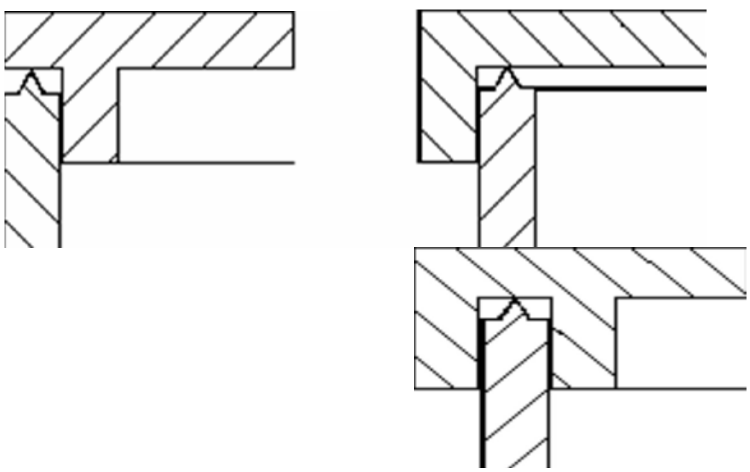
Plastic Assembly Technologies, Inc.

8445 Castlewood Drive, Suite B, Indianapolis, IN 46250

DESIGN FOR ULTRASONIC WELDING

Energy Director Design

While it is possible to ultrasonically weld plastic materials without specific joint design details, the weld process is greatly enhanced by adding proven features that aid in the process. For example, without a means of alignment built into the joint it is impossible to predict where the parts will be positioned after welding. This is due to the nature of the vibratory process created by ultrasonic welding. This means of alignment is accomplished through the use of step joints, tongue and groove joints, pins and sockets, raised walls, ribs or other features that are used to keep the vibratory process under control to maintain the desired alignment of the parts after welding.



A feature that is shown in these joint alignment pictures is the molded-in triangular shape of material called an energy director. This molded-in triangular ridge of plastic is very effective at reducing the cycle time to achieve a weld and in compensating for non-uniform wall surfaces. The energy director design has been used for years as a means of focusing the energy to improve weld strength and reduce cycle time.

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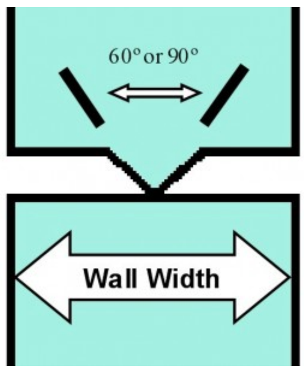
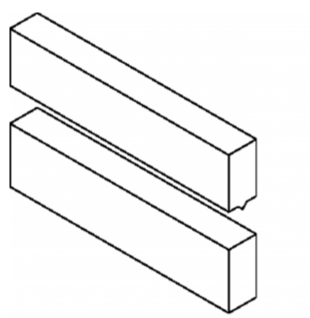
The energy director is typically placed only on one half of the part and runs along the surface to be welded. Without this energy director the weld quality would be suspect for many applications. The peak of the energy director should be sharp with a triangular shape formed from a 60º or 90º included angle. A 60º angle is generally used with crystalline materials and a 90º is used with amorphous materials. Material types by polymer structure are illustrated below:



Amorphous Resins 90º Angle

ABS-Acrylonitrile Butadiene Styrene
ABS/PC-ABS/Polycarbonate
ASA-Acrylonitrile Styrene
Acetate
PC-Polycarbonate
PEI-Polyetherimide
PES-Polyethersulfone
PMMA-Acrylic
PPO-Polyphenylene Oxide
PS-Polystyrene
PSU-Polysulfone
PVC-Polyvinyl Chloride (Rigid)
SAN-Styrene Acrylonitrile
SBC-Styrene Block Polymers

