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General Classification of SONOREACTORS

We have a number of options to address **flow-through Sonochemistry**. As you can see there are many elements we can use in our reactor-chamber designs. We can offer complete systems built for your needs or for clients with the capability to construct the chamber parts we may also consider selling just the ultrasonic components.

In addition to some standard components you will find that we are offering some very unique technology. For example if you decide on the very high surface power density probe solution please note that ours is the highest power system available. None of the leading industry brands are offering the same level of power output to the liquid. This is very important for some Sonochemical testing where you need to test low power as well as very high power.

Our Pipe-Clamp solution is a technology that will only function with our MMM generators. We can design clamps to fit nearly any size pipe and drive 1 to 5 converters and clamp assemblies from one generator.

SONOREACTORS Group A: HVPD

- High Volumetric (typically 5 to 50, or even until 1000 W/dm³) and low surface Power Density (typically 0.5 to 2 W/cm²)
- Large radiating surface/s (transducer arrays)
- Multi-frequency, sweeping and single frequency systems

SONOREACTORS Group B: HSPD

- High Surface-Power-Density of ultrasonic radiation: HSPD
Typically 100 W/cm² or higher (until 500 W/cm²)
- Small radiating surface and very high intensity of radiation, like a torch
- Single frequency, single-Probe Systems

SONOREACTORS Intermediary Group C: Between A & B

- High Volumetric (typically 5 to 50 W/dm³) and moderate-to-high surface Power Density (2 to 20 W/cm²)
- Large radiating surface/s
- Multi-frequency and single frequency systems
- Single-Probe Systems, transducer arrays, tubular, solid rod and combinations with Clamp-On reactors...

SONOREACTORS Intermediary Group D: A+B in-line

- Combinations of two independently operating reactors (A and B) mutually connected in-line.

Normal and acceptable situations (for sonochemistry) are to treat liquids like: water solutions, fuels, alcohol, petroleum, milk... Basically lower density and lower viscosity liquids. If we attempt ultrasonic processing of heavy oils and high density liquids, we may notice some negative effects (like increased heating, overloading, slow processing...). If we like to mix ultrasonically solids and liquids, solid content should be transformed in a powder or in a liquid form (by heating, if applicable), and sufficient quantity of liquid solvent should be added in order to get relatively low average density and viscosity.

If the objective is to mix and homogenize set of different ingredients (liquids and powders), for initial mixing could be beneficial to apply certain high amplitude gain sonotrode (Group B, HSPD) which has the strongest ultrasonic radiation on the sonotrode end. This way delivered/radiated surface power density (W/cm²) from the sonotrode end will be very high and we can realize difficult mixtures... Later we may apply reactor HVPD from the Group A, in order to finalize processing.

If we need to optimize some chemical process, synthesis, accelerate chemical reaction, produce biodiesel, produce new molecules... in that case is better to apply bigger sonotrodes (reactors from Groups C & D) which are radiating omni-directionally, (for instance axially and cylindrically in all directions), this way delivering to a liquid sufficient level of cavitation and higher volumetric power density (W/cm³).

We need to learn more about your application to give better advice on the equipment that will best meet your needs. Please tell us: What kind of liquid material you wish to treat? Do you prefer to use the effects of even cavitation or a combination high acoustic power plus cavitation to break particles? Will you need to treat a large volume or small volume? Is your need for batch treatment or continuous flow?

