Die-Cut Components Guide

A Quick & Easy Guide to Enhance your Product's Design and Performance by leveraging Die-Cut Components

---

Overview

As devices are getting smaller, lighter, and sleeker, engineers are constantly scouring for innovative ways to improve the performance and aesthetics of their products. Fortunately, die-cut components are drastically changing the way we create products and address design and technical challenges. Made of several non-printed materials, die-cut components are cut into different shapes to solve specific problems such as thermal management, bonding, sealing, or electrical insulation.

This brief guide will walk you through some of the most widely utilized die-cut components that can drastically enhance the functionality and longevity of your product. Depending on the specific design challenges that you are trying to overcome, there are a multitude of factors that go into consideration before selecting the most optimal solution. This guide will outline some of the unique characteristics, properties, advantages, and applications of these die-cut components, and equip you with a few design considerations to keep in mind when creating your next product.

INTRODUCTION

Designers and engineers are constantly looking for innovative and intelligent solutions to improve the aesthetics and performance of their products. All devices need protection from external elements such as dust, moisture, and extreme temperatures. On top of addressing these environmental conditions, engineers also face several other design hurdles such as mitigating the friction between two components, blocking the EMI emissions, or preventing the device from overheating.


Custom Die-cut Components

As new devices are entering the market, the need for die-cut components is steadily escalating. Made of several non-printed materials, die-cut components are cut into different shapes to solve specific problems such as sound and vibration dampening, EMI shielding, electrical insulation, thermal management, bonding, gap filling, and sealing. From a simple electronic bike to complex industrial controllers, or small mobile phones to massive airplanes, die-cut components can be employed in a wide spectrum of products and industries.

NOISE AND VIBRATION DAMPENERS

Buzz, squeak, and rattle (BSR), a term frequently used by automotive engineers, refers to the incessant noise or unwanted squeaky sound that you hear in your car at times. While BSR remains one of the most common, yet challenging problems of the automotive industry, it is also of paramount importance in other industries including electronics, aerospace, and appliances. BSR can be caused by any moving components or the improper bonding and attachment of two parts. Whether it's a cooling fan, medical pump, or washing machine, moving components within a device often cause friction, damaging the parts over their lifetime. In addition, devices, especially hand-held and portable ones, are prone to severe impact by a sudden hit or drop on the floor. Minimizing noise, vibration, and harshness (NVH) is critical to the optimal performance and longevity of any device.

In the past, the issue of NVH was addressed by inserting a piece of neoprene or rubber between two components, held together by a screw, nut, or bolt. While this solution helps to reduce vibration, the mechanical fasteners create a rigid bond that is susceptible to cracking or breaking on impact. In recent times, engineers often try to attack the problem of vibration at the source, which is commonly known as vibration isolation. However, in cases where isolation is not possible, the issue is resolved by introducing noise and vibration dampeners. The dampeners essentially absorb the noise and dissipate it over the surface, thus mitigating fatigue, stress, and vibration.

Acoustic Management Solutions

Finding the right noise-blocking solutions can not only improve device quality but also enhance the end-user experience. Fortunately, material manufacturers have opened doors to multiple acoustic management solutions in the form of acoustic foams, tapes, and adhesives. In addition to replacing mechanical fasteners, these solutions exhibit high resiliency and shock absorption characteristics.

This cost-effective approach to acoustic damping offers the following advantages:

- Minimize noise, vibration, and harshness (NVH)
- Reduce buzz, squeak, and rattle (BSR)
- High viscoelasticity, resiliency, and dimensional stability
- Quick and easy application
- Improve durability and performance of the device

While each application requires a customized solution, there are certain product families that are predominantly utilized by Boyd to resolve noise and vibration design challenges. Each product family has a wide array of options to select from, offering peculiar advantages over one another.

