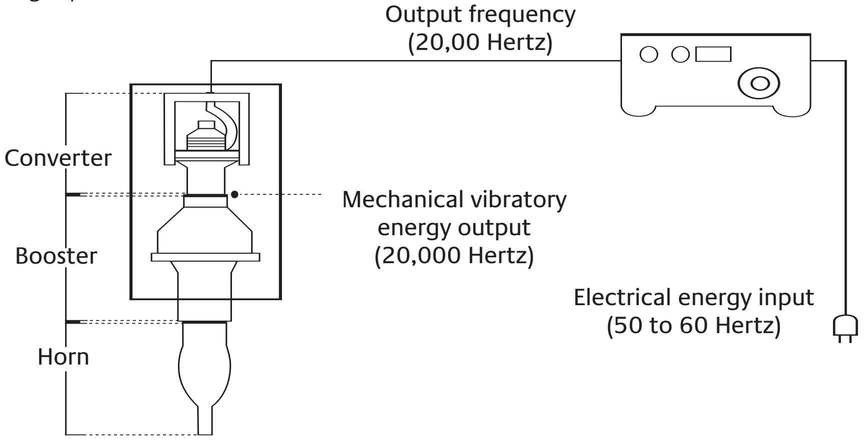
SABIC
Innovative
Plastics™

Ultrasonic welding

Ultrasonic welding is one of the most common methods of assembling two thermoplastic parts. Ultrasonics provides strong, reliable bonds at very fast cycle times. A single ultrasonic welder can be used to join parts up to approximately 8” in diameter, but several welders can be combined or “ganged together” to weld larger parts.



An ultrasonic welding system generally consists of two major components. The first is the power supply, which converts 60 cycle electric power to high frequency (generally 20,000 cycle) electrical energy. This unit may also contain process controls for the welder. The second unit houses the elements that convert the electrical energy to mechanical motion and apply it to the part in the proper form. The converter contains the driver and the piezoelectric elements that provide this vibrating mechanical energy. A booster unit connected to the converter increases, decreases, or just couples the vibrational amplitude from the converter to the horn. Boosters that supply from 0.5 to 2.5 times the converter output amplitude are commonly available.

The mechanical motion then is transmitted via a horn to the part. The horn is designed specifically for the parts to be assembled—delivering the proper amplitude directly to the joint area.

Only one of the mating plastic parts comes in contact with the horn. The part transmits the ultrasonic energy to the bonding area, producing a rapid, consistent weld. Both mating halves remain cool, except at the weld interface, where the energy is quickly converted to heat and plastic melt.

Optimum energy transmission and control occur when the horn is close to the bond. “Near field” welding describes the process when the horn is within 0.25” of the weld(see Figure 1). “Far field” welding, with distances greater than 0.25”, is less effective.

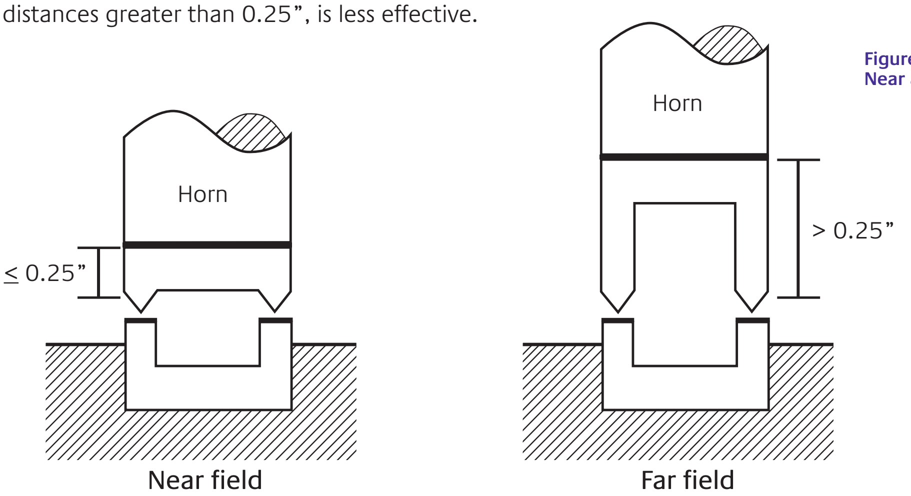
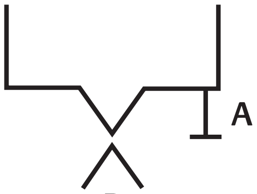


Figure 1
Near and far field welding

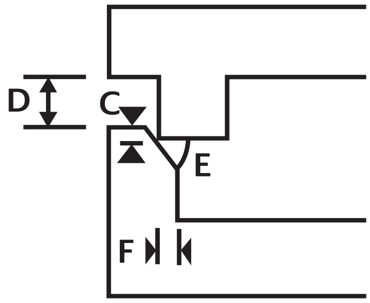
The key elements for successful ultrasonic welding include joint design, part design, horn configuration and fixturing. The factors that most influence these elements are

