Zenith Ultrasonic Generator/Tank and Table-top Systems

manufactured by

Zenith Ultrasonics Inc.
P.O. Box 412
85 Oak St.
Norwood, NJ 07648-0412
800-432-SONIC
Fax: 201-768-6999

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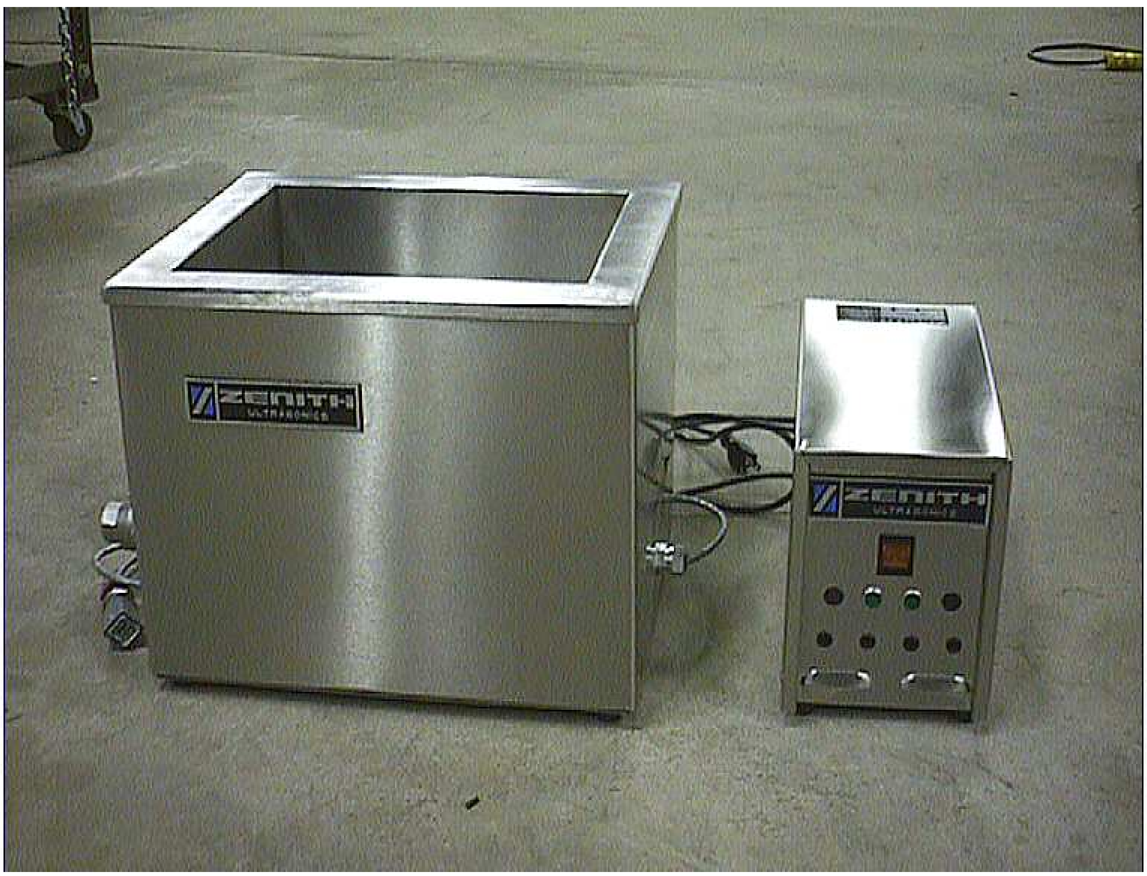
Zenith Ultrasonic Generator/Tank and Table-Top System Instructions

The following manual will provide operating instructions for Zenith's line of Generator/Tank ultrasonic cleaning systems, as well as instructions for the operation of smaller table-top systems, such as the PM line and Z line. A Generator/Tank System is a 2-piece ultrasonic cleaning system, composed of the actual cleaning tank, and a separate ultrasonic generator which connects to the tank with RF shielded cable. The ultrasonic generator is responsible for converting standard electrical current into a frequency and voltage required to properly operate the ultrasonic transducers, the devices on the cleaning tank which covert electrical energy into mechanical vibration. These mechanical vibrations will produce the cleaning effect in the tank. For detailed data regarding the nature and properties of ultrasonic systems, see the "Ultrasonic Tips & Techniques" section of this manual.



Ultrasonic Cleaning Tank (left) and 80Khz OMEGA-HF Generator.

UNPACKING THE SYSTEM:

When the ultrasonic system first arrives, it will be packaged either in a standard shipping carton, or on a cushioned wood pallet, depending on the size of the cleaning system. The system itself will be protected by bubble wrap, stretchwrap protective film, and shipping "peanuts" to ensure safe shipping. However, when the package is first received, note the outer condition of the carton or packaging. If noticeable damage is visible, immediately tell the trucker to make a note of this. If the system is damaged, a claim may be required.

Unpack the system by un-strapping and removing exterior tril-wall cardboard, or removing system from shipping carton. Remove all bubble wrap and stretchwrap films, being careful not to cut into the cleaning system when using knives. Even table-top systems are manufactured with high-polished materials which are easy to clean.

CONNECT GENERATOR TO TANK:

Connect the ultrasonic generator to the cleaning tank once system has been unpacked. A quick-disconnect liquid-tight fitting has been included for connection. Plug male connector into female connector, then use latches to lock connector into place. Male and female connectors can only fit 1 way, no need to worry about proper fitting alignment. **If your systems is a 1-piece table-top cleaning unit, such as a PM-3 or PM-4, this step may not be required**.

CONNECT ELECTRICAL SUPPLY:

Most table-top cleaning systems will utilize 120 volt standard household electrical current, and these systems are equipped with a standard grounded wall plug. NOTE: BE SURE TO UTILIZE THE 3RD GROUNDING PLUG, AS PROPER GROUNDING IS ESSENTIAL FOR PROPER AND SAFE OPERATION OF THIS CLEANING SYSTEM.

Larger generator/tank systems which require excessively high amperage current are usually manufactured using either 220 volt single-phase with neutral, or 220 volt 3-phase with neutral. If other voltages are required, a transformer must be purchased that will convert your facility supply to either of the above voltages. See your serial number plate for details regarding your system. Any of the above listed voltages will typically require hard-wiring at your facility. Installation of electrical supply should be performed by licensed electrical engineers. If hard wiring is required, your system will NOT include any power cable at all. If a 220 volt power cable IS supplied, the system can be plugged into the required female socket with the required voltage, phase, and amperage feed.

FILL CLEANING TANK:

At this time, fill the cleaning tank with the required cleaning agents. MAKE SURE DRAIN VALVE ON THE TANK IS CLOSED. When filling the tank, remember that parts submerged in the tank will displace liquid, thereby raising the liquid level in the tank. The best performance will be achieved by MINIMIZING the liquid quantity in the tank. This will increase the watt-per-liter power density of the cleaning systems. Fill tank with enough liquid to just barely cover your parts.