1) Polyurethane Foams

Polyurethane foams are open-celled materials with high dimensional stability and excellent viscoelasticity that hold up well under continued vibration. With a high resistance to stress, relaxation, and compression, urethane foams do not collapse under pressure and always return to 99% of their original dimension. Ensuring consistency and reliability in crucial applications, urethane foams are seen in various constructions ranging from extra soft, very soft, soft, firm, to very firm. These durable foams are flame retardant, chemical resistant, and can sustain a broad range of temperatures from -40°C to 90°C. Equipped with excellent gap filling, sealing, and gasketing properties, these foams offer good absorption for medium to high impact.

Roll of Roger's PORON Urethane Foam

Polyurethane foams are primarily divided into two types: supported and unsupported. While both offer similar characteristics, the key difference between the two is that the supported foams come with a thin layer of PET film backing on one side. The market today is significantly dominated by the "unsupported" foams.

Key features of polyurethane foams include:

- Resistance to stress and compression
- Low outgassing, flame retardance, and chemical resistance
- Thickness range: 0.03 to 0.5 mils approximately
- Common polyurethane foams (unsupported): 4701-30, 4701-41, 4701-60, and 4790-92

2) Silicones

Silicones can be made of cellular, solid, or specialty silicone materials, offer similar benefits and features as the polyurethane foam. The chief differentiating factor is silicone's high flame resistance and the ability to withstand high temperatures. The cellular silicones, available in varying thicknesses, provide high resistance to compression and high tensile strength. Solid silicones, made of solid rubber-like material, are available in a range of durometers from 10-40 Shore A. The specialty silicones, bringing together a combination of cellular and solid silicones, are seen in durometers from 40-70 Shore A.

3) Vibration Damping Tapes

With a soft aluminum backing, vibration damping tapes mitigate resonant noise, vibration, and fatigue. Used for attaching irregular and uneven surfaces, the tapes can hold up to 50 pounds per square inch of strength. They are pressure-sensitive tapes with high viscoelasticity that reduce stress and dissipate noise across the surface. Like vibration damping tapes, very high bond tapes also offer dampening properties due to their high viscoelasticity.

The main characteristics of vibration tapes include:

- High viscoelasticity
- High tensile strength
- Thickness range: 7.5 to 17.5 mils approximately

4) Slick Surface Tapes

Slick surface tapes utilize Ultra-High Molecular Weight Polyethylene (UHMW-PE) and Polytetrafluorethylene (PTFE) formulations to mitigate friction between the two contact surfaces.

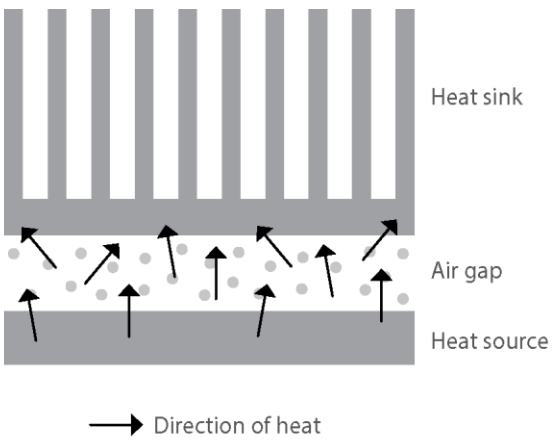
Unique properties and examples of slick surface tapes include:

- Low coefficient of friction
- High dimensional stability

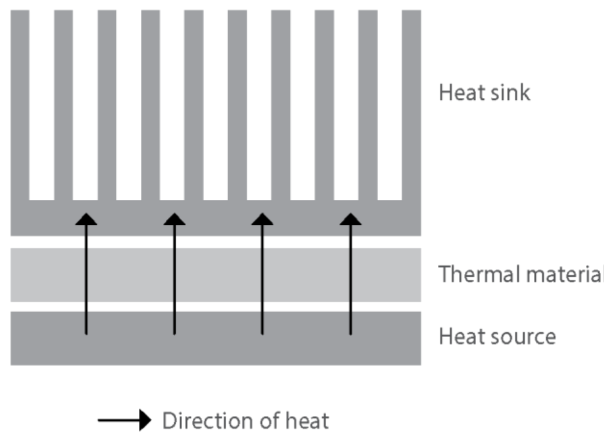
THERMAL MANAGEMENT

As electronic devices are getting smaller, a major concern for engineers and designers is the dissipation of heat. All electronic devices emit heat; Without a proper heat outlet, the internal temperatures of the device can significantly increase which can ultimately result in failure. Trapped heat in a device can not only damage critical internal components but can also negatively impact the performance of the device. To lower the temperature of the device, it is essential to dissipate the heat from the heat source to a heat sink (air duct or vent). Thermal interface materials facilitate the transport of heat away from the heat source.