- resin grade
- near or far field
- surface cleanliness
- welder power
- uniform wall sections
- weld time
- single bond plane
- hold time
- simplicity of shape
- clamping force

Figure 2
Joint design



Energy director

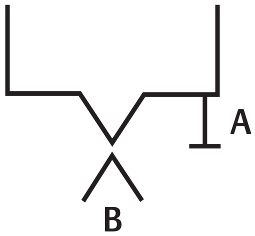


Shear joint

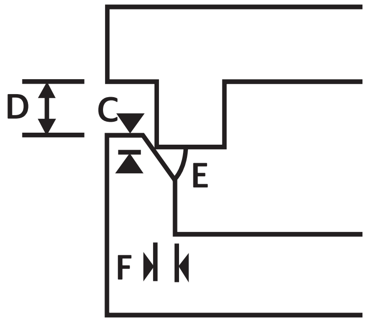
Optimum joint designs incorporate the following
- a small initial contact area (i.e. an energy director; see figure 2)
- uniform contact
- proper part alignment
- allowance for material flow (flash traps)
- a suitable horn contact area
- location of the joint as close as possible to the horn
- allowance for rigid fixturing of the bottom part

Acrylics boast rapid cure at room temperature with a setting time of approximately 60 to 90 seconds and full cure within 30 minutes or less. Application of heat may reduce cure times.

Typical joint dimensions



Energy director



Shear joint

Energy director

Height A = .025” (Amorphous)
.020” (Crystalline)
Angle B = 75 to 90 degrees

Shear joint

Lead-in C = .020”
Depth D = .050”
Angle E = 30 to 45 degrees

Interference per side	for part width
F = .008” - .012”	< .750”
.012” - .018”	.750” - 1.50”
.016” - .020”	> 1.5”

Energy directors in an ultrasonic joint serve to focus the energy into a line contact around the weld rather than a full surface contact. Focusing the energy into a smaller area controls the location and flow of the melt, resulting in a strong and repeatable bond. The energy director also initiates the melt much more quickly, improving cycle times.

Although ultrasonic welding is commonly used in the plastics industry, it is a complex process. When a welding problem shuts down production, an orderly approach to coordinating all of the available resources is mandatory. Ultrasonic welding is not rocket science—most of it is common sense engineering. The outline below provides step-by-step guidelines on how to resolve ultrasonic welding questions and issues.

Step 1. Get the right people involved

- For SABIC Innovative Plastics, the local Application Development Engineer can be the quarterback for attacking the problem.
- Involve the welder supplier (Branson, Dukane, Ultrasonic Seal, etc.). They can best verify that the machine is working properly, the proper equipment is being used, and the process variables are reasonable.
- Involve the horn and fixturing supplier (if different from the welder supplier). They can verify that the horn is working properly and that the fixturing is holding the part well without absorbing the ultrasonic energy.

Step 2. Document past history and comparable experience of the end user

- If the problem started with a change in resin, tooling, or part design, then there is a base line for comparison (i.e. Does the problem go away if you change back?). Even without an obvious change, you may be able to use past experience as a base line (i.e. does the end user have a similar part using ultrasonics?).
- Because ultrasonic welding is highly dependent on both design and material, one of the best ways to document a problem is by comparisons (i.e. "We only get three quarters of the strength we had on the old part.")

Step 3. Document the actual problem

- Is melt occurring at the joint? Are both halves of the joint melting? Is the melt uniform all around the part?
- If both halves are melting, are they sticking to each other?
- If the problem is the strength of the weld, there may be a simple mechanical explanation, such as degraded material, notches (a non-welded area can be a notch), part warpage (causing an incomplete weld), etc.
- If it is difficult to verify what is happening at the joint, it may help to mold clear parts, or different color parts, to make it easier to see where the melted material is going.

Step 4. Try simple things first ("What changed?")

- Does the joint design match recommendations?
- Does the part match the prints?
- Is it a far-field weld?
- Is the horn providing the proper amplitude?
- Does the welder have enough power to weld the part in that material?
- Does the welder have enough power to weld the part in that material?
- Is the joint clean, so that friction and melt are not inhibited?
- Try varying weld time and weld pressure.
- Try varying the welding amplitude by changing the booster.

Step 5. If the problem persists, or if the weldability of the material is questionable

- The welder suppliers generally have regional welding labs that can take parts, horns and fixtures to do a detailed welding study on the actual parts. State-of-the-art microprocessor controlled welders provide better control and documentation of the entire welding process.

Step 6. As the final option, consider and evaluate changes

- Changing the joint design, material, or assembly method. Since these options could be time consuming and/or expensive, they should generally be considered a last resort.