the processed liquid in the batch container. The horn is immersed into the liquid to its nodal point (to the depth of about 5 – 6 cm/2 – 2.5 in).

Flow-Through Mode Configurations

Recirculating and **single-pass** configurations are possible with the **flow-through** processing mode. In the recirculating configuration (Figure 2), the processed liquid passes through the reactor chamber multiple times, which increases the cumulative exposure time. This configuration is recommended for challenging processes, such as extraction, nano-emulsification, dispersing/deagglomeration, etc. The single-pass configuration is commonly used as part of multistep processing involving different modalities. In this configuration, the processed liquid coming from a previous processing step passes through the reactor chamber, after which it is either collected as the finished product or continues down the line for further processing. Please contact ISM for further details on peripheral equipment items offered with the LSP-600.

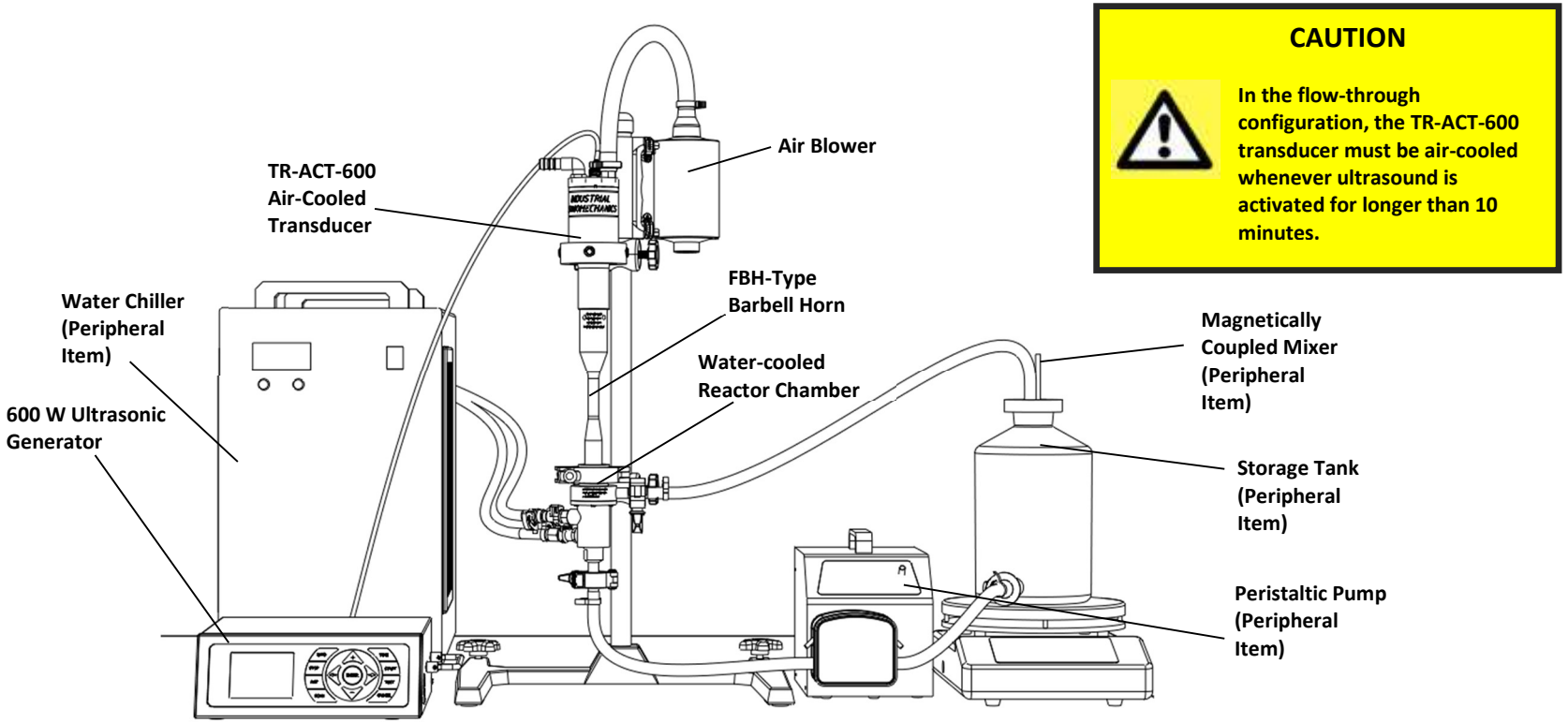


Figure 2. LSP-600 ultrasonic processor configured in the recirculating flow-through mode. The 600 W ultrasonic generator excites vibration in the TR-ACT-600 transducer. The vibration amplitude is amplified by the FBH-type Barbell Horn®, and the ultrasonic energy is delivered to the processed liquid flowing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

Section 2

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.

Stay Alert – Watch what you are doing at all times. Use common sense. Do not operate the system when you are tired, under the influence of illicit drugs or alcohol, taking prescription medication or distracted from the job at hand.

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. Unauthorized modifications will void equipment warranty.

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 the *Electrical Safety* section 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.

WARNING

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.

WARNING

If you have a two-prong electrical receptacle, replace it with a properly grounded three-prong type. Have a qualified electrician replace it following the National Electric Code and any local codes and ordinances that apply.

Electrical Safety

Power Grounding

For safety, the 600 W ultrasonic generator has a three-wire, grounding-type cord. Figure 3 illustrates the grounded plug options available with the power cord (120 or 240 VAC, 15 Amp for USA and 240 VAC, 16 Amp for Continental Europe, left to right).

120 VAC Plug **240 VAC Plug** **240 VAC Plug**

Figure 3. 120 and 240 VAC-rated grounded plugs available with the generator power cord.

Section 3

Generator Installation, Connections and Layout

Unpacking

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

Electrical Requirements

The ultrasonic generator requires a fused, single-phase 3-terminal grounding type 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 excessive dust, dirt, explosive and corrosive fumes, and extremes of temperature and humidity. Also note that the LSP-600 transducer is air-cooled and not sealed to the outside environment, which makes it unsuitable for high-humidity conditions and processing flammable materials, such as fuels and organic solvents.

When positioning the unit, be sure to leave adequate space around it so that all vents are clear and connections can be easily accessed.

Placement

Make certain the generator placement and cable routing allow for easy access and that they do not interfere with normal operation. The operator should have unobstructed access to all control switches and a clear view of the LCD screen and operating keys. When placing the generator, allow at least 13 cm (5 in) of space on each side of the generator chassis for air circulation.

WARNING

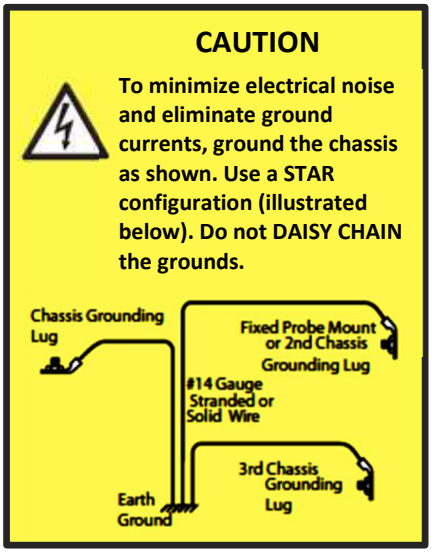
Do not allow any liquid or mist to enter the internal area of the generator in any way, for example, through its air inlet or outlet. This may cause an electrical short.

CAUTION

Allow for at least 13 cm/5 in of space on each side of the generator for ventilation. The cooling fan must be allowed to easily draw in fresh air to cool the internal components, reduce thermal gradients and increase generator components' life span.

RFI Grounding

In addition to the safety considerations previously mentioned, proper grounding of the generator power cord is recommended for the effective suppression of electrical noise or RFI (Radio Frequency Interference). Every ultrasonic generator contains a 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. For best results, you may additionally run a grounding wire from the ground stud connection (**I** in Fig. 4) to the nearest grounded metal pipe or equivalent earth ground and secure it with a ground clamp.



Connecting Cables (Part 1)

- Connect the supplied AC power cord to the generator's Power Cable Input (**H** in Fig. 4). Do not plug the cord into the power outlet yet.
- Ground the generator chassis with the supplied 14-gauge wire. Attach one end the grounding stud (**I** in Fig. 4) and attach the other end to the nearest grounded metal pipe or equal earth ground.

Chassis and Connectors

Schematics of the side and rear views of the generator are presented in Figure . Descriptions of each item are provided in Table 1.