ACTIVATE CLEANING SYSTEM:

The system is now ready for operation. Activate the START toggle switch located on the ultrasonic generator. The Generator Indicator Lights, green in color and located on the ultrasonic generator control panel, will light up, indicating correct ultrasonic generator operation. A buzzing should be emitted from the cleaning tank, indicating that the sound waves are being generated by the transducers in the tank. The sound may, at first, be rather dull, but will slowly gain in volume and apparent power. This is the process of Ultrasonic Degassing. Every fluid has a certain amount of dissolved gasses in it, which must be removed before correct ultrasonic operation can commence. By running the ultrasonic system, the gasses will be forced out of solution. We suggest that you read the Ultrasonic Tips & Techniques section of this manual for full explanation of all ultrasonic properties which are vital to effective ultrasonic cleaning operations. NOTE: ULTRASONICS REQUIRE THAT AT LEAST 3 " OF LIQUID ALWAYS EXISTS ABOVE THE ULTRASONIC TRANSDUCERS, USUALLY MOUNTED ON THE TANK BOTTOM. RUNNING THE ULTRASONICS DRY WILL PERMANENTLY AND QUICKLY DESTROY THE CLEANING SYSTEM, AND WILL NOT BE COVERED UNDER THE SYSTEM WARRANTEE.

COMMENCE CLEANING OPERATIONS:

Once system is degassed and heated to the appropriate temperatures (if required), parts can be submerged for cleaning operations.

DRAINING THE CLEANING TANK:

Zenith ultrasonic cleaning systems include a nickel-plated or 316L stainless steel ball valve for draining of tanks manually. A switch-controlled drain system, with or without drain pump, may have been included as optional equipment. If so, see the "Switch-Controlled Drain Systems" instruction guide found in this instruction manual.

To drain tanks manually, rotate the drain valve lever arm 90 degrees. If your system was equipped with an optional stainless steel ball valve, the lever will have a locking collar which must be raised in order to rotate the arm.

POWER INTENSITY CONTROLLERS:

Some cleaning systems may include Power Intensity Controls, which provide the ability to reduce ultrasonic power being emitted into the cleaning tank. If this feature was ordered with your cleaning system, the control panel of the Ultrasonic Generator will include 1 small black dial knob for each generator included with the system. If the system has 3 generator indicator lights, 3 such dial controls will exist. To reduce power, simply rotate dial counterclockwise, and rotate clockwise to increase power.

If the generator for your cleaning system is blue painted steel rather than stainless steel, a single power intensity controller will be included, along with an electrical meter. MAKE SURE that the needle on the meter resides just below the redline during normal operation. Fuse may blow if system is operated in red zone.

OTHER SYSTEM SPECIFICATIONS:

Most Zenith ultrasonic generator/tank systems have #4 finished 316L stainless steel tank exteriors with #4 finished 316L stainless steel tank interiors. Ultrasonic generator cabinets are typically #4 polished 316L stainless steel. Plumbing will be manufactured of 316L stainless steel, flexible braided thick-wall CPVC hose (max temp 170 degrees), flexible stainless steel hose, or rigid stainless steel hard plumbing, depending on system purchased and options chosen.

Ultrasonic transducers are piezoelectric variety, and ONLY Natural Frequency, NEVER Frequency Modified. See Tips & Technique for definition of these terms.

Ultrasonic cleaning system may be operated continuously, or intermittently. Switching of system on and off will not affect long-term system reliability. Systems are rated for 24 hour/day operation.

For additional information contact Zenith Ultrasonics at 800-432-SONIC. Our technicians will ensure that you get any information you require.

SYSTEM MAINTENANCE:

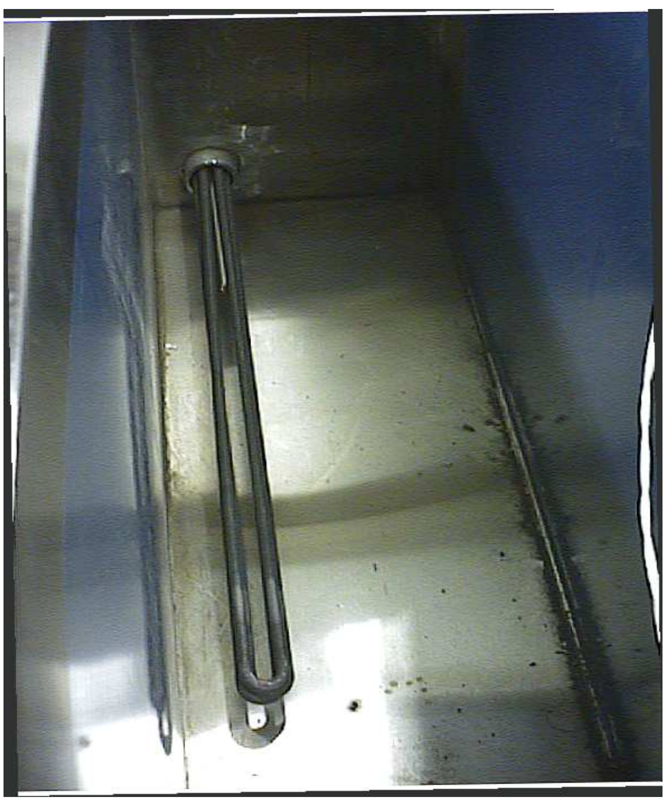
Zenith tabletop ultrasonic cleaning systems require virtually no maintenance at all, other than keeping the cleaning tank and ultrasonic generator as clean as possible. Try to prevent liquids from dripping down the front of the ultrasonic cleaning tank, as this may lead to water entering the bottom of the electronic enclosure of this tank.

When lowering parts into the ultrasonic cleaning tank, try to do so as gently as possible. Dropping heavy objects into the tank may permanently damage ultrasonic transducers which will not be covered under the system warranty

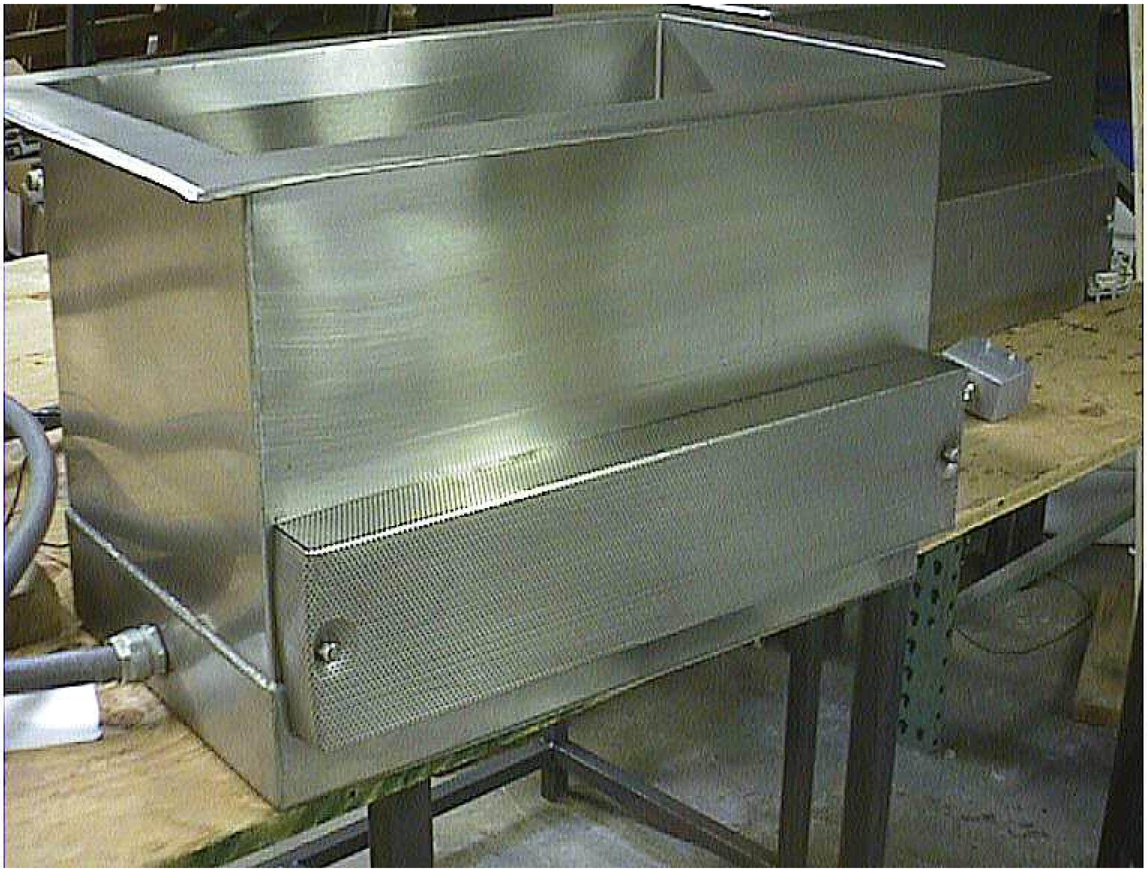
Thermostatically Controlled Heater Systems