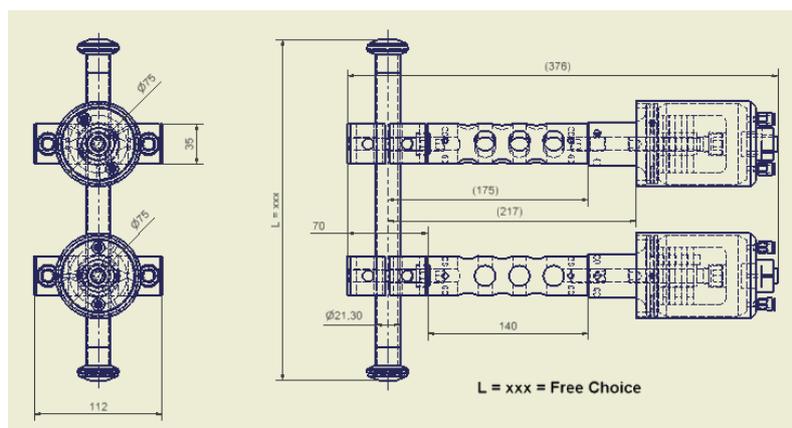
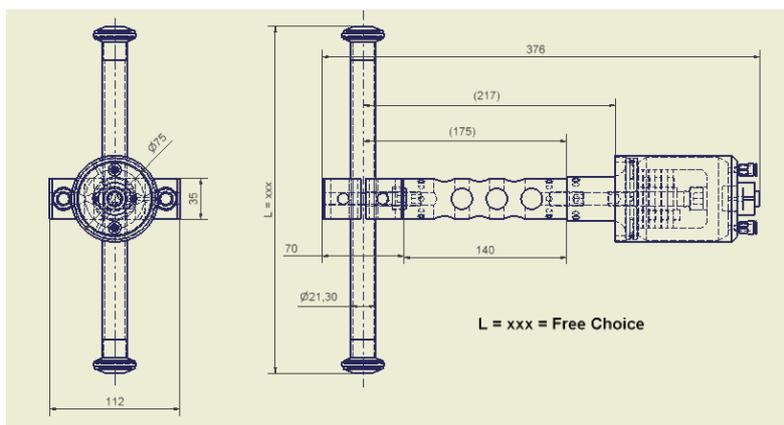
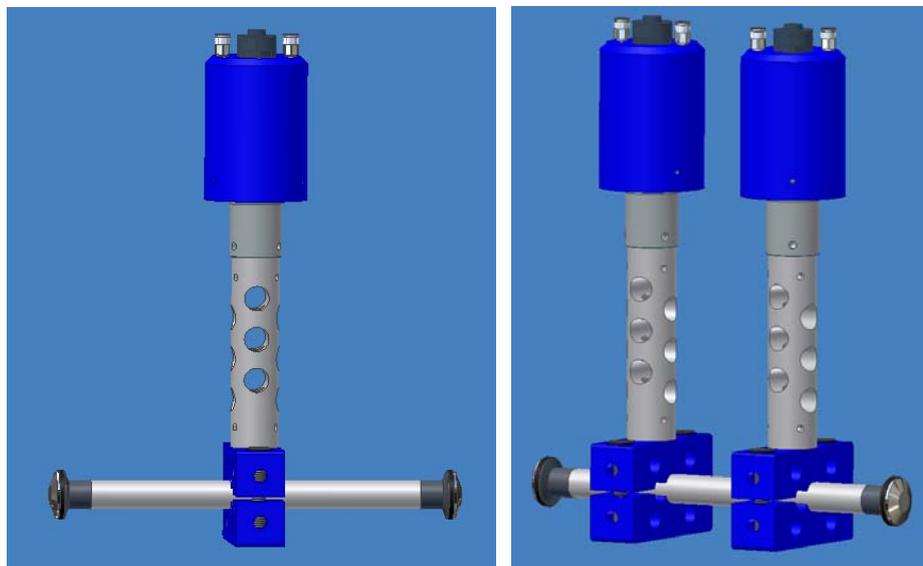
Please visit our website for more details and have a look at our production line technology, or contact us directly with any inquiries.

Applications of Flow-through Ultrasonic Reactor Systems:

- **Sonochemistry**
- **For organic and/or inorganic materials processing**
- **Homogenization** - making uniform mixtures of liquids or liquid suspensions.
- **Emulsification** - processing foods, pharmaceuticals, and cosmetics.
- **Dissolution** - dissolving solids in solvents.
- **Degassing** - removing gases from solutions without heat or vacuum.
- **Reaction Acceleration** - cavitation accelerates chemical and physical reactions.
- **Cracking in petrochemical technologies & biodiesel production**
- Cylindrical **360° internally radiating** chamber.
- Internal or external **liquid atomizing or powder making** sonotrode.
- **Powders production in liquid phase** by precipitation (minimizing the particle sizes including surface treatment).
- **Disruption and Cell Lysing** - will break open biological tissues and cells to extract enzymes and DNA, **prepare vaccines**. This technology provides a method for **ultrasonically lysing cells and spores** in a liquid flowing continuously or intermittently through a cylindrical reactor.
- **Transdermal Drug Delivery** (no more needles).
- **Bioengineering and genetic research** (extracting cells' fluids).
- **Activation of seeds:** almost 100% successful germination and healthier plants.
- **Filtering**
- **Sterilization**
- **Extractions from organic and inorganic materials**
- **Food products treatment**
- **Electroplating & Electrochemistry processes optimization**
- **Fine Particle Dispersion** - e.g. nanoparticles processing
- **Nano-particles & nano-emulsions technologies**
- **Cells disruptors**
- **Atomizing low and high viscosity liquids**
- **Liquid food processing**
- **Liquids processing on high temperatures (until 250°C)**