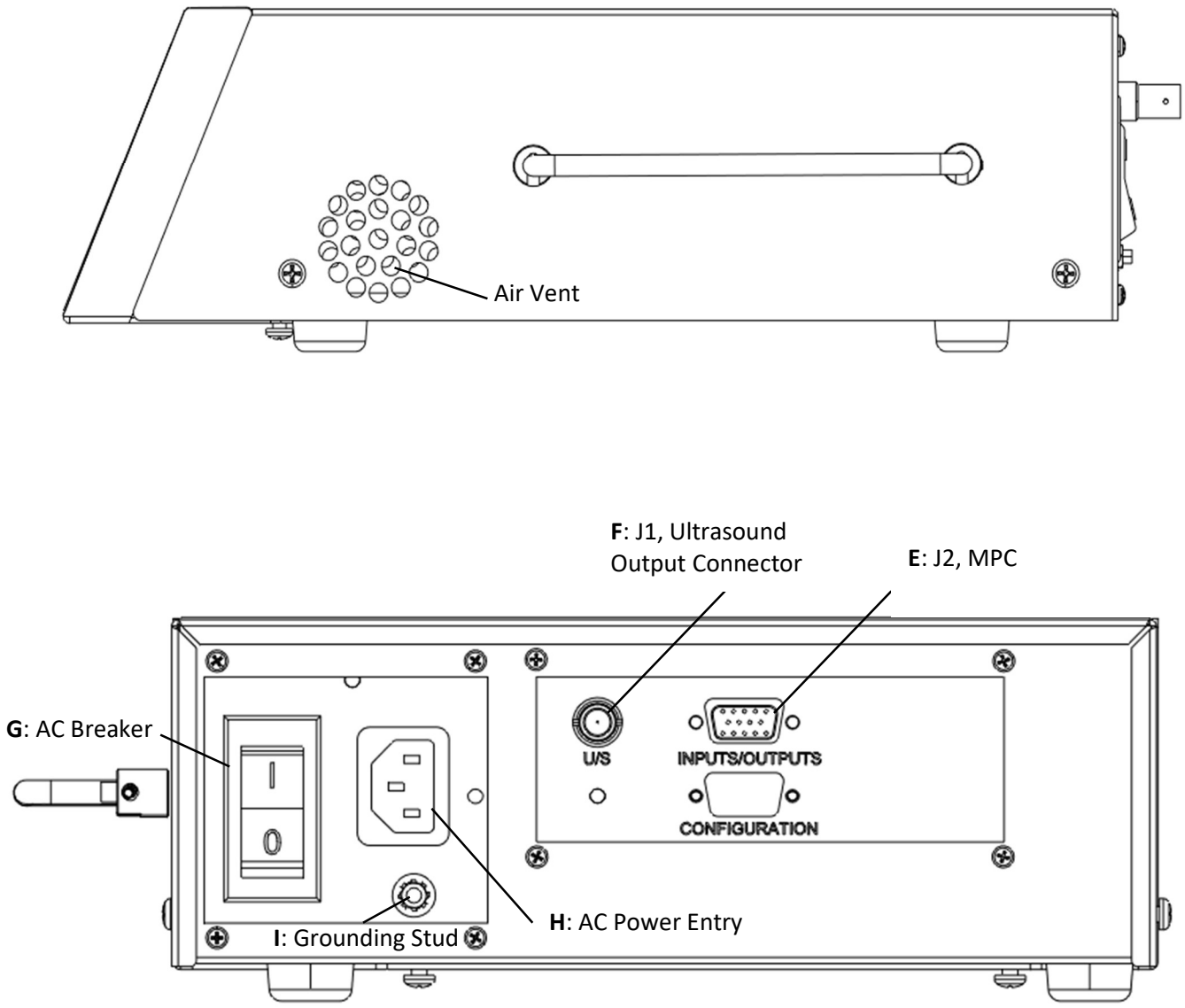


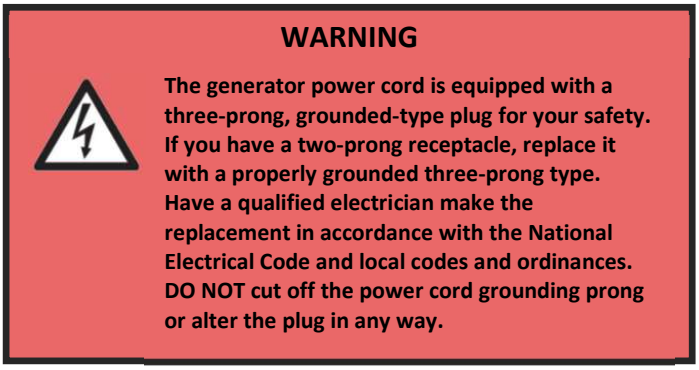
Figure 4. Side and Rear views of the generator.

Letter	Description
E	Inputs/Outputs Connector – connections for remote generator control via input signals and for remote readout of status output signals
F	Ultrasound Output Connector – coaxial high-voltage connection to ultrasound cable
G	Power Switch/Circuit Breaker – used to switch the generator ON and OFF
H	AC Power Entry
I	Chassis Grounding Stud – chassis connection for a protective earth ground (RFI grounding)

Table 1. Description of items on the side and rear of the generator.

AC Power Inlet

The AC line cord supplied with the generator is matched to its power rating of 600 W. It is equipped with a 250 VAC, 20 Amp-rated plug.



Connecting Cables (Part 2)

- Attach the ultrasound cable between the transducer and the Ultrasound Output Connector (**F** in Figure 4).
- Plug the generator's AC line cord into an approved AC outlet.

Proper Handling of Cable Slack

When taking up slack in cables, the extra length should be coiled up (left-side of Figure 5) rather than folded (right-side of Figure 5).

Figure 5. Proper cable slack take-up.

Avoid excessive tension and bends. Cables should be routed such that there are no abrupt bends in the cables, especially near their connectors.

Power Switch/Circuit Breaker

The Power Switch/Circuit Breaker (**G** in Fig. 4) has a rocker type actuator switch that will activate or deactivate the AC power to the system. The power **ON** position is marked with the internationally recognized **I** symbol, the power **OFF** position is marked with the **0** symbol. This power switch also integrates an appropriately sized over-current protection circuit breaker in the generator.

If an over-current condition trips the circuit breaker, it will automatically switch to the **OFF** position. If the circuit breaker trips due to a transient condition, it can be reset by switching the actuator back to the **ON** position. If after resetting the circuit breaker it immediately trips again, an internal system malfunction is likely, and the generator will require service. Do not repeatedly try to reset the circuit breaker to avoid causing more damage to the generator.

Inputs/Outputs Connector

The Inputs/Outputs (I/O) connector (**E** in Fig. 4) includes connections for all basic generator control input and output signals that will typically be associated with an automated control system. A cable attached to this connector includes all available system control signals, which can be controlled by an output card or output port on a controller.

All I/O signals on this connector are electrically isolated (signals are NOT referenced to chassis ground). Inputs are activated when there is a 24 Vdc difference between the Input pin and the Input Common pin. The electrically isolated I/O signals can be activated/monitored from an automation controller with either sinking (NPN) or sourcing (PNP) I/O depending upon how the isolated common connection is terminated. All inputs sink or source 10 mA of current from a 24 Vdc power supply. The total output current cannot exceed 500 mA when using the +22 Vdc generator output (pin 1). If an external supply is used, the maximum current for each output is 400 mA.

The I/O connector is a HD-15 (high density D-subminiature 15 pin female) connector. For details on custom automation system wiring and assembly at this connector, see Appendix II.

Ultrasound Output Connector

The Ultrasound Output Connector (**F** in Fig. 4) 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 output connector mates with a fully shielded coaxial ultrasound cable that is secured with a simple and reliable quarter-turn bayonet style attachment mechanism.

WARNING

The ultrasonic output from this connector (that drives the attached ultrasonic load) has a very high AC voltage. At high power levels, the output can also 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, which can destroy the ultrasound connectors.

Do not use your generator if there is any evidence of arcing (black carbon deposits) on either the ultrasound output connector or the ultrasound cable connectors.

Figure 6. Ultrasound output connector.

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.

Front Panel Operating Keys

This section provides an overview of the operating keys of the generator's front panel (see Fig. 7 and Table 2).

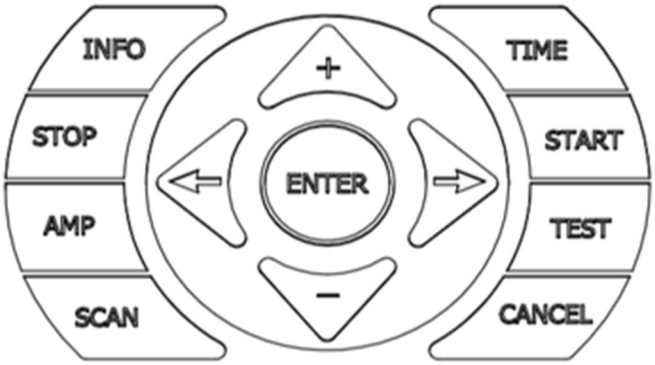


Figure 7. Front panel operating keys.

KEY	FRONT PANEL
ENTER	Confirm/Accept Menu Options and Clear Alarms
+ / -	Navigate Up and Down on Display
←/→	Navigate Left and Right on Display
STOP	Stop Ultrasonic Output
START	Start Ultrasonic Output
AMP	Select and Set Ultrasonic Amplitude (% of maximum)
TEST	Test Ultrasonic Stack (HOLD to initiate ultrasound)
SCAN	Perform Scan Stack Procedure
CANCEL	Go to Menu/Cancel Selection and Go to Main Screen

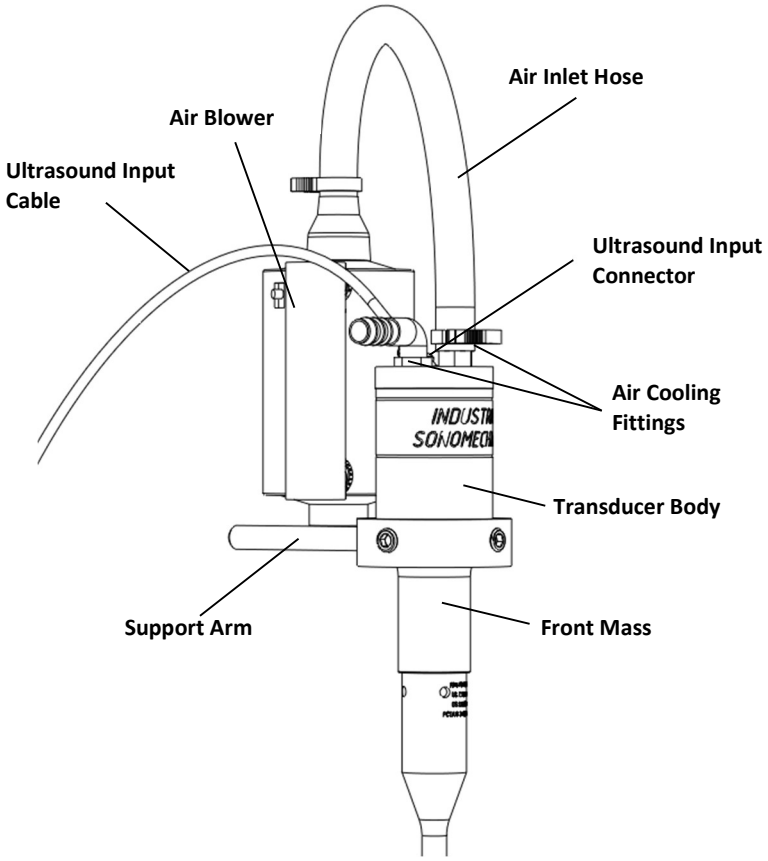
Table 2. Description of front panel operating keys.

Section 4

System Assembly, Testing and Operation

Air-Cooled Ultrasonic Transducer (TR-ACT-600)

Ultrasonic transducers convert the electric energy coming from an ultrasonic generator into mechanical energy in the form of ultrasonic vibration.



CAUTION

Operating the TR-ACT-600 transducer without air cooling over 10 minutes may cause irreversible damage.