Measured in watt per square meter of surface area for a temperature gradient of one Kelvin for every meter thickness (W/m-k), thermal conductivity is the rate at which heat passes through a material. When an integrated circuit (IC) in a device gets hot, a thermal material drives the heat in a vertical direction away from the heat source. W/m-k is the measurement of how fast the heat is transferred from the IC to the heat sink. However, if the thermal material doesn’t intimately contact with the IC, it creates air bubbles. These air bubbles can slow down or impede the transfer of heat. A thorough understanding of conductivity and impedance is vital in selecting the optimal thermal material for any given application.



Transfer of heat without thermal material



Transfer of heat with thermal material

Thermal Interface Materials

Thermal interface materials enhance the thermal conduction between the two components. The uneven surface area of a heat source and sink, due to the lack of common contact points, make it difficult to conduct heat between each other. Thermal materials can be extremely soft materials that bridge the gap between the two components, thereby creating more contact points and directing the heat more efficiently and effectively. Some advantages of thermal interface materials include:

- Enhance thermal coupling between the heat source and heat sink
- High conformability to uneven and irregular substrates
- Quick and easy application
- Improve durability and performance

Thermal Interface Materials are available in a variety of styles, as described below.

1) Thermal Gap Fillers

Thermal gap fillers are hyper-soft thermal conductive interface pads that contact both the IC and heat sink, bringing the impedance closer to zero. Designed in a variety of thermal conductivities and softness grades, thermal pads flow into the nooks and crannies of the heat sink and IC to offer a high degree of “wet out” for more efficient heat transfer, effectively filling any gaps between interface surfaces. The two types of thermal gap fillers are as follows:

A) Silicone Thermal Gap Fillers - Seen in several applications such as handheld electronics, memory modules, telecommunications hardware, notebook and desktop computers, flat panel displays, etc., silicone thermal pads make up most of the market despite their tendency to outgas. Key features and examples of silicone thermal gap filler pads include:

- Thermal conductivity range: Up to 8.0 W/m-k
- Thickness range: 0.25 to 5mm approximately


Thermal pads

B) Non-Silicone Gap Fillers - Made of acrylic materials, non-silicone thermal pads provide the same qualities as silicone pads. However, since outgassing from silicone pads can produce fogging on a lens, non-silicone pads are a great alternative as they do not outgas. Ideal for applications such as camera and video lenses, the key features and examples of non-silicone thermal pads include:

- Thermal conductivity range: Up to 7.8 W/m-k
- Thickness range: 0.16 to 0.4mm approximately

2) Thermally Conductive Tapes

Thermally conductive tapes are acrylic adhesives with highly conductive ceramic particles. While thermal pads fill the gap between the IC and heat sink, the sink needs to be ultimately mounted to the printed circuit board. The conductive tapes can be used to bond the IC and heat sink together without using mechanical fasteners. These thin, high adhesion tapes are utilized for bonding heat sinks, heat spreaders, and other cooling devices to IC packages and power transistors. However, tapes offer very low thermal conductivity (approximately 0.6 W/m-k). While this low transfer of heat may not work for many applications, it is well suited for the growing market of low-temperature LEDs.

