ASCEND® PERFORMANCE MATERIALS

Problem:

Weld Lines

Weld lines form when two melt fronts come together in the cavity or when a single melt front passes around a cut-out or other geometry that causes it to split and recombine. Weld lines are visible to varying degrees on any molded part. However, if the integrity of a weld line is particularly poor, it can lead to poor part strength and brittleness.

TECH TIPS

Your Vydyne® technical services team offers step-by-step troubleshooting tips to help locate and solve problems that may occur during injection molding in order for you to get production back up and running.

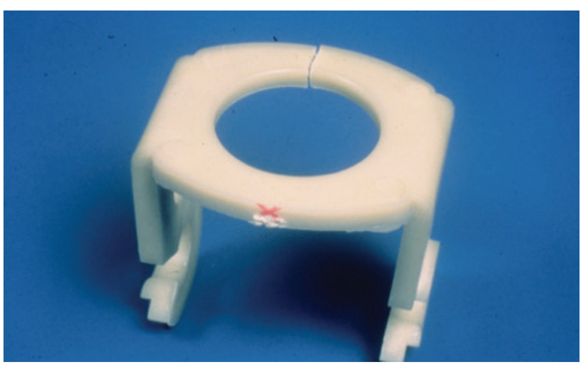
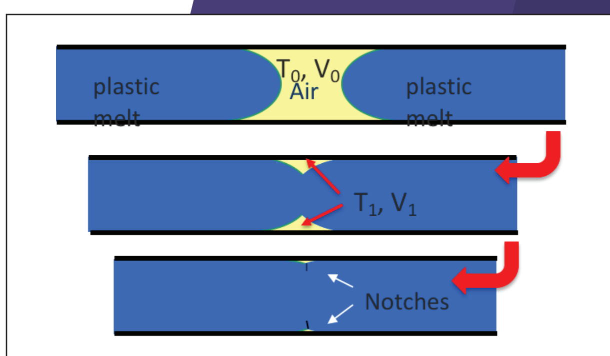


Figure 1. Weld line failure in a glass-filled nylon clevis part



$T_1 = T_0 (V_0/V_1)^{\gamma-1}$

Air compression can lead to thermal degradation of material in contact with air.

Notches and unfavorable fiber orientation can significantly reduce weld line strength, toughness and surface quality.

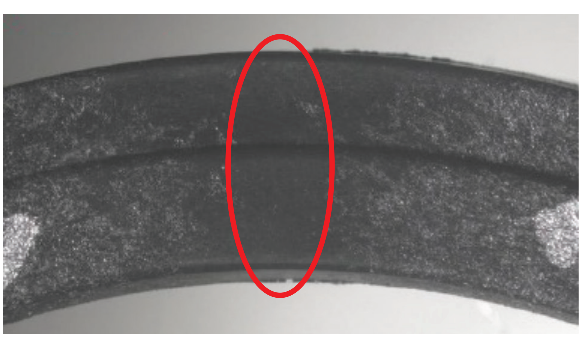


Figure 2. Resin-rich area (no glass fiber) showing weld line

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How does weld line affect product quality?

Weld line in a molded part is weaker than the parent material strength. Poor weld line quality can lead to short-term or long-term product failures, initiated at the weld line. Examples of such failure are shown in Figure 1. For glass-filled grades, the thickness at the weld line can be slightly larger than the nominal value due to lower shrinkage associated with vertical fiber orientation at the weld line cross section. Such thickness deviation can lead to issues such as gasket seal leakage where the weld line crosses a gasket.

Root causes

Many factors—including processing conditions, material, part design and mold design—can influence the visibility and strength of a weld line.

- Weld lines are visible to varying degrees on any molded part depending on gate location, flow length, melt/mold temperature, cavity pressure and venting. If the integrity of a weld line is poor, it can lead to lower part strength, poor aesthetics, trapped air, short shots, etc. Many factors may influence weld line properties including processing conditions, material, part design, and mold layout.
- Butt welds where two flow fronts come together at or near 180° are the worst. The melt fronts compress the air that cannot be vented out and causes short shots, voids, burning or leaves small V-notches at the edges of the weld. This weld is weaker and may break during assembly or in use. When locating gates during mold design, it is always desirable to position weld lines on non-critical surfaces and avoid butt welds wherever possible.

How to troubleshoot

Evaluate the molding process

First, determine if the molding process is consistent from shot to shot. Most machines have process control programs that allow you to monitor various functions, such as fill/pack transfer position, injection speed and/or pressure, screw recovery time and cushion. If there is too much variation in any of these parameters, there may be a problem with poor melt uniformity and/or the process set-up conditions. Make sure the melt and shot are consistent before analyzing the following parameters.