CAUTION

***The ultrasound 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.**

Figure 8. TR-ACT-600 ultrasonic transducer.

The TR-ACT-600 ultrasonic transducer (Fig. 8) operates at frequencies around 20 kHz and comprises a **transducer body**, an **ultrasound input connector**, a **support arm**, and **air-cooling fittings**. It is compatible with both the FBH and CH-type horns. An **air blower** may also be provided with the unit. TR-ACT-600 is air-cooled and not sealed to the outside environment.

CAUTION

TheTR-ACT-600 transducer must be cooled using the provided air blower (at its lowest setting) if operating for more than 10 minutes or temperature limit is reached.

In no event can the transducer's front mass (area just above where the transducer meets the horn) be allowed to exceed 54 °C (129 °F).

Cooling Air Inlet & Outlet

If operating longer than 10 minutes, it is imperative to cool the transducer using the supplied air blower (Figure 2 and 8).

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.

Support Arm

The support arm (Fig. 14) 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 other areas of the transducer.

CAUTION

NEVER place any clamps on the transducer. Use only the provided support arm to secure it.

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 (attached to the Ultrasound Input Cable) is a SHV-BNC high-voltage connector. It provides superior shielding of electrical noise and mates with a corresponding connector on a fully shielded coaxial ultrasound cable that on the other side is attached to the SHV-BNC-type Ultrasound Output Connector on the generator (**F** in Figure 4).

Ultrasonic Barbell Horn®

Liquids exposed to high-intensity ultrasound undergo ultrasonic cavitation, which produces violently and asymmetrically imploding vacuum bubbles and causes micro-jets that create extreme mechanical shear forces. These forces are responsible for the well-known ability of ultrasound to facilitate many physical and chemical processes. To produce sufficient cavitation intensity while retaining large ultrasound-emitting surfaces, the ultrasonic transducer is equipped with a high-gain Barbell Horn®, which amplifies the vibration amplitude generated by the transducer and delivers the ultrasonic energy to the processed liquid.

The LSP-600 ultrasonic processor is typically supplied with an FBH-type ultrasonic Barbell Horn® (**A** in Figure 9).

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.

NOTE

Record each ultrasonic horn's frequency and power when operating in free air and in water (Appendix III). This provides reference information throughout the life cycle of each horn.

CAUTION

NEVER clamp the horn in a vise. The resulting scratches or gouges on the surface are stress risers, which may result in horn cracks and failure.

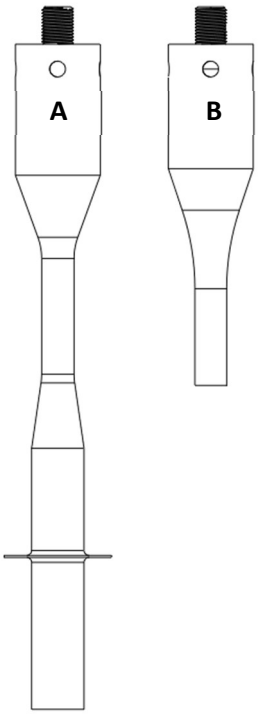


Figure 9. Horns compatible with the LSP-600 ultrasonic processor. A – FBH-F20D21G5s; B – CH-F20D45G5s.

ID	Batch or Flow-Through	Maximum Amplitude [µm]	Typical Processed Liquid Volume	Process Liquid Viscosity Allowance	Notes
A	Flow-Through or Batch	115	100 - 2000 mL	≤ 100 cP	This horn is typically supplied with the LSP-600. It is commonly used for flow-through applications but can also be utilized in batch-mode processing.
B	Batch	107	15 - 100 mL	≤ 100 cP	This horn is used for small-batch processing.

Table 3. Horns compatible with the LSP-600 ultrasonic processor.

Attaching the Barbell Horn® to the Transducer

1. Inspect all surfaces to be joined for stress cracks, chips, or gouges. Any of these irregularities will affect operation and could lead to equipment damage.
2. Ensure that the mating surfaces of the two components are clean and smooth (they can be cleaned with ethanol or isopropyl alcohol). These surfaces must make intimate contact for the mechanical energy to pass from one component to the next. Pitting or a buildup of dirt on a mating surface will interfere with the energy transfer and reduce the delivered power.
3. Remove any foreign matter from the horn's threaded stud and transducer's mating hole.
4. (For flow-through mode only) Place the reactor chamber lid over the top of the FBH-type Barbell Horn®.
5. Place the provided mylar acoustic washer over the horn's stud against the horn's mating surface before assembling the components.
6. Thread the components together by hand and then tighten using the supplied spanner wrenches. See Figure 0 for the correct tightening procedure.
7. After attaching the horn, perform the *Scan Stack Procedure* described in Appendix I and then benchmark the ultrasonic stack (transducer/horn assembly) (Appendix III).

CAUTION

Never leave a horn/transducer assembly hand tight. If the assembly is installed without being properly torqued down, it may vibrate severely, damaging the mating surfaces and causing the generator to overload.

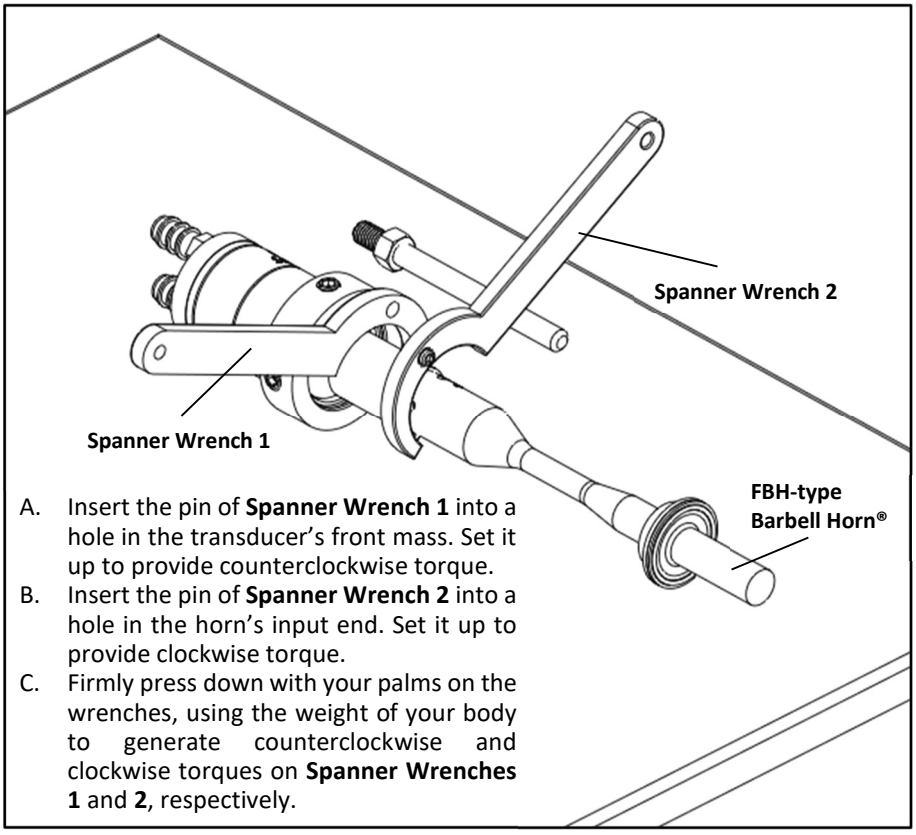
Always use the mylar washer (one) during this procedure, otherwise mating surfaces may permanently bond. Make sure the washer is in good condition, without scratches or rips. Using a damaged washer may cause the assembly to operate incorrectly.

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

Any unusually loud noise from the transducer/horn assembly indicates that it may have been assembled improperly. 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.



A. Insert the pin of **Spanner Wrench 1** into a hole in the transducer's front mass. Set it up to provide counterclockwise torque.
B. Insert the pin of **Spanner Wrench 2** into a hole in the horn's input end. Set it up to provide clockwise torque.
C. Firmly press down with your palms on the wrenches, using the weight of your body to generate counterclockwise and clockwise torques on **Spanner Wrenches 1** and **2**, respectively.

Figure 10. Attaching a Barbell Horn® to the TR-ACT-600 transducer.

Detaching the Barbell Horn® from the Transducer

If you wish to replace an ultrasonic horn, it can be detached from the transducer as follows. On all transducers and horns with spanner wrench holes, use only the correct size spanner wrenches to provide sufficient torque to loosen a joint (Figure 11).

A. Insert the pin of **Spanner Wrench 1** into a hole in the transducer's front mass. Hold it against the workbench to prevent counterclockwise movement.
B. Insert the pin of **Spanner Wrench 2** into a hole in the horn's input end. Set it up to provide counterclockwise torque.
C. If disassembly isn't possible by putting weight on the handle end of **Spanner Wrench 2**, you may tap it with a rubber mallet to generate counterclockwise torque. When the horn turns with respect to the transducer, remove the wrenches and continue to unthread the horn by hand.

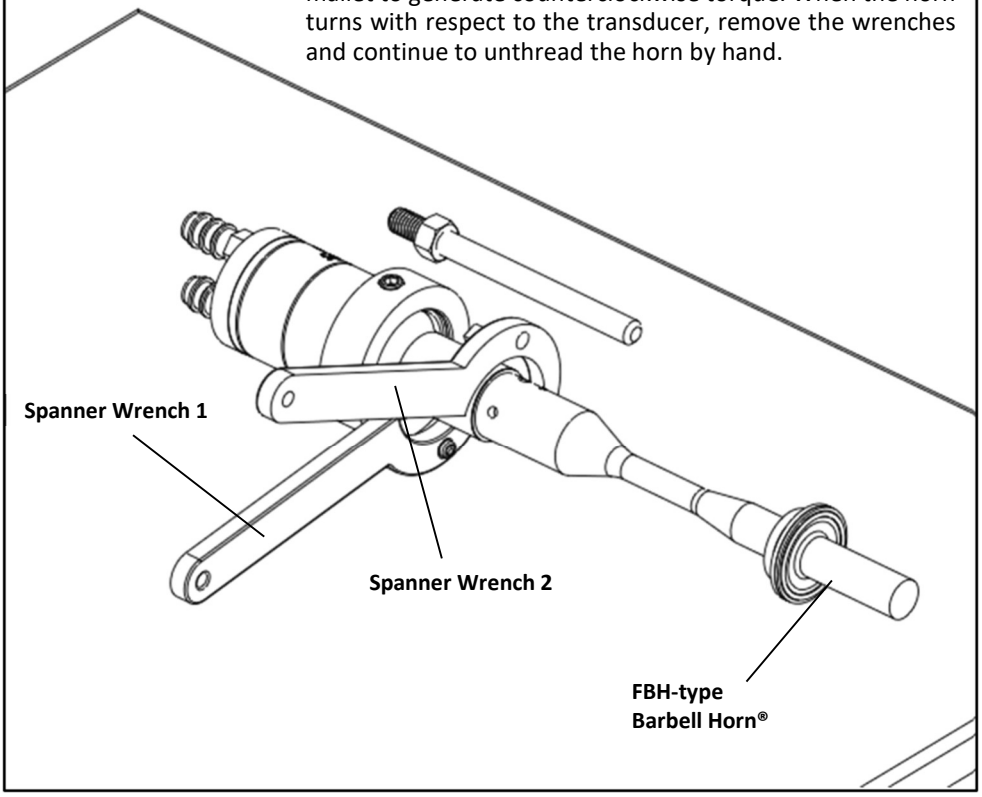


Figure 11. Removing a Barbell Horn® from the TR-ACT-600 transducer.