Clamp-On Tubular MMM Reactors

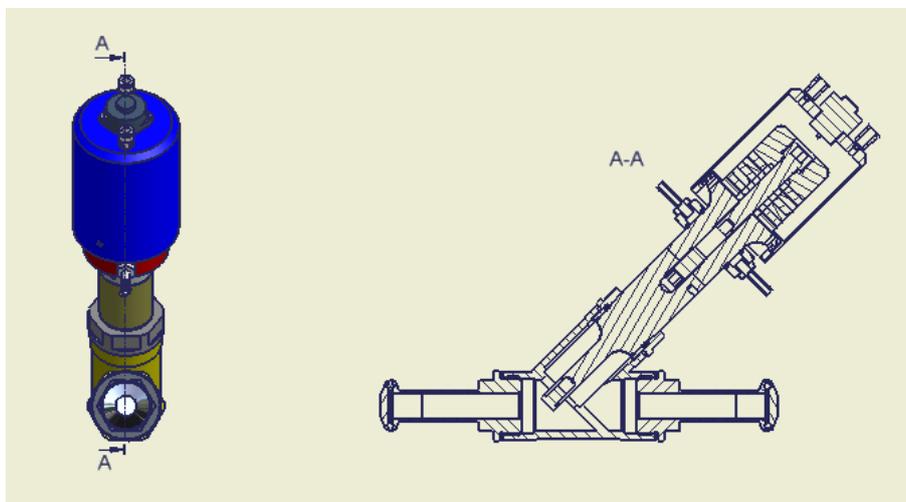
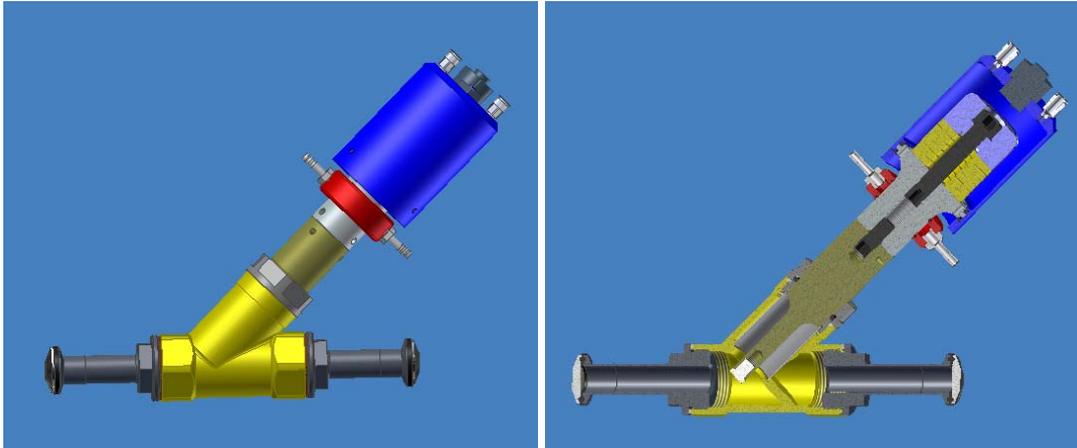
MMM frequency SONOREACTORS Group A: HVPD



http://mastersonics.com/documents/mmm_applications/liquids_processing/tubular_clamp_on_reactors.pdf

Y-Flow-Cell Probe Reactor

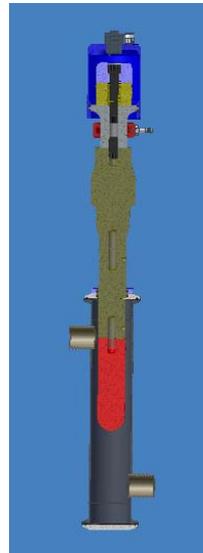
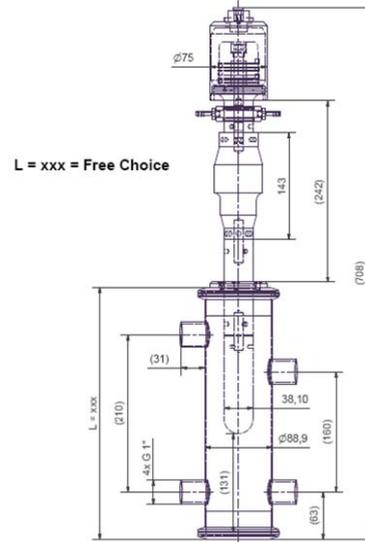
Fixed frequency SONOREACTORS Group B: HSPD



http://mastersonics.com/documents/mmm_applications/liquids_processing/heavy-duty-high-intensity-sonicator-2.pdf

Heavy Duty, High Intensity Probe SONICATOR

Fixed frequency Intermediary Group C
Between A & B: HVPD-&-HSPD



http://mastersonics.com/documents/mmm_applications/liquids_processing/heavy-duty-high-intensity-sonicator-2.pdf