Zenith thermostatically controlled heater systems are designed to heat up and maintain elevated cleaning and/or rinsing fluid temperatures. Heater systems are available in a "Heater Bar" variety, where metal heater bars are mounted to the outside wall of the tank, or an "Immersion" variety, where the heater element is actually submerged in the fluid itself. Heater systems are temperature controlled with either a user-programmable digital temperature controller with large digits, or a dial-type mechanical thermostatic control.

There are advantages and disadvantages to each heater type. Immersion heaters are more electrically efficient, since the element itself actually resides in the fluid itself. Bar heater systems must first heat the wall of the tank before the energy is transferred into the fluid. However, since bar heaters are mounted to the outside wall of the tank, the inner tank can remain smooth with no protruding heater elements which may trap dirt or contamination. This is an important consideration for semiconductor or other ultracritical cleaning applications where minimization of trapped contaminants is preferred. Smaller tank designs will also typically include the heater bar system, since heater bars are available in smaller watt increments to heat these tanks.



Immersion Heater Bars Extend Into Tank to Heat Fluids



Bar Heater Unit Mounted to Outside of Tank Keeps Tank Interior Smooth.

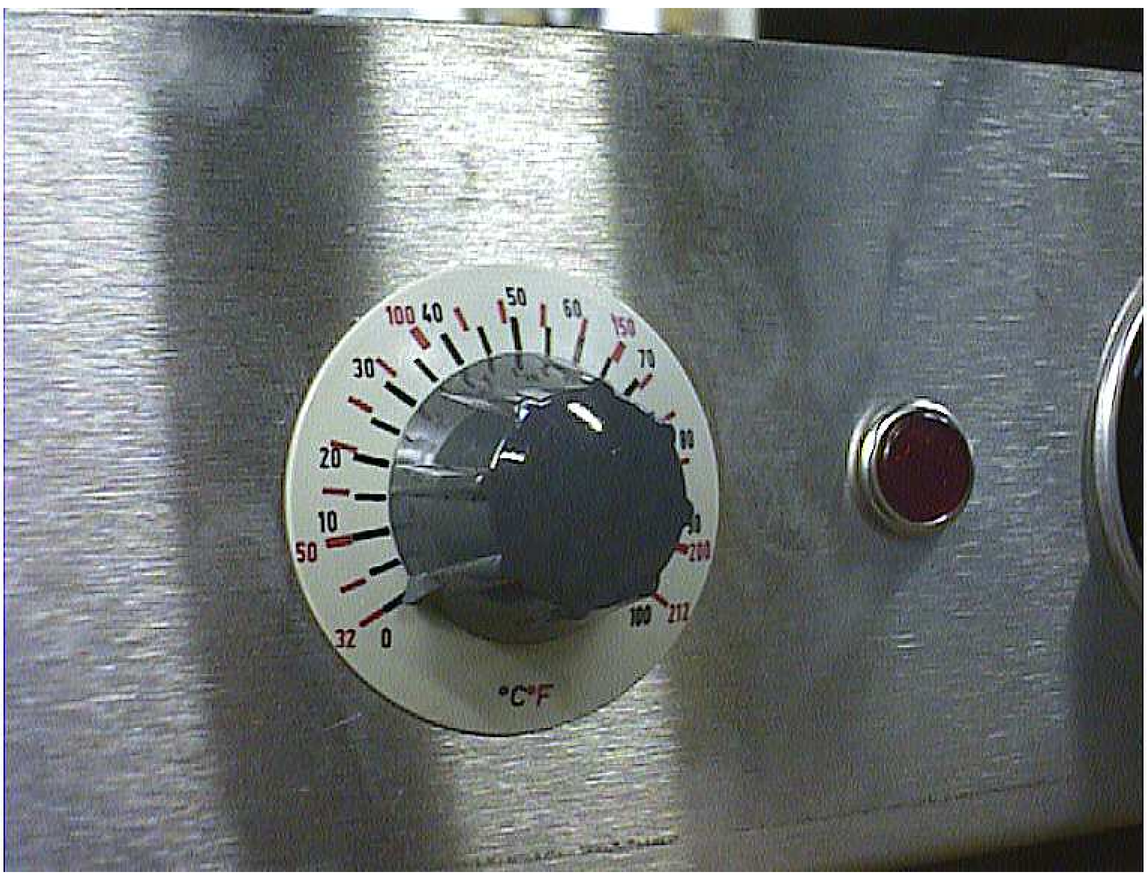
Zenith typically mounts its immersion heater elements in a "heater cove," a small recessed tank area in which the heater element resides. By incorporating this heater cove design, no basket or part interferences will take place, since the heater element is off to the side where it can not interfere. Heater bars in bar system designs are mounted nearest to the bottom of the tank as possible. IT IS CRITICAL THAT EITHER THE HEATER BARS OR IMMERSION HEATER ELEMENTS BE ALWAYS IN CONTACT WITH LIQUID TO PREVENT THEM FROM BURNING OUT. Heater systems ALWAYS require that the heater elements be submerged, or in contact with liquid. If liquid is not present, the heater bar will overheat, and the elements destroyed in a matter of minutes. HEATER BURN-OUT IS NOT COVERED UNDER YOUR WARRANTY. Ensure that the tank is always filled with enough liquid to submerge the heater elements, or cover the tank area where the heater bars are mounted. **Typically, smaller tanks will require least 5" of liquid, while larger tanks may require at least 10" of liquid to ensure that the at heaters do not burn out**. Those with smaller depths should be always filled to operating level, 1” from the top of the tank.

ACTIVATING THE HEATER SYSTEM :

All Zenith heater systems include a control panel switch to activate the heater system. Locate the switch or switches on the control panel marked "heater". Heaters may include Clean Heat, Rinse Heat, Rust Prev. Heat, or other, depending on the type of system purchased. To activate the heater system, simple turn on the control panel switch. Smaller Zenith systems will have a lighted rocker switch, while larger systems may include oil-tight NEMA 4X switches for heater activation.

USING DIAL THERMOSTATIC CONTROLS

The dial-type thermostatic control is typically installed on small table-top cleaning systems. To operate, simply rotate the dial of the control until the arrow is at your setpoint temperature. The heater system will now turn on and off, maintaining your setpoint temperature to +- 5 degrees Fahrenheit. The dial-type controller WILL NOT indicate the current temperature of the fluid being monitored. However, a close approximation can be established by rotating the thermostatic control back and forth until a faint click is heard. As soon as the thermostat clicks, stop it in position and read the temperature that the arrow points to on the dial. This is the current fluid temperature.