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

The transducer support arm and the reactor chamber should be removed before detaching the horn from the transducer.

Reactor Chamber (RC-LSP-600)

With the use of the **reactor chamber** (flow cell), the LSP-600 ultrasonic processor can be configured for continuous or recirculating (Figure 2) liquid processing in the **flow-through mode**. When a large amount of material needs to be processed, this arrangement is preferable to the **batch mode** because it results in a much higher processing capacity, improved ultrasonic exposure uniformity and better temperature stability. In the **flow-through mode**, the use of the reactor chamber ensures that all processed liquid is directed through the active cavitation zone created by the incorporated **Barbell Horn®**, resulting in homogeneous ultrasonic exposure and high product quality. The RC-LSP-600 reactor chamber includes a water-cooling jacket to help maintain the temperature of the processed liquid at the desired level.

Figure 2 shows the reactor chamber assembled with an **FBH-Type Barbell Horn®**. The output diameter of the horn is 21 mm, and the internal volume of the **reactor chamber** is about 35 ml. The penetration of the horn into the chamber is arranged such that the non-vibrating mounting flange on the horn is "sandwiched" between the body of the **reactor chamber** and its lid with a split sanitary gasket, which ensures a reliable, pressure-resistant seal. The processed liquid is supplied through a 1/2" sanitary flanged **processed liquid inlet** and collected through a 1/2" sanitary flanged **processed liquid outlet**.

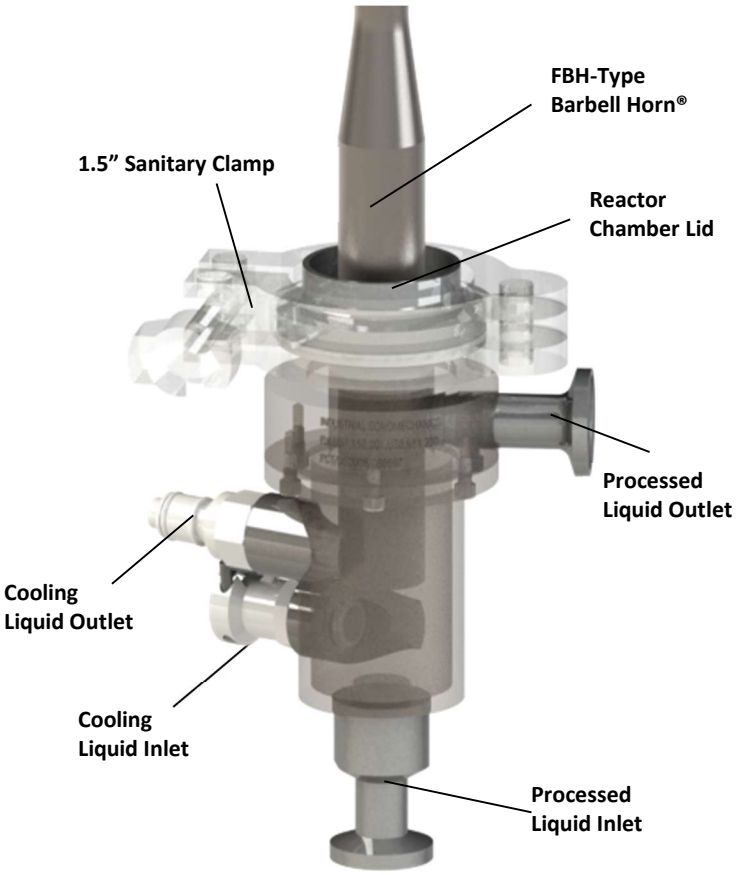


Figure 12. Reactor chamber for the *LSP-600 processor*.

CAUTION

Never attempt to rotate, pull, push, or support any objects on the Processed Liquid Inlet or Outlet.

Assembling the Reactor Chamber with a Barbell Horn®

Follow the steps below to properly assemble the reactor chamber:

Step 1. (Figure 13)

a. Make sure that the **split sanitary gasket** is evenly placed around the **horn flange**.

b. Place **reactor chamber lid** over the horn from the horn's **input end**, so that its bottom is in contact with the **split sanitary gasket**.

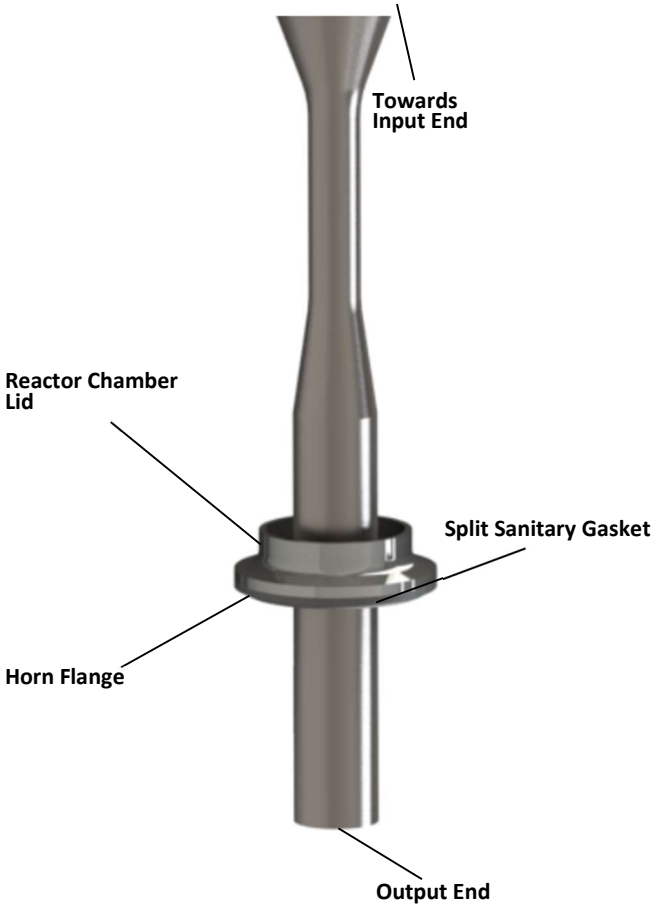


Figure 13. Step 1 of the reactor chamber assembly procedure.

Step 2. (Figure 14)

a. Assemble the transducer with the horn as described in Figure 0.
b. Attach **support arms** to the transducer and reactor chamber (see *Support Arm* section above).
c. Secure the **transducer** by its support arm on the support stand.
d. Secure the **reactor chamber** by its support arm on the support stand below the **transducer** and **horn**.
e. Align the **reactor chamber** such that when it is lifted, the horn can enter its internal area.

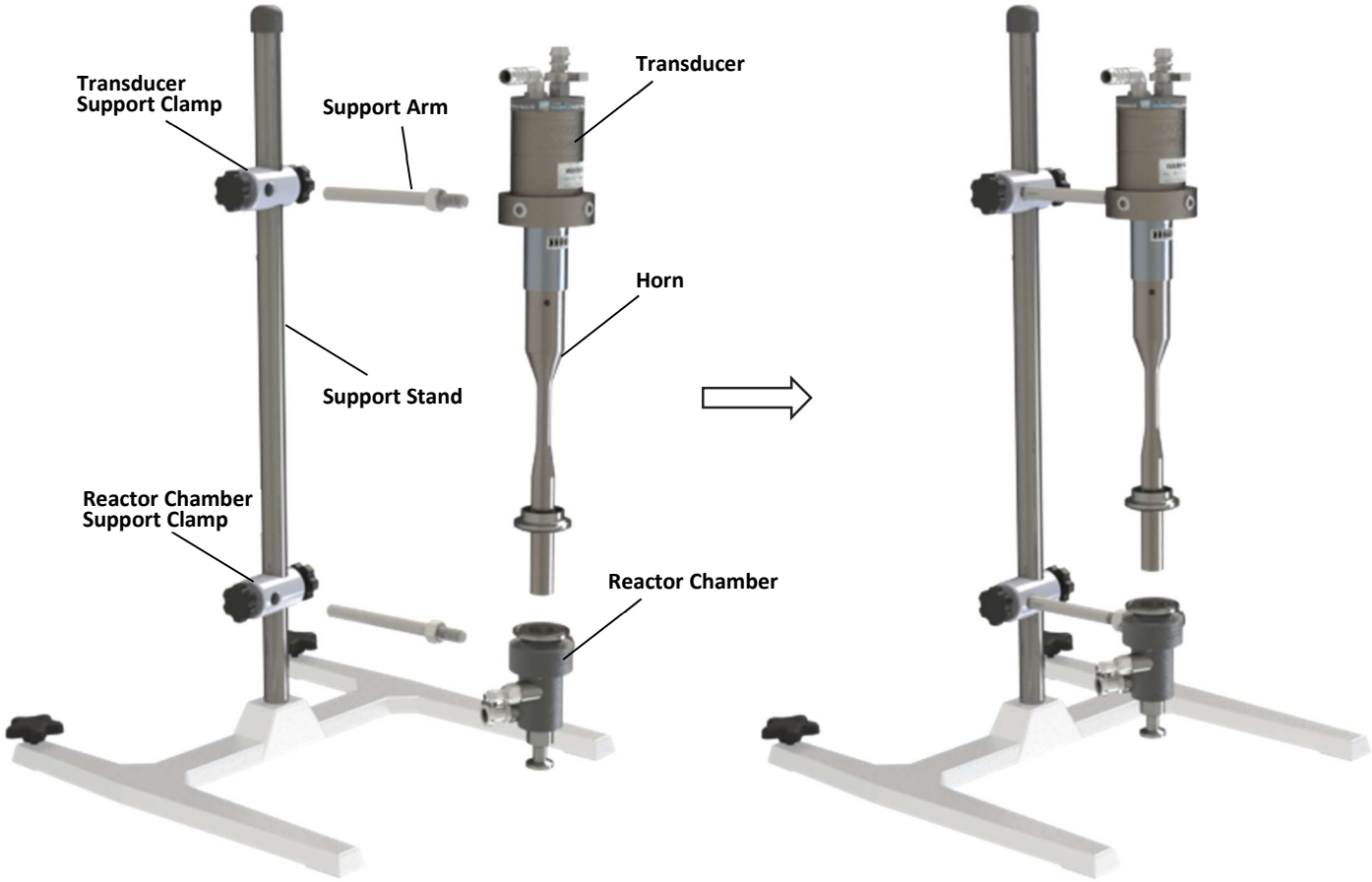


Figure 14. Step 2 of the reactor chamber assembly procedure.

