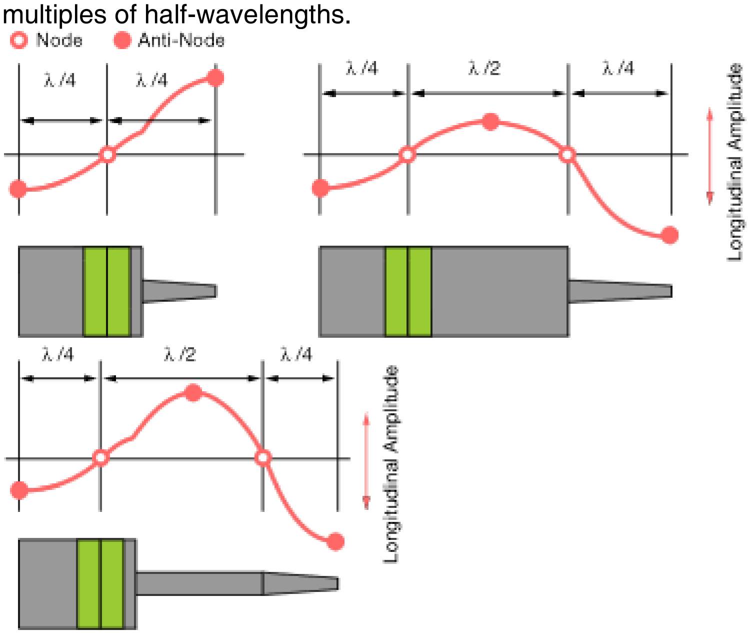
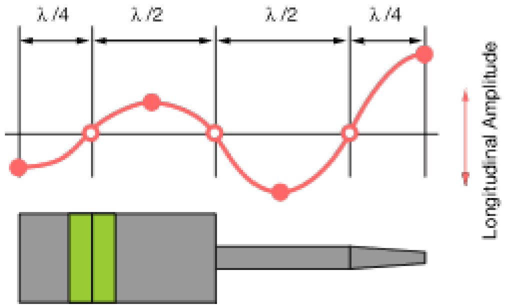
How Ultrasonic Nozzles Work

Every ultrasonic nozzle operates at a specific resonant frequency, which is determined primarily by the length of the nozzle. In order to produce standing, sinusoidal longitudinal waves, a necessity for the sustained vibration that produces atomization, the nozzle must be an integral number of half-wavelengths long. This requirement arises because both free ends of a nozzle must be anti-nodes; that is, points of maximum vibrational amplitude. Open-ended organ pipes and chimes are other examples of this type of wave motion.

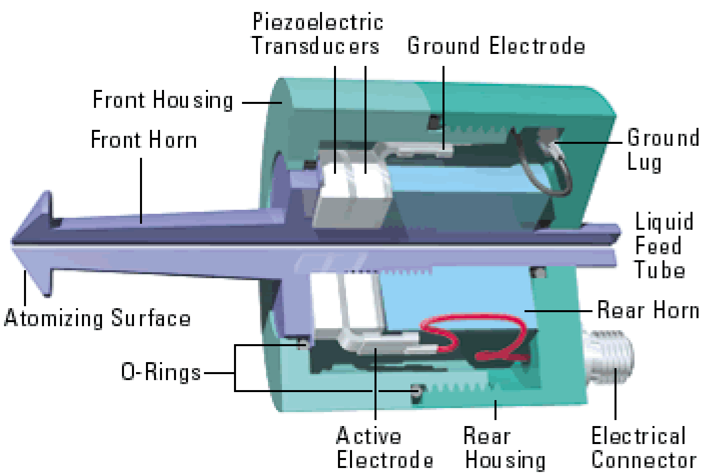
The illustration below shows several variations of Sono-Tek nozzle designs, all having lengths equal to integral multiples of half-wavelengths.





Notice that in each case, the point at the junction of the two piezoelectric transducers is a node, a point of zero vibrational amplitude. This is so because the transducers are arranged such that their polarities are opposed(+/+ or -/- at the junction). This causes them to always expand or contract against each other with equal force.
The significantly greater amplitude of the standing wave at the atomizing surface end of the nozzle is the result of the amplification of motion provided by the step diameter transition between the large central section of the nozzle and the slender stem that terminates in the atomizing surface.
Sono-Tek nozzles are manufactured in various sizes spanning the range of frequencies from 25 - 120 kHz. To give a sense of the physical size of these nozzles, one wavelength at 25 kHz is approximately 8 in., while at 120 kHz it is 1.6 in. A 48 kHz nozzle, one of the more common types in use, is approximately 2 in. long for the half-wavelength version.

A cross-sectional view of a typical production nozzle is shown below. There are several features worth noting.



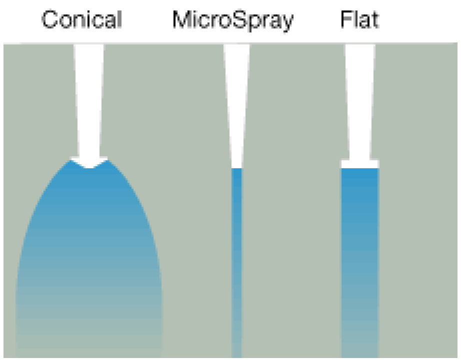
The electrically active elements are contained within a sealed housing that protects the lead zirconate/titanate piezoelectric transducers, electrodes, and connecting wires from external contamination. Chemically impervious o-rings assure the integrity of the seal.

The housing provides a convenient location for mounting the nozzle in most applications since it is the only portion of the nozzle that is not ultrasonically active. For applications involving an interface to a vacuum chamber or another type of chemical reaction chamber, the housing can be fitted with or made an integral part of a mounting flange that bolts to an existing port on the reactor.

Both the front and rear horns are fabricated from a very high-strength titanium alloy (Ti-6Al-4V). This alloy also exhibits exceptional resistance to chemical attack. The housing is fabricated from 316 stainless steel. The electrical connector is a hermetically sealed SMA connector fabricated from stainless steel. The o-ring seals between the titanium horns and the front and rear portions of the housing are Kalrez (trademark of Dupont). The o-ring seal between the front and rear housings is Viton (trademark of Dupont).

The liquid feed tube that runs the entire length of the nozzle is an integral part of the front titanium horn. Thus, the liquid only comes into contact with titanium within the nozzle. Typically, the nozzle is supplied with a 316 stainless steel compression fitting mounted on the rear of the liquid feed tube, which is mated to appropriate polymeric tubing.

The nozzle shown above features a cone-shaped atomizing surface. Its purpose is to spread out the spray. Some applications require that the spray be very narrow. In those cases, the atomizing surface is sculptured into a flat or nearly-flat surface. Depending on the width requirements of the spray pattern and the required flow rate, the atomizing surface may have a very small diameter or an extended, flat section. The possibilities are shown below.



The illustration on the left in the diagram above indicates a cone-shaped spray pattern resulting from the conically shaped atomizing surface. Typically, spray envelope diameters from 2-3 inches can be achieved.
The center illustration is characteristic of Sono-Tek MicroSpray™ nozzles. For this type of nozzle, the orifice size ranges from 0.015-0.040 inches. It is usually recommended for use in applications where flow rates are very low and narrow spray patterns are needed.
The illustration on the right depicts a cylindrical spray shape used in applications where the flow rate can be relatively high, but where the lateral extent of the spray pattern must be limited.