Heavy Duty, High Intensity Probe SONICATOR & Clamp-On Reactor

Fixed and MMM frequency Intermediary Group C
Between A & B: HVPD-&-HSPD

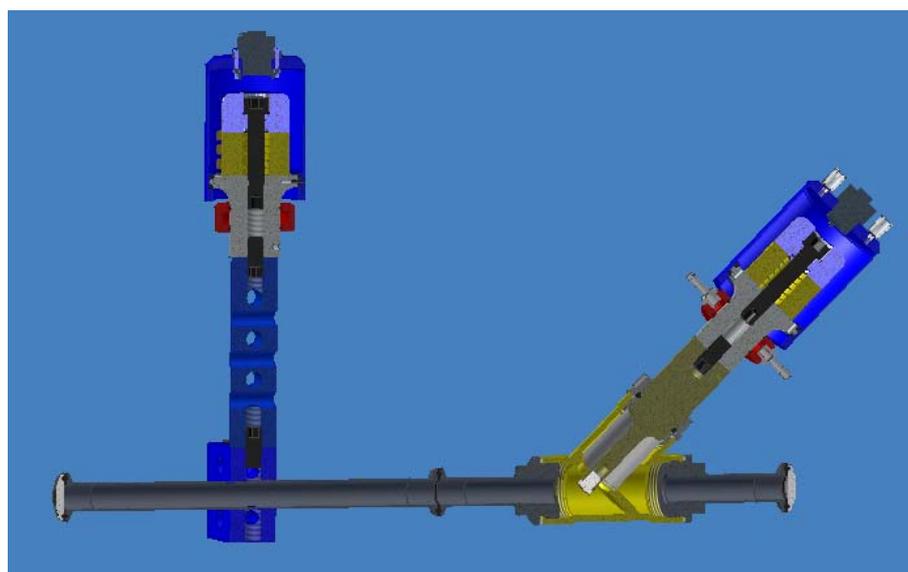
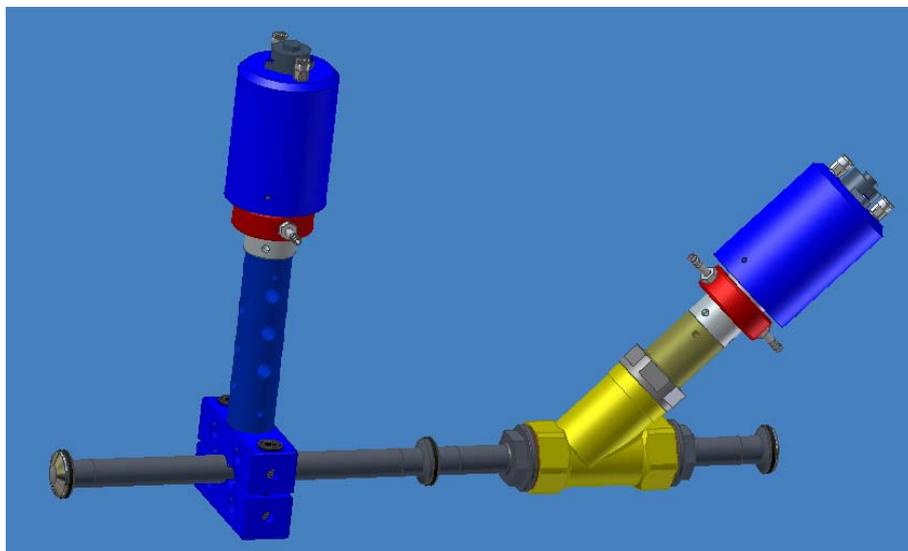


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Clamp-On & Y-Flow-Cell Reactor

SONOREACTORS Group D (A+B inline: HVPD+HSPD)
Fixed and MMM frequency Group: A & B in-line



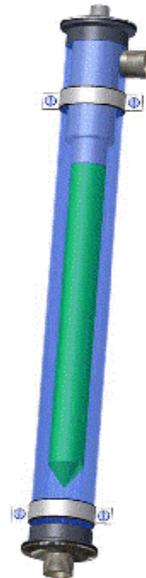
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Ultrasonic Liquid Processing

Applications:

- Mixing and Homogenizing
- Cell Disruption / Cell Lysis
- Sonochemical Reactions
- Particle Breakdown, Nano Particle Processing
- Physical Contacting Liquid/Liquid, Liquid/Solids, Liquid/Gas
- Liquid Degassing (with modified reactors or flow cells)
- Biodiesel Processing