Step 3. (Figure 15)

a. Loosen the **reactor chamber support clamp** and slide up the **reactor chamber** with the **clamp** on the **support stand** so that the **split sanitary gasket** fits onto the **reactor chamber sanitary adapter**.
b. Tighten the **reactor chamber** support clamp.
c. Place the **1.5" sanitary clamp** around the **reactor chamber lid/horn flange with split sanitary gasket/reactor chamber sanitary adapter** assembly and tighten by hand while verifying proper alignment. Do not use any tools for this operation as this may overtighten the assembly.

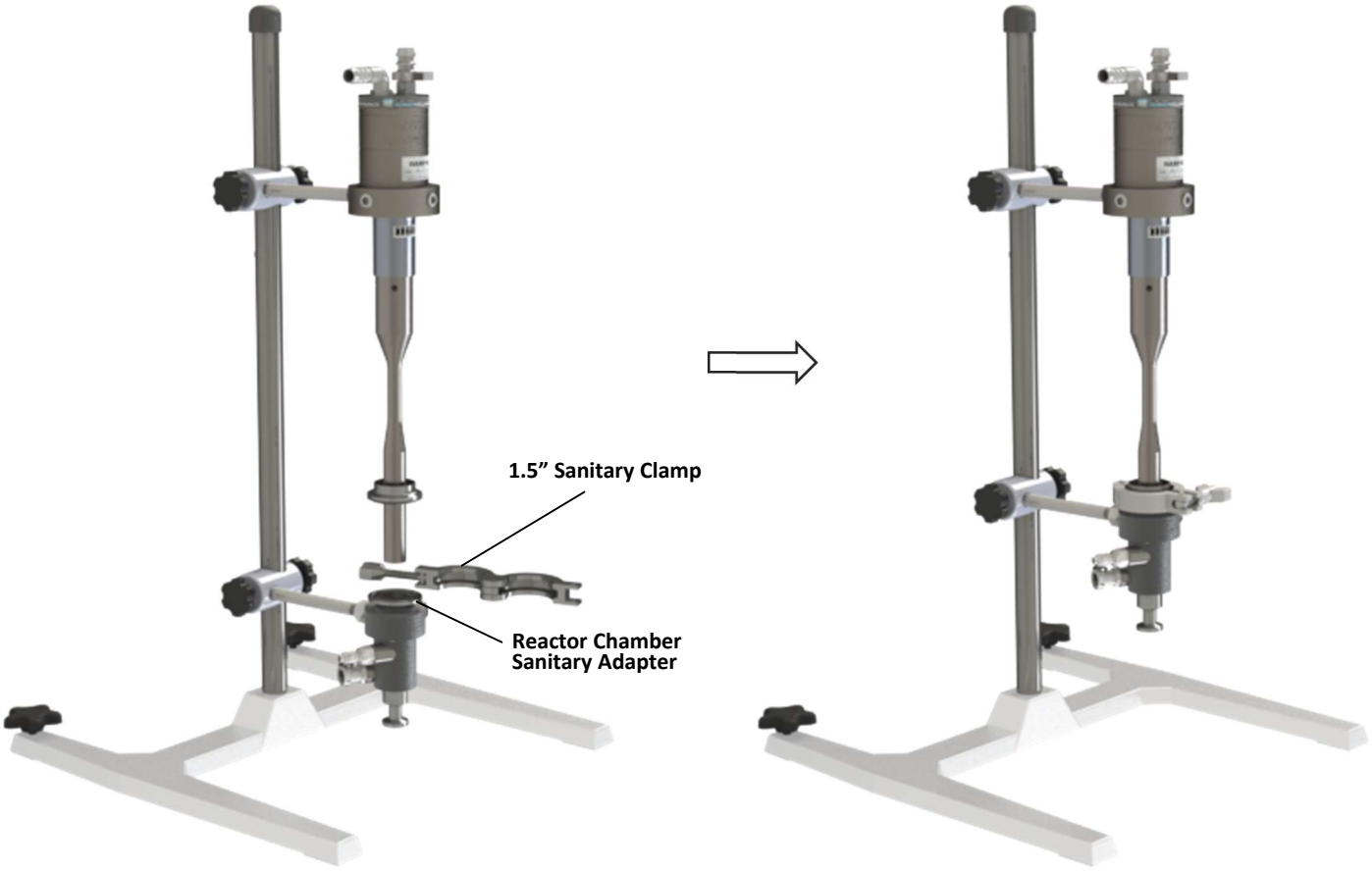


Figure 15. Step 3 of the reactor chamber assembly procedure.

CAUTION

Do not flip the orientation of the reactor chamber lid (gasket groove should face down).

Make sure to use the supplied split sanitary gasket when using the reactor chamber.

CAUTION

A loud, piercing noise while attempting to initiate ultrasound or an abnormally high power readings when ultrasound is activated may indicate that the reactor chamber was not assembled properly. Disassemble the reactor chamber (see below) and repeat the assembly steps.

Disassembling the Reactor Chamber from a Barbell Horn®

Follow the steps below to properly disassemble the reactor chamber (Figure 16):

a. With the transducer/horn/reactor chamber assembly positioned on the support stand, remove the **1.5" sanitary clamp**.
b. Lower the **reactor chamber** after loosening the clamp that secures the reactor chamber to the support stand.
c. Remove the **reactor chamber** by pulling it forward after loosening the clamp that secures the reactor chamber's support arm.
d. If you will be detaching the horn from the transducer, remove the ultrasonic stack (transducer/horn assembly) from the support stand by pulling it forward after loosening the clamp that secures the transducer's support arm. Then see the "Detaching the Barbell Horn® from the Transducer" section above.

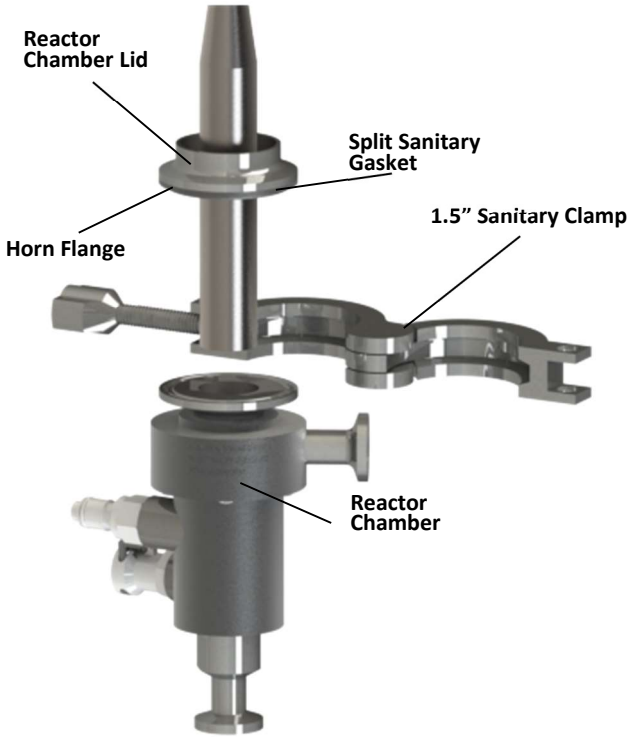


Figure 16. Reactor chamber disassembly procedure.

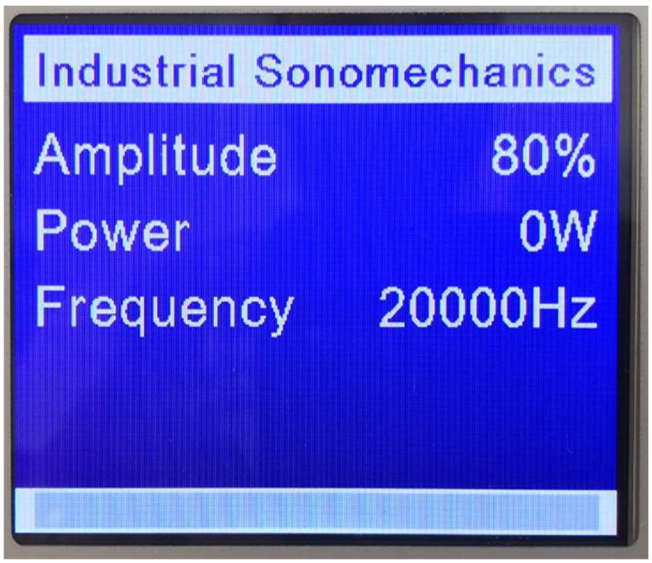
NOTE

The horn does not need to be detached from the transducer to remove the reactor chamber.