Dial Thermostat Control with Indicator Light

USING THE DIGITAL TEMPERATURE CONTROLLER

Larger Zenith systems, or high-grade smaller systems, may include the large-digit digital temperature controller for controlling the heating system. This controller is significantly more accurate than the dial-type system, and will provide operators with a digital read-out of the current fluid temperature at all times. The controller will activate upon activation of the heater system. A few seconds after the controller turns on, the current fluid temperature reading will be displayed. To set the controller's setpoint temperature, push the “*” button once. The display will depict the setpoint followed by the letters “SP”, indicating that this is the current set-point value. To change set-points, use the arrow keys to adjust the value. Once you are finished adjusting the value, press the “*” button again to display the current bath temperature. As the heater system turns on and off, an audible clicking of the control relay will be heard. Also, if the heater is currently being activated, a small green dot labeled “K1” will be lit up. As soon as power is cut to the heater, this light will deactivate.

This digital temperature controller is capable of performing complex temperature monitoring procedures.

NOTE: TURN OFF HEATING SYSTEM AND WAIT FOR 10-15 MINUTES BEFORE DRAINING TO AVOID HEATER SYSTEM DAMAGE NOT COVERED UNDER THE WARRANTEE.

NOTE: ULTRASONIC ACTIVITY WILL PRODUCE FALSE READING ON DIGITAL TEMPERATURE CONTROLLER. The vibration created by ultrasonic activity will increase reading on temperature controller by up to 10 degrees F. Temperature should be measured with ultrasonics OFF.

NOTE: MAXIMUM TEMPERATURE ON ALL ZENITH ULTRASONIC SYSTEMS IS 175 DEGREES FAHRENHEIT UNLESS OTHERWISE NOTED. Setting the temperature too high may permanently damage the ultrasonic system by depolarizing the ultrasonic transducers.

NOTE: Maximum ultrasonic cleaning effects with water-based cleaning agents takes place at a fluid temperature of 140 degrees Fahrenheit. See the Ultrasonic Cleaning section for more details.

NOTE: The digital temperature controller includes a NEMA 4X seal. The dial thermostat seal is not NEMA rated.

NOTE: In some cases, the dial-type thermostat may reside on the immersion heater unit itself. If this is the case, the heater should be externally visible, with the thermostat dial directly attached to the heater. Operate this dial thermostat identically to the standard control panel dial-type thermostat previously described.

NOTE: Over time, immersion heater elements may become covered with particulates and debris which should be periodically removed to eliminate energy losses.

NOTE: WE CANNOT EMPHASIZE ENOUGH THE IMPORTANCE OF KEEPING HEATER ELEMENTS COVERED WITH LIQUID. If you are not sure exactly where heater bars may be mounted, remove the outer access panels or skirt of the system to expose the outer wall of the tank. Heater bar mounting locations will then easily be seen. Immersion heater elements can be seen inside of the cleaning tank. Both must always be covered in liquid to prevent permanent damage to the heater system.

NOTE: Dryer tanks will include the same digital temperature controller to keep operating temperature of drying tank constant at set-point temperature. To activate a dryer tank, turn on the DRYER TANK switch, then follow these instructions to set the digital temperature controller. Drying tanks have maximum operating temperature of 225 degrees F. If higher-temp insulation is used, higher temperatures are obtainable.

Ultrasonic Timer Instructions

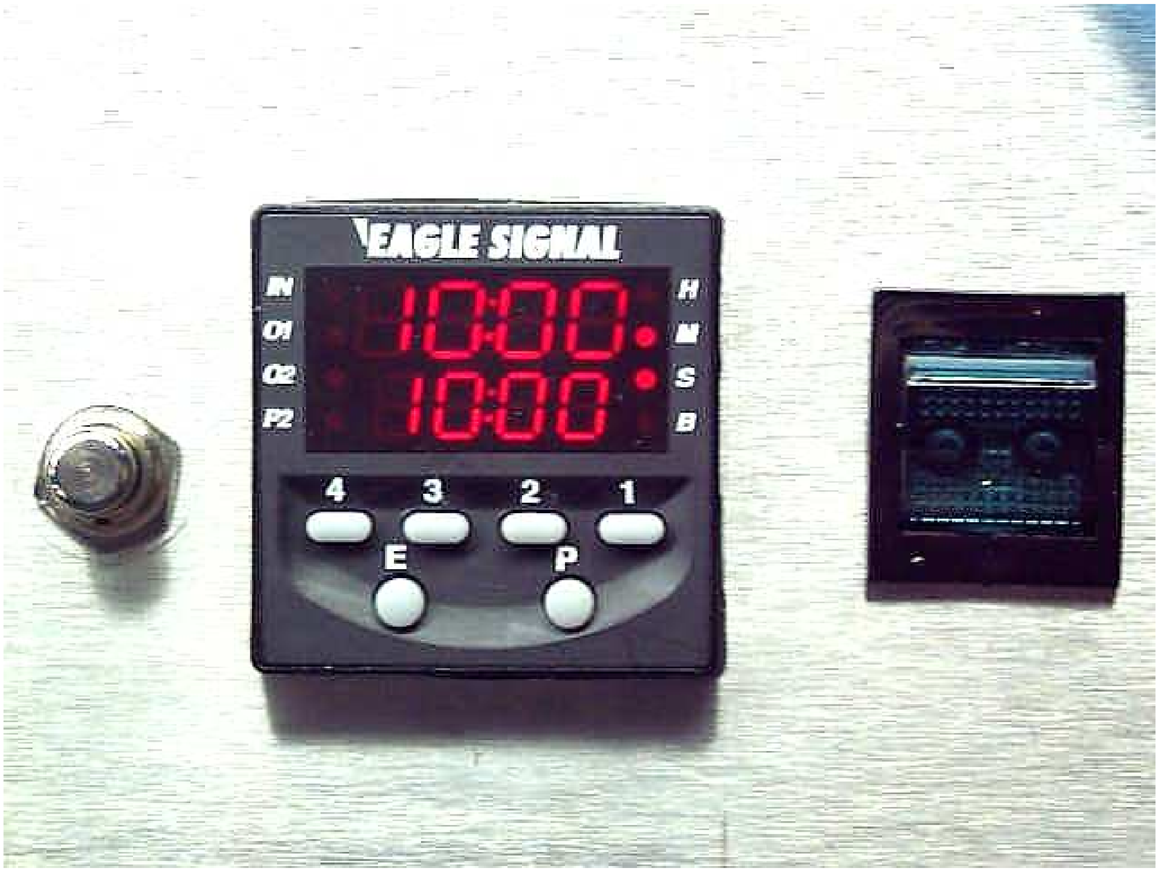
Zenith ultrasonic cleaning systems are available with ultrasonic timer controls which control the duration of the ultrasonic cleaning cycle, or other devices. 2 types of timers are available; backlit LCD digital timers with ranges from 24 hours to .1 seconds, and 0-30 minute dial-type mechanical timers, typically used with small table-top cleaning systems. This instruction sheet will describe the operation of both timers.

MECHANICAL TIMER INSTRUCTIONS:

Zenith table-top cleaning systems may include a mechanical timer with 0-30 minute range. To operate this timer, turn OFF the ultrasonic switch on the control panel of the cleaning system, rotate the dial past 5 minutes and set the dial to the desired value. The timer will count down to zero-at which time the ultrasonic system will shut off. The Zenith PM series of cleaning systems typically includes mechanical timers.

DIGITAL TIMER INSTRUCTIONS:

The digital timer installed with Zenith equipment has many capabilities and functions, most of which you will never have to utilize. In most cases, only simple timer functions will be required.



The digital timer is a black device that will be mounted to the control panel, and will have a digital backlit LED display. The large red on top of the smaller numerals in the center of the display represents the timer current value, while the smaller numerals at the bottom of the display represents the current set-point of the timer.