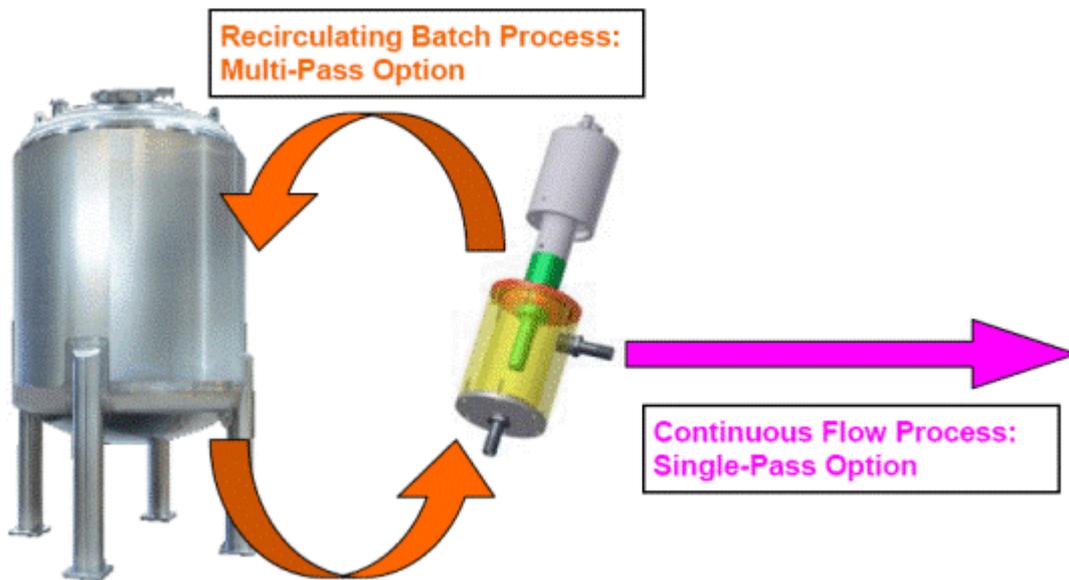
Applications & Systems Development:

- Application & Technical Consulting
- Equipment Development
 - Continuous Flow-Cell Designs
 - Batch Reactor Designs
 - High Intensity - Short Flow Path
 - Moderate Intensity - Extended Flow Path
- Process Development
- Custom Systems Integration



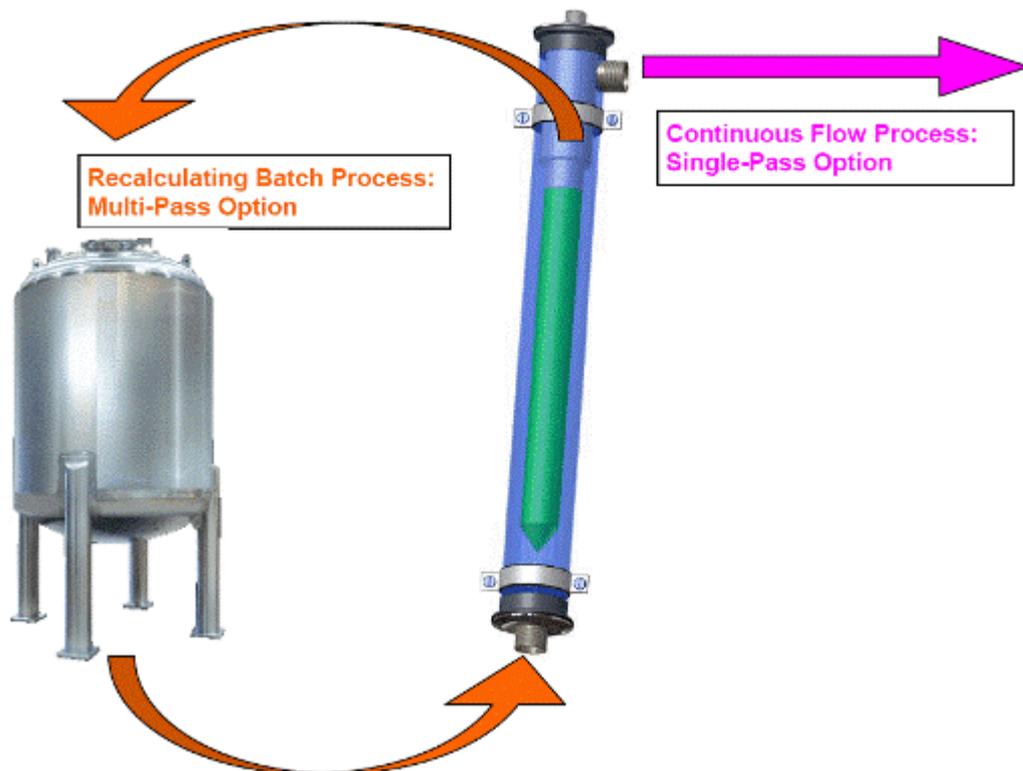
High Intensity Flow Cell:

- High, Moderate, or Low Intensity probes (shown in Green below) to focus and concentrate ultrasonic energy on liquid or liquid slurry directed through the high intensity ultrasonic field.
- A standard flow cell volume is 250 ml. (Custom sizes can be delivered.)
- Standard Inlet/Outlet are ½ inch fittings. (Custom sizes can be delivered.)
- Flow rates can be modified by inlet/outlet size and pressure.
- Ultrasonic Power Ranges Available from 100 W to 1500 W (depending on power settings, probe length, probe diameter and liquid viscosity)



Extended Treatment - Moderate Intensity Flow Cell:

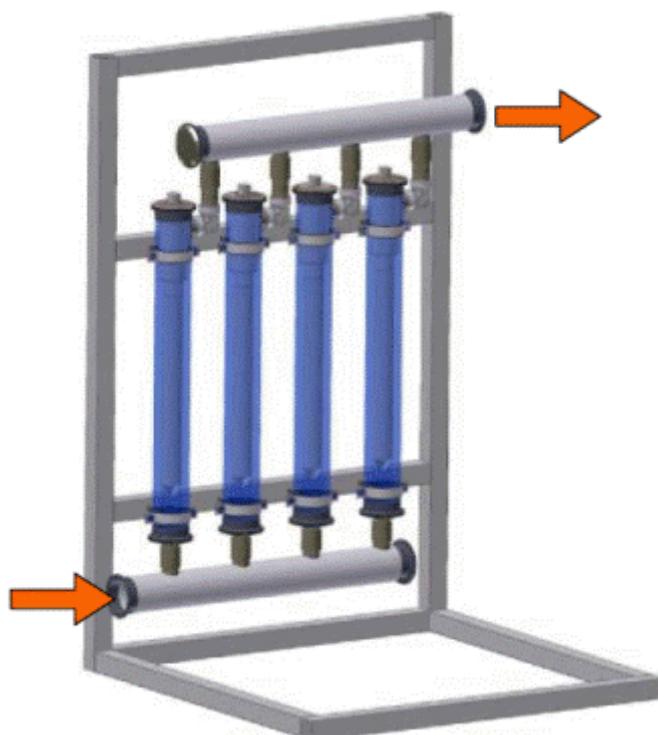
- Moderate Intensity probes (shown in Green below) spread ultrasonic energy over the length and circumference of the probe. Liquid or liquid slurry directed through the length of the tube is continuously treated by the moderate intensity ultrasonic field.
- Ultrasonic Power Ranges Available from 600 W to 2200 W (depending on power settings, probe length, probe diameter and liquid viscosity)
- Total reactor lengths from 400 mm to 1500mm
 - Active Element length 200 mm to 1200 mm (shown in green)
- Long Flow Cell volumes can be customized. (e.g. from 1 liter to 10 liters)
- Treatment volume and flow rate adjusted by modification of outer reactor diameter and length.
- Flow rates are additionally adjusted by input/output fittings and liquid pressure.
- Standard Inlet/Outlet(s) are 1 inch fittings. (Custom sizes can be delivered.)



Multi-Path or Extended Treatment - Moderate Intensity Flow Cell:

Long flow cells may be organized as follows:

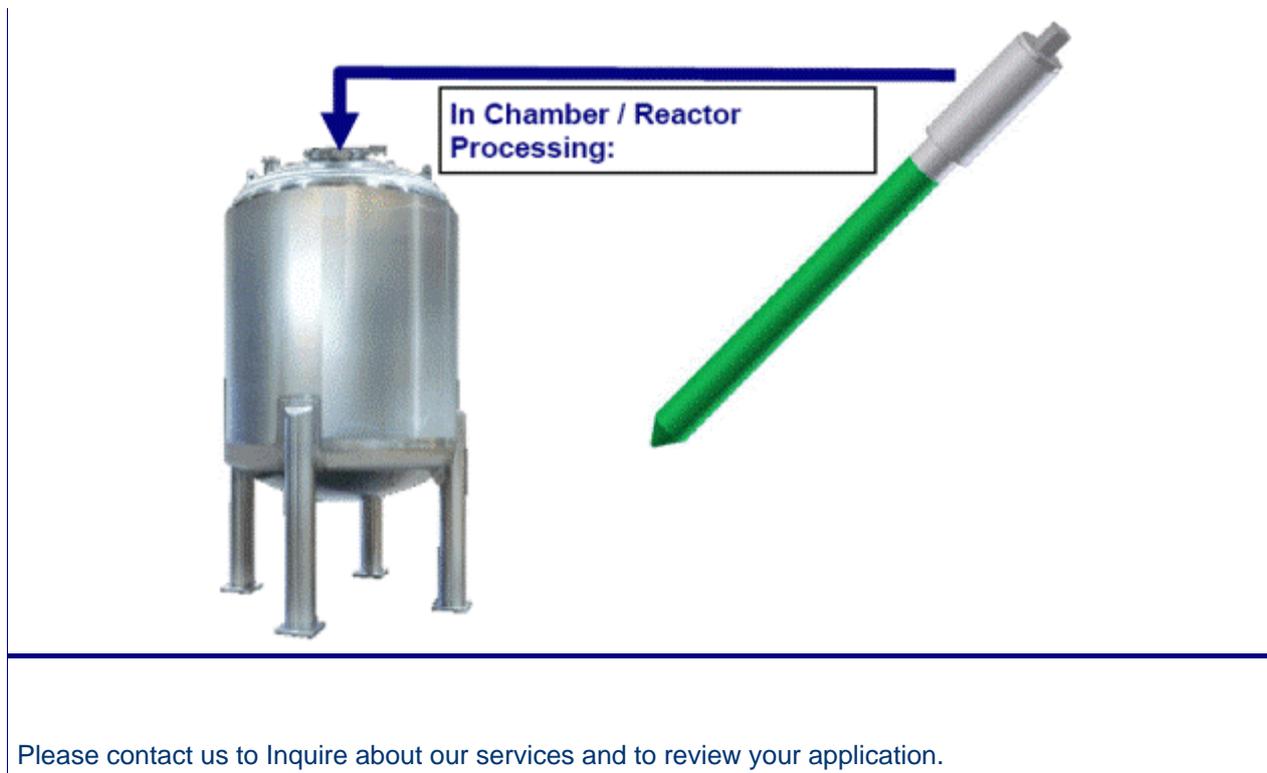
- Parallel Path – Feed multiple flow cells from a single source (shown below):
 - Will increase flow rates.
 - Will extend treatment time through each reactor cell.
 - Provides built in redundancy should there be a component failure.
 - Allows simplified modular expansion
 - Example below could be adapted to 4 x 2,200 watt systems for a total skid processor of 8,800 watts. (true power output)
- Series Path – Feeding from one flow cell into the next offers:
 - Long ultrasonic exposure if required.
 - Extended treatment time offers more power input and exposure to cavitation fields to improve some processes.
 - Modular approach allows simplified fine tuning of the process for more or less ultrasonic treatment.
 - Example above could be adapted to 4 x 2,200 watt systems for a total skid processor of 8,800 watts. (true power output)
- Combined Parallel and Series Path – For example feed from cell 1 to cell 2 and exit. In parallel feed a separate stream from cell 3 to cell 4 and exit.
 - Will increase the exposure time compared to single cell and improve flow rates by providing 2 process paths
 - Provides built in redundancy should there be a component failure.
 - Allows simplified modular expansion.
 - Example above could be adapted for 2 x 2,200 watt systems for a total path power of 4,400 watts. Two paths of 4,400 watt offer a total skid processor of 8,800 watts. (true power output)
- Flow cells may be mounted on skids or in cabinets.