Adjusting Parameters and Batch-Mode Testing

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

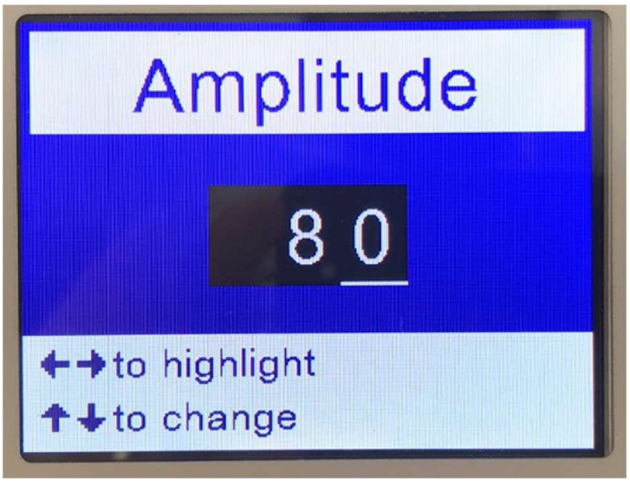
1. Plug the power cord attached to the generator (**H** in Fig. 4) into a grounded electrical outlet.
2. Flip the AC breaker switch on the rear of the generator to the ON position (**G** in Figure 4). The screen will display the following by default:



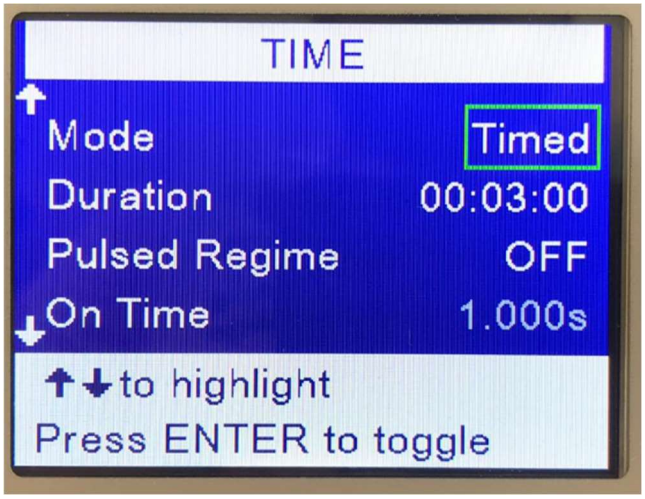
NOTE

The Frequency setting displayed by default on the generator screen will vary.

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, Pulsed Regime and On Time*. In *Timed* mode, ultrasound will initiate when the **START** key is pressed and will stop once the *Duration* time has elapsed (unless the **STOP** key is pressed or a process alarm is activated before the time elapses):



5. (FOR ADVANCED USERS) When it is *ON*, *Pulsed Regime* allows the operator to implement a duty cycle in their process. This means that the user can choose a certain amount of *On Time* and *Off Time* throughout the duration of ultrasonic exposure. Note that when *Pulsed Regime* is *ON*, after the operator presses **START**, the amount of time set for *Duration* will only accrue during the *On Time* of the duty cycle.

6. It is also possible to initiate ultrasound by pressing and holding the **TEST** button. Release it to stop ultrasound.

Testing the System

Use the following steps to make sure your LSP-600 processor is running according to specifications. These tests should be performed with the FBH-type Barbell Horn® directly immersed in water (no reactor chamber) at the temperature of approximately 25 °C (77 °F).

System Test in Water (Batch Mode Configuration)

1. Assemble your LSP-600 processor in the batch-mode configuration (see Figure 1).
2. Fill a 1 L container with water (about ¾ full) and place it under the ultrasonic stack (transducer/horn assembly).
3. Insert the FBH-type Barbell Horn® into the water by about 6 cm (to its flange) and make sure that there is at least 3 cm of distance from the tip of the horn to the bottom of the container.
4. Set the amplitude to 50 % and place noise canceling earmuffs over your ears.
5. Press the **START** button to initiate ultrasound. You should hear a loud hiss and notice cavitation in the liquid. The generator power display should show approximately 200 W, and the temperature of the water should begin to increase. Record the power and frequency corresponding to this ultrasonic stack operating at the 50 % amplitude setting in Appendix III.
6. After 1 – 2 minutes, press **STOP** to deactivate ultrasound.
7. Set the amplitude to 90 % and keep the noise canceling earmuffs over your ears.

8. Press the **START** button to initiate ultrasound. You should now hear a louder hiss and notice intense cavitation in the liquid. The generator power display should show approximately 400 W, and the water temperature should begin to increase faster. Record the power and frequency corresponding to this ultrasonic stack at the 90 % amplitude setting in Appendix III.
9. After 1 – 2 minutes, press **STOP** to deactivate ultrasound.

Section 5

Maintenance & Troubleshooting

General Maintenance

It is recommended to periodically inspect the unit to ensure optimum and safe performance. The inspection should be scheduled as a routine maintenance procedure, performed with the unit unplugged from the AC power source.

Check the generator, transducer, and all cables periodically for signs of contamination. If found, move the ultrasonic processor away from the source of the contaminant.

Examine the condition of the ultrasound cable. Inspect the wire insulation for damage such as wear, burning 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.

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.

Barbell Horn® Maintenance

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

Proper horn care is essential for dependable operation. Cavitation will, however, cause the tip to erode over time. It is recommended that a preventative maintenance schedule be adopted to examine the unit at regular intervals. Horns should be benchmarked for power and frequency (see Appendix III) during every scheduled maintenance check.

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 (e.g., glass cleaner).

Barbell Horns® and Reactor Chamber

Horns and reactor chamber can be cleaned using water with dish soap or isopropyl alcohol. Additionally, before and after using a horn in an experiment, be sure to briefly (< 30 sec) run it in clean water 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.

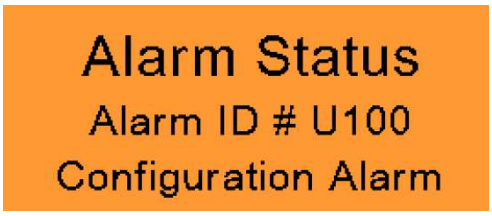
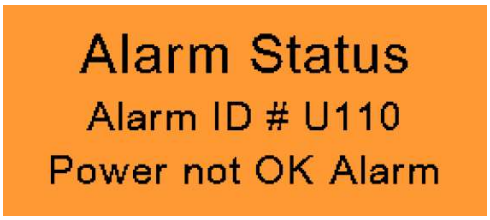
Failure	Probable Causes	Suggested Solutions
Damaged Connector or Cable	• Tension applied across the ultrasound cable. • Ultrasound connector not secured into bayonet-type connection. • Electrical short (arcing).	Contact your ISM client representative about a new ultrasound cable.
Electrical Short/ Malfunction	• Incorrect wiring of the equipment. • Operating on an incorrect voltage.	Check the rear of your generator and transducer to ensure proper connections. Additionally check whether your generator operates at 120 or 240 V.
Loud Screech While Ultrasonic Output is Being Supplied	• 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 10 mins without cooling (overheated). • System was dropped. • Transducer was clamped improperly. • The tip of the 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 vibrations applied during sonication, the junction will always feel hot (and also painful) if it is pressed 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.

Process Alarms

The table below provides information for each Alarm ID #. 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 (transducer/horn assembly). Test the ultrasonic system in air (no liquid in contact with the horn). If this Alarm Status persists, perform the *Scan Stack Protocol*. If the SCAN fails or if the Alarm Status still persists, disassemble/reassemble the ultrasonic stack and re-attempt the above.
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 an excessively viscous liquid. Try to start the ultrasonic stack in air and if the error persists perform the *Scan Stack Protocol*.
Alarm Status Alarm ID # U116 Ultrasound Voltage Exceeded	Ultrasound voltage exceeded input voltage. Most often caused by a severe frequency mismatch when attempting to start the ultrasonic stack in an excessively viscous liquid. Try and start the ultrasonic stack in air and if the error persists perform the *Scan Stack Protocol*.
Alarm Status Alarm ID # U108 Average Overload Alarm	Output power exceeded the rated power of the generator. Most often this occurs because the flow rate is too high leading to excessive pressure in the reactor chamber or the when the processed liquid is too viscous. For the former, reduce the flow rate and restart the ultrasound. For the latter, try warming the liquid to reduce its viscosity and restart the ultrasound.

	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.
	Generator model number does not match internal generator configuration. Cycle power. If the fault persists, contact ISM for support.
	AC line voltage is not within the specified limits. Check incoming AC line voltage to ensure it is proper. If AC line voltage measurement is correct, and alarm persists, contact ISM for support.

If you repeatedly experience any of the Process Alarms, perform the following troubleshooting steps:

Step 1 Make sure the horn and the transducer are properly assembled. Confirm that there is **ONE** mylar acoustic washer between the horn and transducer and that the assembly has been properly tightened with the provided spanner wrenches.

a. If the unit is set up in the flow-through mode, make sure that the reactor chamber is assembled properly and is being supported by the provided support arm.

Step 2 If you continue to experience the error, try operating your system with the horn in air.

a. In the batch mode, lift your horn out of the liquid, set the amplitude to 80 % and attempt to initiate ultrasound. If the ultrasonic stack (transducer/horn assembly) successfully starts **AND** the power displayed on the generator is within 40 W of the value indicated for your horn on the bottom of the *Scan Stack Protocol* (Appendix I) or the value you benchmarked (Appendix III) for your ultrasonic stack when you received it, then continue to Step 3. If a Process Alarm persists, then disassemble and reassemble the ultrasonic stack, perform the *Scan Stack Protocol,* and attempt to initiate ultrasound again. If the fault persists, please contact ISM.

b. In the flow-through mode, drain all liquid out of your reactor chamber, set the amplitude to 80 % and attempt to initiate ultrasound with the empty reactor chamber. If the ultrasonic stack successfully starts **AND** the power displayed on the generator is within 40 W of the value indicated for your horn on the bottom of the *Scan Stack Protocol* (Appendix I) or the value you benchmarked (Appendix III) for your ultrasonic stack when you received it, then continue to Step 3. If a fault error persists, remove the reactor chamber from the ultrasonic stack assembly and then disassemble and reassemble the ultrasonic stack. Do not attach the reactor chamber. Perform the *Scan Stack Protocol* and attempt to initiate ultrasound again. If the ultrasonic stack successfully starts **AND** the power displayed on the generator at 80 % amplitude is within 40 W of the value indicated for your horn on the bottom of the *Scan Stack Protocol* (Appendix I) or the value you benchmarked (Appendix III) for your ultrasonic stack when you received it, then reassemble the reactor chamber and repeat Step 2b. If the fault persists, please contact ISM.