Buttons numbered 1-4 are typically used to change timer current values. This timer has a maximum 4-digit display, and each button represents one of the digits that can be programmed. Each time one of these buttons is depressed, the value of that digit will decrease by 1. To see how this works first hand, press one of the buttons, and see the setpoint value change on the display. After changing the setpoint value, press BOTH the “E” and “P” buttons simultaneously to enter the new value into the timer. After performing this operation, both the setpoint, and current values on the display should be the same.

The timer has been factory set to operate in minutes and seconds. A maximum value of 99 minutes and 99 seconds can be programmed. However, should you need to increase the range of the timer, you can program the timer to operate in hours and minutes. To do this, press AND HOLD the “P” button on the timer, until the display shows strange letters, indicating that you have entered the programming mode. Then, press the “P” button until the display reads “TRN1.” Once this occurs, press the “E” button, and notice that the small dots on the right side of the display move. You will need to move the dots to the “H” on the timer to set it to hours. Once this is complete, press AND HOLD the “P” button until the display shows numerical values again.

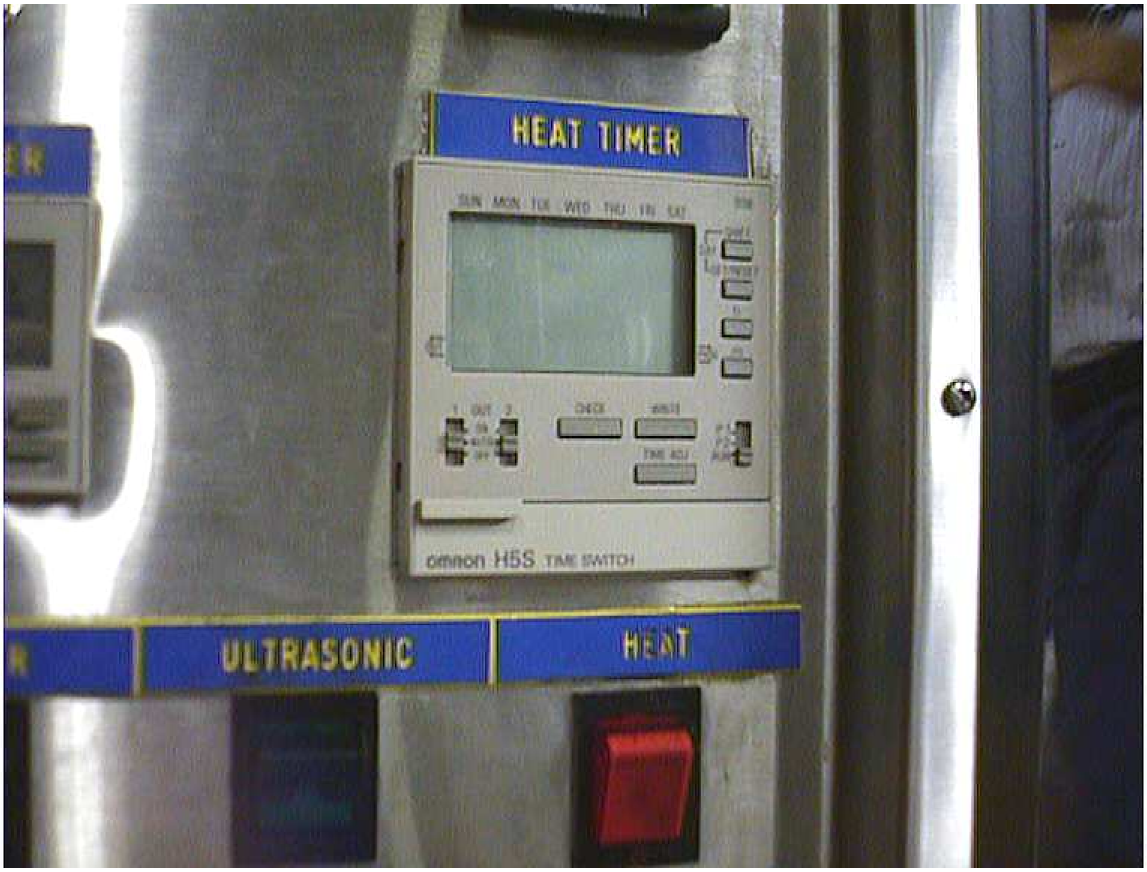
OPERATING THE DIGITAL TIMER:

Operation of the digital timer is very easy. Although this timer has many auxiliary functions, most operators use simple timing functions, which will be described herein.

STEP #1: Set Timer Setpoint Value: Using buttons 1-4, change the timer setpoint value as earlier described. As the buttons are pressed, notice the timer value changing (small digits at display bottom represent setpoint values). Once you have entered the number, press BOTH the “P” and “E” buttons simultaneously to enter the value into the timer.

STEP #2: **Press START Button**: Timer is now ready for operation. Press the START button to activate the timer, which is the small silver pushbutton switch located directly next to the timer. Ultrasonics will immediately activate, current timer value will begin to count up or down depending on set-up, and will shut off once timer current value reaches set-point value. NOTE: If ultrasonic system fails to shut off once timer reaches set-point, turn off manual ultrasonic switch, a small rocker switch near the ultrasonic timer. Leaving the manual switch turned ON overrides timer function, and system will stay on until switch is turned off. REMEMBER, TIMER WILL NOT WORK PROPERLY UNLESS MANUAL ULTRASONIC SWITCH IS OFF!!

7-DAY TIMER OPERATIONS:



If you ordered the 7-day timer option, this system will allow you to activate and de-activate the heating system at any time of any day. A separate instruction booklet has been included in the front of this manual that will provide the instructions for setting both the time of day, as well as programming the activation and de-activation cycles.

CROSSFIRE Multiple Frequency Ultrasonics

If you ordered your system equipped with CROSSFIRE Multiple Frequency Ultrasonics, you have purchased the ultimate in ultrasonic cleaning technology. CROSSFIRE systems (patent #5,865,199 and 6,019,852) is Zenith's latest development in ultrasonic systems, and actually combines 2 or more frequencies to provide true multi-frequency cleaning performance.

CROSSFIRE was originally developed to address applications which have contaminants with highly varied particle sizes, and for parts having both simple, and complex design elements on the same part. Since elevated frequencies are better capable to enter small, recessed, or blind part areas, these frequencies are typically included. A lower frequency is also included to address less complicated areas on the parts, as well as heavy industrial grade contamination.

The frequencies which have been installed in your ultrasonic cleaning system have been selected based on the part design, the contaminant in question, the detergents used, and the part's sensitivity to damage by Cavitational Erosion (see description in Ultrasonic Tips and Techniques).

Semiconductor and other sensitive cleaning applications may include combinations of 80Khz and 120Khz. Even higher combinations are used, since these applications include parts that are HIGHLY SENSITIVE to erosion by the ultrasonic cavitation. Industrial applications may include a 25Khz/40Khz or 40Khz/80Khz combination. These lower frequencies are more applicable to the industrial-grade contamination seen in these applications. Also, by including a high-frequency, such as 80Khz, to a 40Khz system, the gaps produced by the standing waves of the 40Khz transducers are effectively filled by the standing waves of the 80Khz system (see Ultrasonic Tips and Techniques). This produces a cleaning action which has virtually no dead spots, and all tank areas will provide evenly-distributed ultrasonic cleaning action.

In some cases, 3 frequencies may be included. These systems are almost always used by high-end semiconductor-related manufacturers which require absolute, zero-residue cleaning performance, with highly varied particle sizes.