- *Injection speed:* A significant cause of weak weld lines and poor weld line aesthetics is slow injection speed. More often than not, injection speeds are set to an arbitrary value without the use of Scientific Molding Principles. When done properly, a shear rate versus viscosity curve is obtained that is unique to that mold and material combination. Using this information, the optimum melt temperature and fill rate is obtained and matched to critical molded part appearance and properties. Using this technique ensures material will flow fast enough to overcome any variations that may occur.
- *Flow front temperature:* Flow front melt temperature needs to be high enough to promote good weld line melding. Set the barrel temperatures to the recommended levels and monitor how material fills the cavity. The recommended melt temperature for Vydyne resins should be between 531°F to 579°F (277°C to 304°C).
- *Cavity pressure:* To achieve a strong and aesthetic weld line, the flow fronts need to come together with sufficient speed and cavity pressure to promote adhesion across the weld line zone. Filling the cavities rapidly also helps ensure high melt temperatures are

maintained. It may be necessary to slow the injection rates down near the point where the weld line forms to facilitate venting and removal of trapped air. It is not uncommon to use a profiled injection rate going from fast to slow at end of fill to promote venting.

- *Mold temperature:* Mold surface temperature can be increased to help facilitate weld line formation, slow solidification and aid in the melding of the weld line.

Evaluate the mold design

Proper mold design can minimize or eliminate a weld line problems. Different facets of the mold design can contribute to poor weld lines in a molded part.

- *Venting:* Inadequate venting may cause weak weld lines in a molded part due to trapped air. Poor venting doesn't allow air to escape from the mold cavity during filling. As the flow fronts come together and the weld line is formed, trapped air is squeezed and pushed back on the melt flow fronts, interfering with the weld. The trapped air forms V-shaped notches that act as stress risers and can promote failure.
- Trapped air may become super-heated and cause burning on the flow front or end of fill. Good mold design practice dictates that venting should be placed every two inches along the parting line of the cavity runner system and at the end of the fill. Vents also should be cleaned on a regular basis so there are no obstructions that could block air from escaping the mold cavity. Vents also can be cut into ejector pins to help facilitate the removal of trapped air from the mold cavity. Venting of runners and along the melt front path will remove as much air as possible and minimize potential weld line issues due to high air volume.
- Vent size recommendations for PA66 are as follows:

Vent Size Requirements	
Width	0.125–0.25 in (3.18–6.35 mm)
Depth	0.0005–0.0015 in (0.013–0.04 mm)
Land	0.03–0.06 in (0.76–1.5 mm)

- *Gate location:* Weak weld lines can be caused by improper gate location. In multi-gated parts, the flow front should be balanced to come together at the same time.
- *Uniform wall thickness:* A part with varying thickness can be difficult to pack out and difficult to properly pack the weld line. With a thick wall and a weld line at the end of fill, the knit line will be weak because the thin wall will freeze off first and not allow the end of the fill to pack out properly. If this occurs, either move the gate so the material is flowing from the thicker area to thinner area or adjust the nominal wall sizing so that it is consistent across the part.
- *Flow distance:* Flow length is a very important factor in determining the strength and aesthetics of a weld line. If the flow distance is too long, the melt flow front will be too cool when it forms the weld line and will create a poor joint. To determine the maximum flow length, measure the flow ratio in the mold by measuring the longest flow length, (L), from the gate and divide that by the average nominal wall thickness, (D). If the measured flow ratio (L/D) is greater than 120, consider adding more gates or changing the gate location.

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Evaluate the material

- *Material Moisture:* Material that is not properly dried can cause weak weld lines. Vydyne material is shipped pre-dried in foil-lined packaging. The recommended moisture range for molding Vydyne materials is 0.08% to 0.2% moisture. It is critical to dry material to the manufacturers' recommendations. If material is molded wet, the water in the material vaporizes and can get trapped at the weld lines, causing weak weld lines and poor surface aesthetics.
- *Material Nucleation:* Nylon resins are designed with differing amounts of nucleation. Nylon 66 sets up quickly, depending on levels of nucleation. If the part's weld line is weakened because the material sets up too quickly, consider using a material with a lower level of nucleation. This will increase the set up time and allow more time for packing and knit-line welding.

vydyne pa 66®

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For more information, contact our expert applications specialists or visit **ascendmaterials.com.**

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