Step 3 Once your ultrasonic stack properly operates in air, attempt to run it in pure warm (~25 °C) water.

a. In the batch mode, insert the horn to its flange (by about 5 cm) into a beaker of water (at least 2 L) and attempt to initiate ultrasound. If the ultrasonic stack successfully starts **AND** the power displayed on the generator at 80 % amplitude is within 100 W of the value indicated for your horn on the bottom of the *Scan Stack Protocol* (Appendix I) or the value you benchmarked (Appendix III) for your ultrasonic stack when you received it, continue to Step 4. If a fault error persists or the power is out of the allowed range, please contact ISM.

b. In the flow-through mode, begin pumping water through the reactor chamber. Stop your pump so that there is stagnant water in your reactor chamber and attempt to initiate ultrasound. If the ultrasonic stack successfully starts **AND** the power displayed on the generator at 80 % amplitude is within 100 W of the value indicated for your horn on the bottom of the *Scan Stack Protocol* (Appendix I) or the value you benchmarked (Appendix III) for your ultrasonic stack when you received it, then turn the pump back on. If the unit then reports a fault error, then it is likely that the pumping rate is too high and must be reduced. If after reducing the pumping rate the unit operates normally, then continue to Step 4. If the fault persists in stagnant water, drain the chamber, remove the reactor chamber from the ultrasonic stack, disassemble and reassemble the ultrasonic stack. Do not attach the reactor chamber. Perform the *Scan Stack Protocol* and Step 3a. If successful, reassemble the reactor chamber and repeat Step 3b. If the fault persists, please contact ISM.

Step 4 Once your ultrasonic stack is properly operating in water, perform similar tests with your processed liquid. If the error persists, then there is likely some property of your processed liquid that is preventing cavitation (e.g., too viscous, completely degassed). Please contact ISM to request a call with a specialist to discuss/troubleshoot your application.

Other Harmful Occurrences

While it is unlikely, it is possible for your unit to be operating off specification, yet without triggering a process alarm. Some harmful occurrences with their possible causes and suggested solutions are provided below.

Occurrence	Probable Causes	Suggested Solutions
POWER JUMPS OR DRIFTS DURING OPERATION	The power reading on the display of the generator should generally be stable within about +/- 100 W unless the operating parameters change during processing. Predictable and normal power changes are relatively slow and can be due to the following: • An increase in power due to an increase in pressure in the reactor chamber or a deeper insertion of the horn into the processed liquid. • An increase in power due to an increase in viscosity of the processed liquid or to the degassing of the processed liquid. • A decrease in power due to an increase in temperature or a decrease in viscosity of the processed liquid. • A decrease in power due to foam generation in the processed liquid.	
LEAKS OR CABLE FRAYING OBSERVED	• Manufacturer's error • Careless treatment of equipment • Electrical short	Contact ISM

RAPID HEATING OF THE TRANSDUCER AT THE HORN JUNCTION**	Ultrasonic stack has been assembled improperly or has been damaged.	Disassemble and reassemble your ultrasonic stack. Make sure that there is a Mylar washer (one) between the horn and transducer and that they have been properly coupled with the provided spanner wrenches. If the error persists, please contact ISM.

**Due to the high-frequency vibrations present during sonication, the transducer/horn junction may feel hot (and likely painful) to touch when ultrasound is on. This may be mistaken for "overheating". To correctly judge whether the junction is overheating, initiate ultrasound for 15 seconds, stop the ultrasonic output, and only then feel the junction.

Section 6

Specifications

Generator Specifications

Drawings

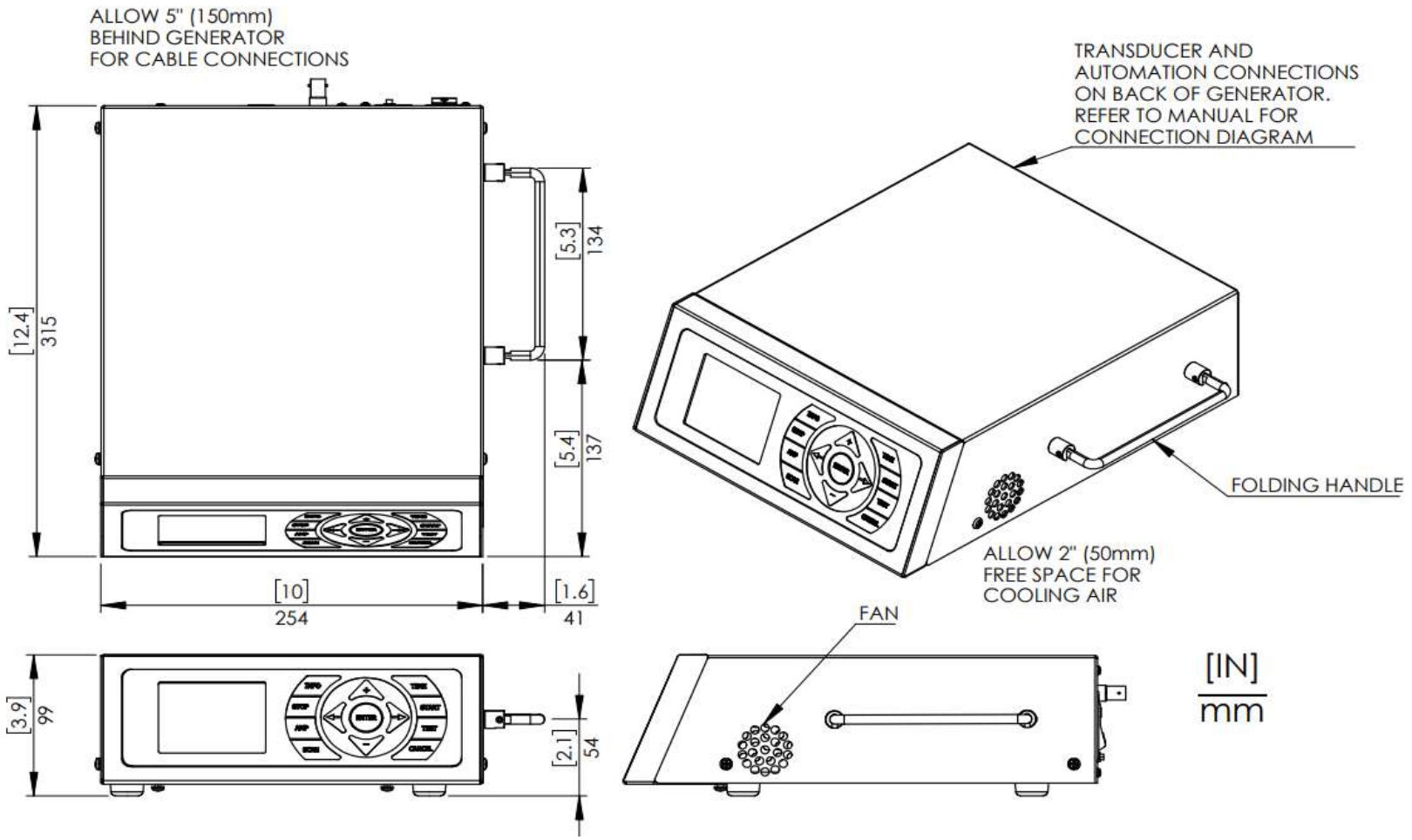


Figure 17. LSP-600 Generator Dimensions.

Weight

12 lb/5.44 kg

AC Power Requirements

100 VAC – 240 VAC, 50/60 Hz @ 10 Amps
North American/Japan AC Outlet Rating: 15 Amps
Output Voltage (Max): 1,300 VAC (Nominal)
Output Current (Max): 3 Amps (Nominal)

Regulatory Agency Compliance

FCC

The 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 (European Conformity) Marking

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

- The EMC Directive 2004/108/EC for Heavy Industrial Environment:
    - EN 61000-6-4, EN 55011; EN 61000-6-2, 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/EC
- 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 generator has an IP (International Protection) rating from the IEC (International Electrotechnical Commission). The rating is IP2X, in compliance with finger-safe industry standards.

UL & CSA

The generator complies with these standards:

- Underwriters Laboratories (UL): UL61010-1
- National Standards of Canada (CSA): CAN/CSA C22.2 No. 61010-1 as verified by TÜV Rheinland.

CAUTION

DO NOT make any modifications to the 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.

Specifications for Ultrasonic Stack and Peripheral Components

Stack Component	Description	Specification
TR-ACT-600 transducer	Air cooling port (Air Inlet) of the TR-ACT-600 cooling jacket	5/8” Hose Barb Coupling to 3/8” NPT Male-type Thread
	Air cooling port (Air Outlet) of the TR-ACT-600 cooling jacket	5/8” Hose Barb Coupling to 3/8” NPT Male-type Thread
	Threaded holes for the Air Inlet and Air Outlet adapters	3/8” NPT Female-type Thread
RC-LSP-600 reactor chamber	Stainless Steel adapter to connect to the Processed Liquid Inlet and Outlet of the RC-LSP-600	1/2" Tri Clamp to ½" Hose Barb
PP-LSP-1200	Silicone tubing that comes with the peristaltic pump	1/2” ID
CHLLR-1400	PVC tubing that comes with the chiller	3/8” ID