In Chamber Processing and Custom Reactors:

- High Intensity ultrasonics can be effectively used in small vessels or as external lab scale processors.
- Moderate Intensity ultrasonics are normally better suited for larger vessels
- Probe lengths are available from 60 mm to 1200 mm
- Ultrasonic Power Range 100 W to 2200 W (dependent on ultrasonic power supply, length and diameter of probe, liquid processed)
- Treatment volume is dependent on the liquid characteristics and the type of ultrasonic system used.
- High Intensity systems use titanium probes with a standard transducer. Only the active probe can be submersed into the liquid with these systems.
- Moderate intensity systems offer the option to completely submerge the transducer housing into a liquid. Optional waterproof stainless steel cables allow for deep submersion (3 to 5 meters). Submersible transducers and probes have the following characteristics:
 - Parallel Path – Feed multiple flow cells from a single source (shown below):
 - Probe material is titanium (shown in green)
 - Transducer housing is stainless steel (shown in grey)
 - There is a Teflon seal at the base of the housing.
 - Bulkhead mounting is provided with a threaded section at the top of the transducer. Optionally a stainless steel braided hose may be purchased to submerge all of the transducer deeper into the

liquid.



Ultrasonic Liquid Filtering and Inline Filter Cleaning

Our ultrasonic systems offer new design flexibility and adaptability to most any size inline filtration system for micron or submicron materials dispersed in a liquid.

Ultrasonic Filtration Advantages:

- Significant increase in flow rates.
 - Cleaner filter element
 - Ultrasonic effects are actively working to reduce surface tension, cohesive forces, and/or adhesive forces.
- Allows in process self cleaning of the filter for continuous processing.
- Greatly improves reverse flow filter cleaning and de-blinding.

Example Applications:

- Micron and submicron materials dispersed in liquids
- Metal powder slurry
- Ceramic slurry
- Biotech and Pharmaceutical products
- Water and wastewater processing

New Technology Offers Adaptability:

- New transducer clamp-on technology allows easy adaptation to existing housing designs and retrofit possibilities.
- For any filter type: Sintered Metal Filters, Membrane, Ceramic, etc.



New Wideband Ultrasonic Systems:

MPI offers the industry's most advanced ultrasonic technology for liquid and liquid slurry filtering applications. Our wideband ultrasonic generators can stimulate highly efficient sonic to megahertz acoustic energy to most any liquid filled filter chamber. Compared to conventional fixed/frequency solutions our wideband ultrasonic techniques improve filter throughput, improve inline cleaning continuously, and improve reverse flow back flush. Key benefits to the new technology are:

- Wideband (sonic to megahertz) acoustic energy provides

greater acoustic stimulation to improve process flow rates.