The CROSSFIRE system is not just a theoretical calculation of possible frequencies produced. Transducers of differing frequencies are mounted side-by-side, and staggered evenly ON THE SAME TANK SIDE OR IMMERSIBLE SURFACE. This provides true, multiple frequency operation. For best performance, keep parts positioned at least 2 inches above the radiating surface of the transducers, typically the tank bottom.

OPERATIONAL INSTRUCTIONS:

Typically, all transducers, regardless of frequency, will operate simultaneously in a typical CROSSFIRE system. When the switch is turned on, all transducers will emit their individual frequencies into the tank. However, if you have ordered a Frequency Selection Switch, you can operate each frequency independently, or simultaneously. These systems include a 3-position rocker switch. At the center position, all frequencies operate simultaneously. If you wish to operate only a given frequency, move the selector switch to whichever frequency you wish. You will notice a change in the activity in the cleaning tank, and a LOSS OF POWER when operating only 1 frequency, since only a fraction of the transducers is operating. Keep this in mind when performing studies of any kind. Frequency Selection Switches are only included on systems designed for laboratory-grade testing, or customers who simply wish to view the different frequencies operating independently.

Ultrasonic System Tips & Techniques

Although ultrasonic cleaning, in application, is rather simple (introduction of sound waves into a fluid), the actual use of a complex ultrasonic cleaning system can be quite a challenge. A basic understanding of ultrasonic theory is required to fully comprehend the benefits, and limitations, of today's ultrasonic cleaning system.

ULTRASONIC SYSTEM COMPONENTS:

All ultrasonic cleaning systems are composed of transducers (devices attached to tank which emit ultrasonic sound waves), and ultrasonic generators (device which converts 60hz standard electrical cycles to required transducer operating frequency). Both components are required to produce an ultrasonic cleaning system. Transducers utilized at Zenith are piezoelectric variety, with over 97% electrical operating efficiency (over 97% of energy is actually utilized by the ultrasonic transducers, with only 3% loss). Other transducer types, such as Magnetostrictive Transducers (transducers which are essentially electromagnets rather than a ceramic crystal) have only 50-60% electrical efficiency, since much energy is lost in the form of heat. Magneto systems are also frequency-limited, and can only produce a 30Khz frequency output and lower in operating frequency. As a result, Zenith systems utilize only high-efficiency piezoelectric transducers for maximum electrical and cleaning efficiency .

Transducers are mounted either to the bottom of the tank (usually with small table-top systems) or in sealed stainless steel boxes which are mounted to the tank bottom or side walls, known as Immersible Transducer packs. Immersibles will produce a more powerful cleaning output, since the energy must first pass through the liquid before being used to vibrate the tank assembly and other components. Immersibles are also easier to replace in case of failure. If a transducer pack fails, remove the pack and send to Zenith for fast repair. The cleaning system can still be used on-site.

ULTRASONIC THEORY:

Ultrasonic cleaning action is produced when high-frequency sound waves are introduced into a cleaning fluid, thereby producing a physical effect known as Ultrasonic Cavitation. Cavitation is the formation and immediate collapse and subsequent implosion of microscopic bubbles in a fluid which serve to gently remove contaminants such as oil, coolants, fingerprints, particles, rust, and virtually any industrial or contaminant found. Ultrasonic cavitation, being composed of ultra-small bubbles called "*cavities*", can clean part areas which can not be cleaned by any other mechanical method. Fine crevices, blind holes smaller than a single human hair, and even the smallest surface scratches and imperfections, can be cleaned ultrasonically better than by any other known cleaning method.

Ultrasonic cleaning tanks are usually composed of a stainless steel cleaning tank, and a series of Ultrasonic Transducers which are mounted either to the bottom of the cleaning tank, or in hermetically sealed stainless steel boxes which are mounted in the tank, known as Immersible Transducer Banks. When electrically activated, ultrasonic transducers turn electrical energy into mechanical vibration by rapidly expanding and contracting at a given frequency. This vibration of the transducers sends sonic waves into the cleaning tank, in the form of compression cycles and expansion cycles.

When the transducers expand, they push outwards against the tank wall to which it is mounted. The wall of the tank to which the transducer is mounted is called the diaphragm. When the wall is pushed inward, the fluid in the tank is momentarily compressed. A split second later, the transducer contracts, pulling the wall outwards, thereby momentarily pulling the liquid apart. If enough energy exists to overcome the forces holding the fluid molecules together (known as tensile strength), a rip is created in the fluid matrix. This rip, or "bubble" is known as a cavity. The cavity grows in size for as long as the expansion cycle acts upon the fluid. It is important to understand and remember this fact.

At a certain point in time, the expansion cycle converts to the compression portion of the sound wave. Suddenly and violently, the energy that created the cavity reverses energy direction. The side of the cavity facing the transducers collapses inwardly, creating a microscopic jet of liquid which has been theorized to travel at speeds exceeding 400 km/hr. Pressure in the cavity builds so rapidly and so greatly that the temperature inside of the cavity has been theorized to reach temperatures exceeding 5000 degrees Celcius, hotter than the temperature of the sun's surface. It is this jet of liquid which is primarily responsible for the cleaning action produced by the ultrasonic cleaning system. Millions of cavities are produced every micro-second, which essentially cover and gently scour parts which are submerged in the fluid. Reflection of energy throughout the tank creates an environment where cavitation is multi-directional, and able to clean sides and top of parts, although the transducers are mounted on the tank bottom.

Being very small in size, cavities have the capability to reach inside the smallest most detailed part areas, and clean very gently. Even the most sensitive semiconductor components can be ultrasonically cleaned without damage. Although the cavities reach excessively high temperatures, the heat produced by the cavitation is quickly neutralized by the significantly cooler surrounding liquid. Flammable solvents, such as acetone, mineral spirits, alcohol, and others, can be safely used with ultrasonics as a result.

ULTRASONICS ARE DIRECTIONAL

It is important to understand the directionality of the ultrasonic energy output. Most of the scrubbing action produced by the cavities is produced in the direction of transducer diaphragm movement during the compression cycle. If transducers are mounted on the tank bottom, the diaphragm moves upward and downward during the sound cycles, but upward during the compression cycles. This causes the underside of the cavities to implode in an upward direction. Therefore the scrubbing action will be most powerful on the side of the part which directly faces the ultrasonic transducers. If transducers are mounted to the side of the tank, the side of the part which faces the transducers receives the most powerful scrubbing action. The only cavitation produced in other directions is created by reflections of the sonic energy from the side walls of the tank, the surface of the fluid, and reflections off of the parts submerged in the fluid. Therefore, when cleaning ultrasonically, make sure the most critical side of the part always faces the ultrasonic transducers. This may require special fixturing, but maximizes the chances of cleaning success.

ULTRASONIC SHADOWING & TRANSFERENCE

Ultrasonic Shadowing and Ultrasonic Transference are 2 other very important properties of ultrasonic cleaning to understand. All parts regardless of shape, design, or material of construction, will absorb part or all of the available ultrasonic energy being emitted from the transducer diaphragm. Parts which are thin, metallic, and high-density, will tend to absorb little energy, while large, heavy, or low density parts, will absorb most or all of the ultrasonic energy. Therefore, parts directly above the first layer of parts will ALWAYS receive less ultrasonic cleaning action, since the first layer of parts has shadowed the ultrasonic energy from reaching the 2nd part layer. The thinner parts transferred most of the energy, allowing much of the energy to reach the 2nd part layer.