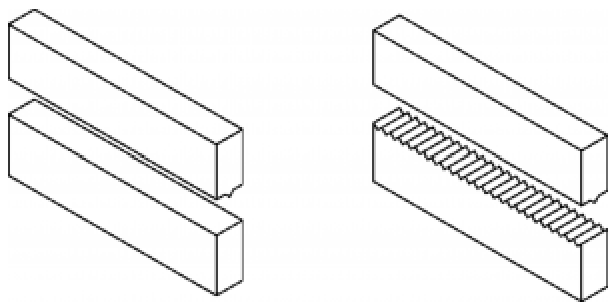


Semi-Crystalline Resins 60º Angle

PA- Polyamide (Nylon)
PBT-Polybutylene terephthalate (Polyester)
PE-Polyethylene
PEEK-polyetheretherketone
PET-Polyethylene terephthalate (Polyester)
PMP-Polymethylpentene
POM- Polyacetal
PP-Polypropylene
PPS-Polyphenylene sulfide

Depending upon the wall thickness and the application, the energy director typically varies in height in a range from .010 to .035 of an inch. The minimum height recommended is .010 for most amorphous materials, .020 for semi-crystalline materials and the amorphous polycarbonate material. While we've seen energy director heights of .060 of an inch tall, most energy directors don't exceed .035. Using a 90º energy director design, the height of the energy director is often determined by the width of the wall where the width of the wall is divided by eight, so that we have an energy director height equal to W/8.

Criss-Cross Energy Director Design



Recent advancements with the energy director design have resulted in the use of the criss-cross energy director design. Essentially, the criss-cross energy director design utilizes the standard energy director shape where a triangular shaped bead of material is molded into the plastic wall. The energy director has typically been placed only on one half of the part and runs along the surface to be welded. Although it usually doesn't matter which of the parts to be welded incorporate the energy director, it is probably more common to find the energy director on the half that the horn contacts. With the use of the criss-cross design, additional energy directors are added to the mating part, which increases the amount of material interaction. On the mating surface opposite the perimeter energy director, a series of perpendicular energy directors are molded-in to mate with the perimeter energy director. See the illustration above.

When a hermetic seal is desired these additional energy directors should take on a saw tooth pattern with each energy director repeating from the base of the proceeding energy director. Because there are energy directors on both mating surfaces, the energy director height on each half should be reduced to prevent excessive material flash during welding. Typically, it is recommended that the criss-cross energy director height be approximately 60% of the standard design.

The criss-cross energy director joint design is particularly effective when used in combination with a tongue and groove. Because of the increased material flow with the criss-cross energy director design, it is recommended that a tongue and groove joint be used to capture the additional plastic and contain the flash.
This criss-cross design certainly increases the mold cost, but we've seen applications where the weld strength has far exceeded expectations and hermetic bonds have been achieved that might not have been achieved using the standard energy director on one mating surface.

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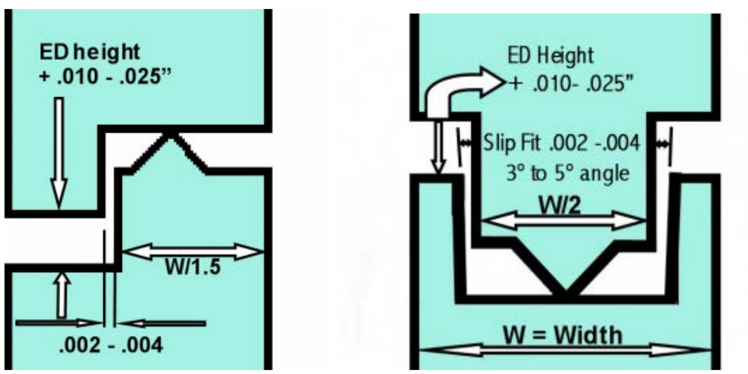
Step and Tongue & Groove Joint with Energy Director

Without some designed in approach to controlling flash, an energy director by itself has the potential for molten material to flow beyond the wall creating flash outside the weld joint. If flash is a problem the use of step joints, tongue and groove joints, flash traps, raised walls and energy director placement have all been employed as a means of controlling the material flow.