- Wideband effects eliminate standing waves seen in fixed frequency systems.
 - Eliminates blinding in low amplitude nodal points
 - Eliminates damage to filters in high amplitude nodal points.
- Fully programmable power and modulation technology
 - Standard power modules in 300 watts, 600 watts, 1200 watts, and up.
 - Pulse Width Modulation Period (Period 10 ms to 1,000 ms)
 - Pulse Width Modulation Ratio (0% to 100%)
 - Special modulation settings (fast sweeping, sweeping, & tracking)
- Transducer from 20 kHz to 45 kHz and higher frequencies on special order.
- Adaptable to most any size and shape filter housing.
- A field adjustable resonant frequency option allows filter housings to be built without specific ultrasonic resonance tuning. This means filter housing designs can be simplified and produced at lower cost.



*Example:
Clamp mounted
Transducer
to standard filter
housing. (Sintered
metal filter)*



Example: Transducer mounted directly to filter housing end.
(Sintered metal filter)



Example: Clamp mount Transducer systems allows easy adaptation to existing housings

Clamp-On Ultrasonic Systems - Principle of operation:

High power ultrasonic transducers are strongly (mechanically and acoustically) coupled to the external cylindrical housing of the filter element. The active filter element inside of the housing is radially stimulated (360°) by intensive ultrasonic vibrations transmitted through the liquid or liquid slurry. With sufficient power and amplitude the ultrasonic vibrations will produce ultrasonic cavitation and streaming effects within the liquid and to the filter element. Oversized particles, powders, impurities, or other materials which usually fill or blind the fine filter structure are forced out of the active filter body. Flow rates are improved by a cleaner filter element plus the ultrasonic acoustic effects are actively working to reduce surface tension, cohesive forces, and or adhesive forces.

Coupling the high power ultrasonic transducer to the filter housing may be accomplished in two ways:

- A custom housing may be designed to allow a direct connection between the transducer and the filter housing. This coupling connection should be optimized to allow ultrasonic stimulation of the entire housing when possible. Coupling may be perpendicular or axial in orientation to the filter housing.
- A new Clamp-On technology allows easy adaptation to existing stainless steel cylindrical filter housing of nearly any size.

To achieve a uniform (surface and 3D) distribution of ultrasonic amplitudes and ultrasonic pressure our wideband systems perform frequency sweeping around the optimal resonant frequency of the resonating system (e.g. 35 to 45 kHz). The speed of applied frequency sweeping is in the range of 50 to 100 sweep intervals per second. Frequency sweeping also reduces the chance that some particles or areas of the filter body remain inactive (non-vibrated).

To eliminate the creation of standing waves and other vibration stationary (or stable) structures inside the filtering tube, low frequency, and full power On/Off pulsing is applied to the ultrasonic signals. This way, the applied pulse repetitive and transitory (mechanical) excitation is able to send shock pressure waves to the filter body. Pulsing shock pressure waves can be many times stronger than the effects of continuous operation. Such mechanical On/Off shocking also produces low frequency and very high vibration amplitudes that are superimposed and mixed with high frequency ultrasonic oscillations, thereby maximizing the effects of filter cleaning.

Programming, Regulating, and Operating Parameters:

Ultrasonically assisted filtration should operate at an optimized ultrasonic power level, meaning no more or no less power than is required. If the input power is more than necessary the ultrasonic transducers will produce excessive high thermal dissipation. If the power is insufficient the filter body will not be efficiently cleaned. When an optimal power regime is found the ultrasonic system should not produce overheating. This situation is closely related to the average liquid flow rate and average liquid temperature inside of the filter housing. Normally much of the delivered ultrasonic energy is dissipated and absorbed by the liquid, which passes through the filter housing. To reach the optimum operational conditions the output ultrasonic power and On-Off pulse-repetitive modulations should be carefully chosen and adjusted for every new application.

To better understand operational optimization it is useful to know that ultrasonic transducers are able to produce and accept significantly more power in a short pulse-repetitive regime than when they operate continuously. Therefore On-Off power modulation becomes an important variable and should be carefully adjusted.

In normal applications the operating temperature of the filter system should never exceed 90°C. Temperatures in the range of 40°C to 60°C, or lower, are considered normal and acceptable for a stable and long operating life of the filter. For higher operating temperatures (higher than 100°C), the filter system and ultrasonics require a special design and cooling options to protect the ultrasonic equipment.

In the event of no-liquid or no-flow conditions, the ultrasonic system must be stopped. Continued operation in these state will cause ultrasonic transducer overheating resulting in subsequent inefficient operation or damage to the transducers. Production systems should be equipped with over-temperature and no-liquid-flow protection mechanism that will shut down ultrasonic generator.

Please contact us by email about your standard or special ultrasonic applications.