Ultrasonic Transference can be most easily visualized by ultrasonically activating a smaller non-ultrasonic tank through simple liquid contact. Fill a small, thin walled metallic vessel with cleaning fluid, and lower the vessel into a cleaning fluid bath which is ultrasonically activated. The moment that the bottom of the vessel touches the liquid surface, the ultrasonic action will transfer into the vessel, and provide a true ultrasonic cleaning bath in the small vessel. This technique can be used to clean items in cleaning fluids other than the fluid in the larger ultrasonic cleaning tank. The thinner the wall of the tank, and the more dense the material, the more energy will be transferred into the small vessel. Now, place a plastic, or cloth object, at the bottom of the small vessel and try the same technique. You will find little or no ultrasonic action in the small vessel. The low-density plastic or cloth shadowed the ultrasonics, and prevented any action above their surfaces. This does not automatically conclude that the parts above the low-density parts will not be cleaned. It is possible that enough energy passes through to remove the contaminant in questions, especially low bond strength contaminants such as oil or coolant. Therefore, parts being ultrasonically cleaned should have critical areas facing the transducers, and will be best cleaned in single-layers to prevent shadowing.

DEGASSING OF CLEANING FLUIDS

The principle of degassing is another important property of ultrasonic cleaning. Degassing is the removal of dissolved gasses usually present in most fresh batches of cleaning fluid, or the removal of gas bubbles which are trapped in blind holes or other detailed part areas. Ultrasonic cavitation can not take place effectively when excessive amounts of dissolved gasses are present in the fluid, since they are relatively flexible and absorb all of the ultrasonic energy. Ultrasonic systems with frequencies of 40Khz and lower must typically be run for 15-30 minutes before cavitation will be maximized. The ultrasonics will slowly force the absorbed gasses out of solution during this period, and maximum ultrasonic energy will be available.

High-frequency ultrasonics above 80Khz will be capable of degassing the cleaning fluid much faster, less than 5 minutes in most cases. Water without a detergent will require much greater degassing periods, with the best activity available after 1 hour of operation. This improved degassing property of high-frequency ultrasonic systems is a direct result of the number of cavities produced in a given time period, as well as the distribution of these cavities. All ultrasonic systems, regardless of frequency or manufacturer, produce a cleaning pattern which is composed of a series of horizontal bands of active cavitation. These bands of energy are known as Standing Waves, and are an inevitable result of ultrasonic cleaning. The area of fluid between these bands is relatively inactive, producing little if any useable cleaning energy. The higher the ultrasonic operating frequency, the closer the standing waves will be to one another, with less dead space inbetween. High frequency systems produce a more even, more consistent cleaning result. However, high frequency sonics produce a more gentle cleaning action as well, since the same amount of input energy is distributed among a greater number of standing waves. For example, an 80Khz ultrasonic system produces double the standing waves of a 40Khz system. However, since the same amount of energy is being provided, the cavitational energy at any one level is roughly 1/2 that of the 40Khz system. This is an important fact. As a result, low frequency systems are used when more powerful cleaning action is required. However, since the energy is less evenly distributed, the system may not consistently clean detailed or critical part areas. It is also important to remember that, with an exceptional cleaning fluid, a high frequency system may be perfectly capable of removing stubborn contaminants. If the fluid is capable of loosening the contaminant-to-part bond to a degree that the available ultrasonic energy can dislodge it, the cleaning process will be successful. High frequency systems, due to their less aggressive cavitational action, is the preferred choice when cleaning sensitive parts which may be damaged by the ultrasonic cavitation. As a guideline, 25Khz ultrasonic systems produce standing waves which are roughly 1" apart. Every 1" starting at the tank bottom, an active 1/8" thick cleaning layer will be present, with little action in between. 40Khz systems will have 1/2" spacing between standing waves, while 80Khz systems will have roughly 1/4" standing wave bands. To overcome even the small 1/4" spacing on the OMEGA-HF cleaning system, Zenith incorporated a Zenith-exclusive "Capacitive Discharge" ultrasonic generator, which produces numerous sub-harmonic frequencies which completely fill the void between standing waves.

Gasses which are trapped in inner part areas or blind holes whill prevent effective cleaning in the areas in which they are trapped. If your parts have blind holes or areas which have the potential to trap gasses when submerged, position the part to release the gases from these areas during the cleaning process.

Tanks with large fluid volumes will take longer to degas, since these systems typically have lower watt/liter power densities. Certain cleaning fluids with excessively low tensile strength may also not be well suited to ultrasonic cleaning. These fluids continuosly produce bubbles from the diaphragm which impedes ultrasonic cleaning action. Most cavities produced in these fluids never implode, but rather remain in the form of a bubble which rises to the fluid surface. Cleaning fluids with extremely high tensile strength, such as Deionized Water, may never produce any cavities at all, since the available energy can not overcome the tensile strength of the fluid. It is important to use cleaning fluids with the proper tensile strength to promote ultrasonic cavitation. Most aqueous cleaning fluid will cavitate well, while solvents have a more difficult time. However, the solvent nature of these fluids may well overcome this by being more effective at dissolving the contaminant in question. Remember, an effective cleaning process requires both a cleaning agent capable of dissolving the contaminant, as well as a mechnical scrubbing action to remove the loosened contaminant. BOTH are required for effective cleaning. For example, imagine trying to remove dry paint from a surface using a soft brush and water. The paint will not budge. However, using an effective solvent, or a wire brush, the paint can easily be removed. The same principle applies to ultrasonic cleaning.

CAVITATIONAL EROSION

Cavitational Erosion is yet another property of ultrasonic cleaning. Ultrasonic Cavitation is the erosion of material from parts being cleaned, or the very cleaning tank itself, by the ultrasonic cavitation itself. Cavitation, as gentle as it is, is capable of flipping away molecules of material, especially those which are exposed for long periods of time. The ultrasonic cleaning tank itself will erode gradually over time. The lower the ultrasonic frequency, the faster the erosion will occur. Low-frequency cleaning tanks manufactured of stainless steel will eventually be covered with small pinholes, especially the ultrasonic diaphragm. Erosion will first appear as a dull grey area on the transducer diaphragm. Over time, the grey areas will darken, and holes will develop. In most cases, low-frequency ultrasonic transducer diaphragms must be replaced long before the ultrasonic system fails. Erosion of the tank and diaphragm may be completely prevented by a hard chrome plating. Electropolished tanks will show cavitational erosion in only a few hours, since the ultra-smooth polished surface is quickly dulled by the ultrasonic action. Cavitational erosion may also damage sensitive components. Systems used for such parts are typically composed of high-frequency ultrasonics with power intensity controls to allow the operator to dial down the ultrasonic energy to a level where damage is no longer produced.

ULTRASONIC NOISE

Noise is another property associated with ultrasonic cleaning systems. Since sound waves are being used to produce mechanical action, audible noise will be produced to some degree. The lower the operating frequency, the louder, more annoying, the noise will be. Low frequency sonics, being closer to the audible human hearing range, will naturally be louder. 20-25Khz systems sound like a high-pitched dog whistle, and require external insulation or hearing protection in many cases for OSHA approved operation.

High-frequency systems, such as the Zenith OMEGA-HF 80Khz system, produce a quiet, gentle, buzzing sound which is much more comfortable to work with.