Two types of joints commonly used to control flash and provide alignment are the step joint and the tongue and groove.



Both of these joints provide excellent flash control and the alignment necessary for a good ultrasonic weld joint design. The tongue and groove design provides the added benefit of being as an excellent reservoir for the melted material. This pooling of plastic material helps contain the material and increases the likelihood of a hermetic seal. The additional height of .010 to .025” added as a gap around the periphery of the part provides a shadow line that helps to hide variation with part tolerances and melt flow during the ultrasonic welding process. This is a feature that we highly recommend because it helps to eliminate potential flash caused by the mating perimeter surfaces touching and it becomes imperceptible to the eye when the weld melt down is not perfect.

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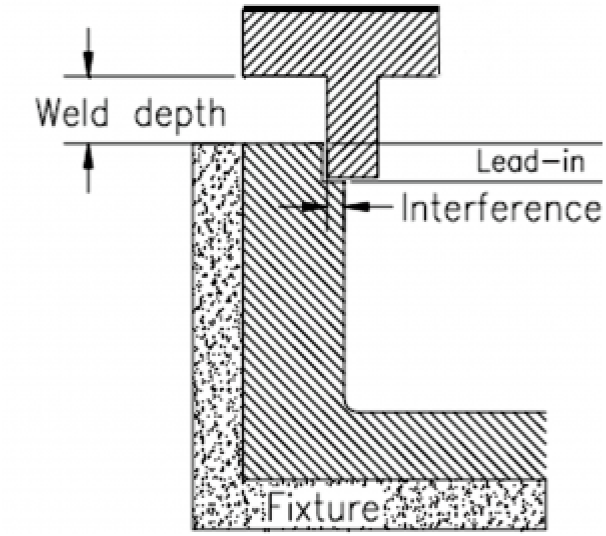
Shear Joint Design



Guidelines for Shear Joint Interference

Maximum Part Dimension	Interference per Side (Range)	Part Dimension Tolerance
Less than 0.75" (18 mm)	0.008" to 0.012" (0.2 to 0.3 mm)	± 0.001" (± 0.025 mm)
0.75" to 1.50" (18 to 35 mm)	0.012" to 0.016" (0.3 to 0.4 mm)	± 0.002" (± 0.050 mm)
Greater than 1.50" (35 mm or larger)	0.016" to 0.020" (0.4 to 0.5 mm)	± 0.003" (± 0.075 mm)

Although the energy director design can work satisfactory for welding semi-crystalline plastic materials, there are circumstances that warrant the use of another type of joint design. When welding materials like nylon, polyacetal, polyester, polyphenylene sulfide, polypropylene or polyethylene and a hermetic seal is required, the shear joint has proven beneficial for many applications. Therefore, the shear joint is frequently used when a hermetic seal is required on semi-crystalline plastic materials.

The reason for using a shear joint relates to the way the semi-crystalline material flows when introduced to heat. These types of plastics have a very sharp melting point and once the heat is reached to create a melt flow, the material immediately becomes liquid and flows rapidly. Semi-crystalline plastics also re-solidify within a small temperature variation. When an energy director is used with semi-crystalline plastics, the molten material gets exposed to a lower temperature when outside of the melt zone and can re-solidify before the desired bond is achieved. Because the melt zone of a shear joint is held along a vertical wall, the temperature variation is reduced within this melt zone since the material is not easily exposed to the surrounding air.

The shear joint is not the answer for all applications. We recommend caution when applying the shear joint to polypropylene or polyethylene due to the lack of rigidity in these materials. The lack of stiffness with these materials often results in pushing past the shear joint instead of melting and welding the material at the joint interface. The shear joint requires high tolerance, so we suggest you use caution incorporating a shear joint design on larger parts. The shear joint should not be used when a part is larger than 3 ½" in diameter or has sharp corners or unusual shapes.