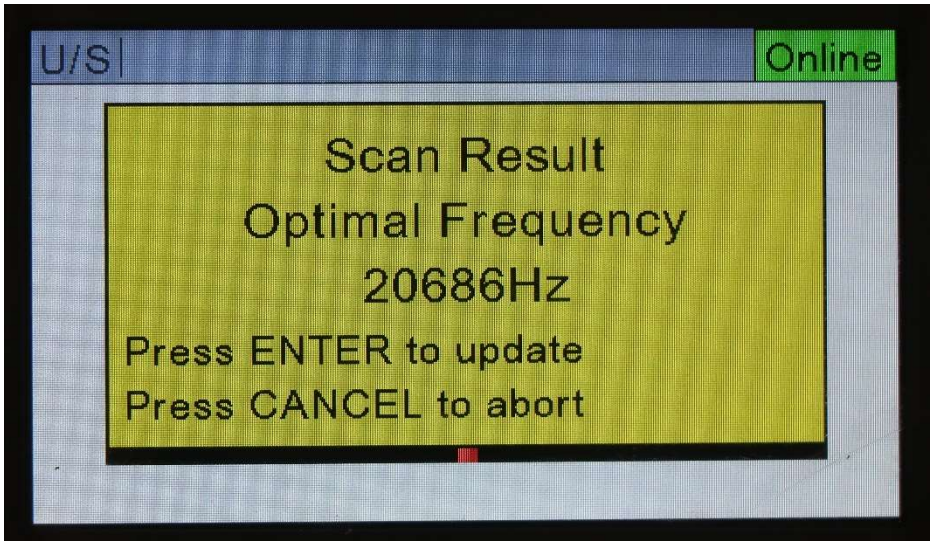
Section 7

APPENDICES

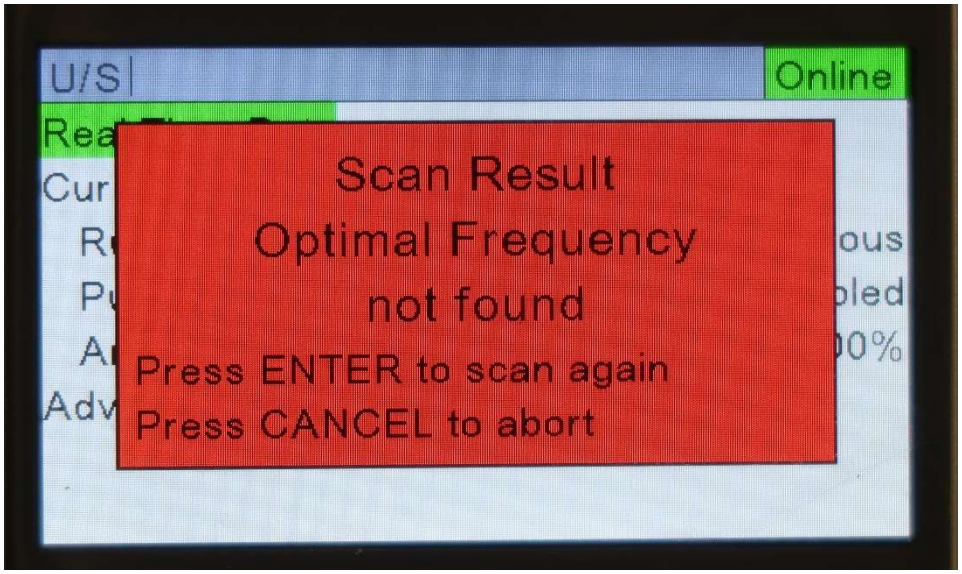
I. Scan Stack Procedure

Each time you intend to use a new ultrasonic horn, you must determine and set its *Free Run Frequency* (FRF) and check its power when operating at the amplitude setting of 80 % in free air. FRF is the initial guess the generator makes when finding the horn's resonant/optimal frequency during operation. FRF can be determined by using the SCAN feature accessible from the ultrasonic generator's front panel. Follow the instructions below to scan the horn:

1. Attach the new horn to the ultrasonic transducer using the provided spanner wrenches and connect the ultrasound cable from the generator to the top of the transducer (skip if already attached).
2. On the generator's keypad press **MENU/CANCEL**, then use the **+/-** keys to navigate to **Advanced Settings** and press **ENTER**.
3. Navigate to **Frequency Control**, press **ENTER**, then navigate to **Wide** and press **ENTER**.
4. Press **SCAN**. A warning message will appear. Confirm that the transducer is properly connected to the generator and that the tip or sides of the horn are not in contact with anything.
5. 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 the **Optimal Frequency not found**. Press **MENU/CANCEL** and begin this protocol from Step 1, confirming that the horn and transducer are assembled properly and that each step is followed carefully. If the **SCAN** continues to fail, please contact ISM.



6. After a successful scan, repeat steps 2 and 3, but set the **Frequency Control** to **Normal**.
7. Set the amplitude to 80 %. Confirm that the tip and sides of the horn are not in contact with anything.
8. 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 (at 80 %, in air) [W] (+/- 20 W)
CH-F20D12.7G6s	20
FBH-F20D21G5s	60

II. Pin Layout and Descriptions for Inputs/Outputs (I/O) Connector

Pin 1 (Enable Out)

This is a current limited voltage source output intended to connect to an E-Stop circuit. As an E-Stop circuit is not used, Pin 1 is internally jumpered to Pin 2 for ultrasound operation to be enabled.

Pin 2 (Enable In)

The output from the E-Stop circuit is connected to this pin when an E-Stop circuit is used. For this specific model, this pin is jumpered to Pin 1 for ultrasound operation to be enabled.

Pin 3 (System Overload Status Output)
Pin 3 is an isolated digital NPN/PNP status output that activates when an output overload condition is tripped. This output will be an open circuit if an output overload condition is not tripped. This output will remain latched ON until the U/S Activate input is switched OFF and then ON again.

Pin 4 (Ultrasound Active Status Output)
Pin 4 is an isolated digital NPN/PNP status output that activates when the system is delivering ultrasonic power to the load attached to the ultrasound output connector. This output will be an open circuit when the ultrasound output is off.

Pin 5 (Any Fault Status Output)
Pin 5 is an isolated digital NPN/PNP status output that activates whenever any fault condition is detected that inhibits ultrasound output and normal system operation. This output will be an open circuit when no system fault conditions are active.

Pin 6 (No Connection)

Pin 7 (Isolated Status Output Common)
Pin 7 is electrically isolated from chassis ground. This common line should be connected to the negative output of a user-provided isolated 24 VDC power supply for a PLC sourcing input card. For a PLC Sinking input card this line is connected to the positive output of the isolated 24 VDC power supply.

Pin 8 (System Ready Status Output)
This status output signal will activate only when the system is ready to activate ultrasound or begin a weld cycle. Pin 8 is an isolated digital NPN/PNP status output that activates when a weld processing cycle is completed and the welding process control system is ready to start the next welding cycle. This output will be an open circuit when the welding process controller determines that the next welding cycle cannot be started. This includes system faults or E-Stop active, but not a process fault like Overload.

Pin 9 (No Connection)

Pin 10 (No Connection)

Pin 11 (Fault Reset Input)
Pin 11 is an isolated input control signal that will reset any output faults when it is activated. It can be used by the automation control system to simplify PLC programming.

Pin 12 (U/S Activate/Cycle Start Input)
Pin 12 is used to activate the generator ultrasound output. When welding in Automation mode, activating this isolated control input will switch the ultrasound output ON, and deactivating this signal will switch ultrasound OFF. When welding by Time or by Energy, this input functions as a cycle initiate. A momentary signal with a minimum duration of 50msec is required to initiate the cycle.

Pin 13 (Isolated Input Common)
[Electrically connected to Pin 5 on MPC I/O connector if MPC Interface option is installed.] Pin 13 is electrically isolated from chassis ground. Using sourcing (PNP) output drivers, this common line would be connected to the automation system power supply common. Using sinking (NPN) output drivers, this common line would be connected to the automation system positive supply output.

Pin 14 (No Connection)

Pin 15 (No Connection)

Pin	Color	Description
1	BLK	Enable Out
2	WHT	Enable In
3	RED	System Overload Status Output
4	GRN	Ultrasound Active Status Output
5	ORN	Any Fault Status Output
6	BLU	No Connection
7	WHT/BLK	Isolated Status Output Common
8	RED/BLK	System Ready Status Output
9	GRN/BLK	No Connection
10	ORN/BLK	No Connection
11	BLU/BLK	Fault Reset Input
12	BLK/WHT	Ultrasound Activate/Cycle Start Input
13	RED/WHT	Isolated Input Common (Sourcing or Sinking Inputs)
14	GRN/WHT	No Connection
15	BLU/WHT	No Connection

III. System to Specification Testing and Stack Benchmarking

It is recommended that you routinely benchmark your ultrasonic stack (transducer/horn assembly) to be able to ensure that system is operating to specifications. Record values for power and frequency corresponding to your ultrasonic stack in Table 4.

Test in air

1. Assemble the transducer and horn properly and secure the ultrasonic stack in the support stand (without the reactor chamber).
2. Plug the generator in a properly rated outlet and connect the ultrasound cable from the generator to the top of the transducer.
3. Set the amplitude on the generator to 80 %
4. Make sure that the horn is dry.
5. Wearing proper ear protection, hold the TEST key on the generator, read the displayed power and frequency values and record them in Table 4.
6. Attach the reactor chamber and repeat steps 4 – 6 (with no liquid in the reactor chamber).

Test in water (batch mode)

1. Assemble the transducer and horn and secure the ultrasonic stack in the support stand (without the reactor chamber).
2. Plug the generator in a properly rated outlet and connect the ultrasound cable from the generator to the top of the transducer.
3. Set the amplitude on the generator to 80 %
4. Insert the horn into a large (> 2 L) beaker of distilled water. The water temperature should be near 20 °C and the horn should be inserted into the liquid by 5 – 6 cm.
5. Wearing proper ear protection, hold the TEST key on the generator, read the displayed power and frequency values and record them in Table 4.

Test in water (flow-through mode)

1. Assemble the transducer, horn and reactor chamber and secure the ultrasonic stack on the support stand.
2. Setup your processed liquid recirculation network (i.e., tubing, storage tank, pump and chiller) and begin recirculating water through the reactor chamber.
3. Plug the generator in a properly rated outlet and connect the ultrasound cable from the generator to the top of the transducer.
4. Set the amplitude on the generator to 80 %.
5. Stop the pump to pause the recirculation of the water. Your reactor chamber should remain filled with water.
6. Wearing proper ear protection, hold the TEST key on the generator, read the displayed power and frequency values and record them in Table 4.

Ultrasonic Stack Power and Frequency Benchmarking

Each time you begin using a new ultrasonic horn, benchmark its frequency and power. This will allow you to track the performance of your horn over time. The first two rows in Table 4 are examples of how the information for each horn should be recorded.

Date	Transducer Serial No.	Horn Serial No.	Free Run Frequency [Hz]	Power at 80 % in Air [W]	Power at 80 % in Water [W]	Notes
01/12/2023	TR-ACT-600 01012023	FBH-F20D21G5s 01012023	20,200 Hz	22 W	380 W	Benchmarking performed in the batch mode.
02/02/2023	TR-ACT-600 01012023	FBH-F20D21G5s 01012023	20,200 Hz	25 W	410 W	Benchmarking performed in the flow-through mode.

Table 4. Benchmarking the ultrasonic stack.