TEMPERATURE TIPS

Excessive cleaning fluid temperature can either improve, or destroy, ultrasonic cleaning action. All aqueous cleaning fluids, especially acids, will greatly improve in performance when heated. Most cleaning processes utilize fluid temperatures of 130-160 degrees in the cleaning tank. When cleaning fluid temperatures are raised above 150 degrees, ultrasonic cleaning action begins to deteriorate. This was confirmed by a Zenith/NASA study in the late 1980's, when a cleaning system was being developed for space shuttle valve cleaning. When fluid temperature gets close to its boiling point, the cavities which are created quickly become filled with fluid vapor, which cushions the implosion of the cavity. Therefore, when possible, keep fluid temperatures of aqueous cleaning agents between 130-160 degrees for best ultrasonic action. It is also important to understand that the cleaning fluid used in ultrasonic cleaning systems will gradually increase in temperature through the cavitational action. Temperatures up to 120 degrees Fahrenheit can be achieved without heating systems in a few hour's time, especially with high-powered systems. If flammable solvents are being used as the cleaning fluid, the system may require a Water Jacket (jacket around tank through which cool water circulates to keep fluid cool) to ensure that fluids do not approach flash point. **NOTE: System should not be heated above 190 degrees, as this will reduce the expected life of the ultrasonic transducers, which may not be covered under system warrantee.**

SWEEP FREQUENCY CIRCUITS

All Zenith ultrasonic systems are equipped with a Sweep Frequency Circuit. This circuit is designed to sweep the ultrasonic generator frequency a few kilohertz above and below the actual transducer operating frequency. This circuit is perhaps the most misunderstood, and over advertised device on the market today. By sweeping the generator output frequency, the position of the standing wave is slightly moved. In theory, the principle sounds valid. However, in actual practice, its level of effectiveness is rather insignificant, and greatly inflated by most Zenith competitors. Claims are made that sweep frequency circuits totally eliminate the dead space between standing waves. This was, and still is, being heavily promoted in the industry. However, the fact is, the sweep circuit does little more that move the standing wave just enough to be visible with the naked eye.

Sweep Circuits are limited by the transducers they are attached to. Transducers are somewhat like a tuning fork; a given size and mass tuning fork will only produce sound at a certain frequency. The same applies to transducers. Transducers only operate at a given operating frequency, and fail to operate once the input frequency falls + or - 4 khz. Therefore, a 40Khz system can only be swept from 37 to 43Khz. This change is simply too small to eliminate the 1/2" dead zone between standing wave bands. This can easily be proven with the Zenith Ultraprobe test instrument, a device which visually displays the mechanical scrubbing action produced by any ultrasonic cleaning system. When a sweep frequency is applied, the standing waves just barely move enough to be visible, with the same dead zone space between. The only benefit that the sweep frequency will provide is when cleaning sensitive components. By moving standing wave bands even this small amount (about 25/1000ths" with a 4Khz sweep), damage produced by erosion will be less, since the energy band is ever-so-slightly moved rather than being positioned on the same spot for the entire duration of the cleaning cycle. However, this is the ONLY benefit this circuit produces.

MECHANICAL AGITATION

Mechanical agitation of parts being cleaned in an ultrasonic cleaning system will aid in the removal of contaminants. Ultrasonic cavitation tends to gently break contaminants from part surfaces, but it does not blast the contaminant away from the part. Contaminants remain in close proximity, and, although loosened, may be trapped in detailed part areas. By moving the parts intermittently, the fluid is flushed though all part areas, removing the contamination from part areas which tend to trap contaminants. However, keep in mind that the movement of cleaning fluid in a low-frequency system may produce extremely loud annoying noise which is very uncomfortable. The noise will continue until the fluid motion has stopped. Therefore, when agitating parts with low frequency systems, turn the ultrasonics off momentarily and allow the fluid to settle before reactivating.

The best reason to intermittently agitate parts during ultrasonic cleaning is the more evenly distribute the ultrasonic energy across the part. Ultrasonic cleaning systems, regarding of frequency or manufacturer, produce a cleaning pattern which is rather unevenly distributed. This can easily be proven using a simple Aluminum Foil Test, where a strip of over-the-counter aluminum foil is lowered into the ultrasonic bath for 30-60 seconds. Hold the foil very steadily, just as your part would be if resting stationary in the tank. After the time period has elapsed, view the foil against a backlight. You will notice that there are areas that have very high power, where holes are punched through the foil, and areas with almost no activity whatsoever. This pattern will change with cleaning fluids, concentration of detergent, and fluid level in the cleaning tank. The pattern will certainly change when a part is introduced.

By mechanically agitating parts during ultrasonic cleaning, parts are scanned past areas of high energy to provide of more evenly cleaned part. This is similar to a turntable in a microwave oven. By rotating the food past high energy areas, the material is more evenly heated. When performing some cleaning, try agitating parts intermittently, and see how drastic an improvement is produced.

FLUID MOTION

Excessive fluid motion will completely destroy all ultrasonic cleaning activity. This is important to remember when incorporating filtration systems in an ultrasonic cleaning tank. If the filtration system must operate during the ultrasonic cleaning cycle, the flow rate must be dialed down to levels where no interference is produced. The lower the operating frequency, the slower the flowrate of the filtration system should be. Zenith filtration systems utilize a magnetic-drive pump and flow control valve to allow precise flow rate control. If at all possible, run the filtration system between cleaning cycles to maximize cleaning activity. When utilizing agitation as previously described, move parts slowly to avoid excessive disturbance of fluids, as well as the introduction of gasses.

PARTS BASKET DESIGNS:

BASKETS SHOULD ALWAYS BE USED WITH ULTRASONIC SYSTEMS!!! It is very important that parts not be allowed to rest directly on the bottom of your ultrasonic cleaning tank. In doing so, not only do you risk damage to your parts, but also reduce the ultrasonic power in the cleaning tank.

The Ultrasonic Transducers which are responsible for emitting energy into the cleaning tank are mounted to the tank bottom. By placing parts on the bottom of the tank, the vibrations being emitted by the ultrasonic transducers is reduced, even fully eliminated with heavy items. Use baskets specifically designed for use with ultrasonic cleaning systems, those that support the load on the outside of the basket. This allows the bottom of the tank to vibrate freely.

Baskets should be constructed of stainless steel wire cloth. Open area on the wire cloth should be as large as possible. Parts fixtures can also be manufactured using stainless steel rod. In every case, remember to keep the mass of the basket or fixture as low as possible, as any added mass will reduce the available ultrasonic power in the cleaning tank.

PERFORMING CLEANING EVALUATIONS

In many cases, new purchasers of ultrasonic cleaning equipment have no idea where to begin, having never used an ultrasonic cleaning system previously. In these cases, you must perform basic cleaning evaluation testing prior to ultrasonic system use to ensure effective cleaning results are obtained.

Your cleaning system has most likely been manufactured for use with aqueous (water-based) cleaning detergents. Aqueous cleaning fluids are usually composed of a detergent concentrate, either acidic, caustic, or neutral in pH, and water. Detergents are mixed with water at a given concentration to produce a working cleaning fluid. Acidic-based cleaning fluids are typically used for removal of heavy contamination such as rust, burned carbon, and similar contaminants. Caustic or Alkaline cleaning agents are typically used to remove other contaminants, such as oils, coolants, particulates, and other similar contaminants. Part composition will play a great role in determining which cleaning agents to use. Aluminum parts, for example, are sensitive, and can be attacked by both alkaline AND acidic cleaning agents. If you need assistance in selecting the appropriate cleaning agent for your application, contact Zenith Ultrasonics at your convenience.

If you already have a cleaning agent in mind, fill the cleaning tank with the detergent/water mixture. Then, heat the fluid to appropriate temperatures (165 degrees F max) and activate the ultrasonics. Every minute or so, check to see how clean the parts are and make notes of the results. Under most circumstances, parts should be cleaned in less than 5 minutes if cleaning agents are well matched. If you find that parts are not clean in 15 minutes, you may be using ineffective cleaning agents for this particular application. Try other combinations of concentration and heat to see if results can be improved. If not, contact Zenith for assistance and possible test-cleaning at the Zenith laboratory.