The key properties and examples of thermal tapes include:

- Thermal conductivity range: Up to 0.6 W/m-k
- Thickness range: 2 to 20 mils approximately

EMI AND RFI SHIELDING

Whether it’s the internal circuits of a computer or a high-powered wireless transmitter, electronic devices and equipment emit electromagnetic (EM) and radio frequency (RF) waves in varying frequencies. These emissions can interfere with one another, causing serious damage to sensitive devices in close proximity. From a temporary glitch to permanent data loss, these emissions can severely impact the performance of a device. EMI emissions can also pose life-threatening threats in the medical and military fields. To overcome this issue, there are different electromagnetic compatibility (EMC) standards that commercial products are required to meet. While these standards tend to vary slightly depending on the country and industry, the aim of the regulatory bodies and committees is to standardize the EMC performance across all electronic devices.

Traditionally, engineers have utilized thin metal sheets or metal housings to contain emissions at the source. Metals can deform under stress or break under impact, eventually causing the EM signals to leak, which may not be the most optimal solution for every application.

EMI/RFI Shielding Materials, Absorbers, and Foams

In today's electronic world, EMI and RFI shielding is increasingly important to ensure that devices function properly. Engineers are adopting new shielding materials in the form of conductive foams, fabrics, and foils that absorb and reduce EM and RF emissions. The advantages of these die-cut shielding materials include:

- Block EMI and RFI emissions from a device
- Avert interaction with surrounding signals
- Prevent data loss and damage to critical components
- Improve durability and performance of the device

Some of the common EMI and RFI shielding solutions can be seen below.

1) Conductive Adhesive Foams

Conductive adhesive foams are compressible foams that provide electrical conductivity through the thickness or depth of a product (Z direction) and in the plane direction (X-Y plane). Since the foams are conductive, when placed between two pieces of metal, they eliminate the need for connectors. With a foam over metalized fabric construction, they possess good EMI and RFI shielding characteristics and offer gap filling properties while maintaining electrical grounding.

Key features of conductive adhesive foams include:

- Foam over metalized fabric construction
- Electrical conductivity in X, Y, and Z direction
- Excellent cushioning and recovering properties

2) EMI Shielding Foils

With a backing of either aluminum, copper, or tin-plated copper, EMI shielding foils come with conductive, non-conductive, or double-coated adhesive. Tin-plated copper-backed foils provide maximum protection against corrosion, so they are predominantly used in outdoor applications.

Key features of EMI shielding foils include:

- Flame retardant
- Thickness range: 2.5 to 5 mils approximately

3) EMI Shielding Fabrics

Like the foils, EMI shielding fabrics are essentially nickel-plated copper metalized fabrics that usually come with a conductive or double-coated conductive adhesive. With a backing of either polyester, non-woven fabric, or rip-stop fabric, shielding fabrics effortlessly conform to unique shapes and offer a better drape as compared to the foils.

Key features of EMI shielding fabrics include:

- High conformability to substrates
- Thickness range: 3 to 5.5 mils approximately

BONDING

Most products require bonding two substrates together during assembly. Bonding two dissimilar substrates has always been challenging given the different textures and surface energies of different materials. For decades, mechanical fasteners such as screws, nuts, bolts, and rivets, were used to adhere two substrates together. These fasteners are not only visible and distracting on a device, but they can deform under stress, loosen over time, and relax after sustained vibration. Additionally, holes drilled in the device for mechanical fasteners accelerate corrosion, expose unpainted areas, and lead to the ingress of moisture and dust over time, thereby severely impacting the durability and performance of the device.

Plastic substrates can also crack while drilling holes and can diminish the life of the device. For outdoor applications, the product is often subjected to elements including rain, humidity, and fluctuating temperatures. Even a small leak or gap between substrates can allow for moisture to seep into the device.

Liquid adhesives are another common solution for bonding two substrates, but they can be challenging to implement. First, the bond line thickness can be inconsistent, which weakens the strength of the bond and altering the dimension of the component. Next, liquid adhesives need time to completely dry and cure, causing a bottleneck in the assembly line. Furthermore, liquid adhesives produce nauseous fumes during the application process which can be irritating to the eyes and require respirators and gloves in environments in which they are used. Finally, they also necessitate separate dispensing equipment, thereby adding to the manufacturing cost in addition to maintenance and cleaning costs.

Bonding Solutions

Fortunately, die-cut adhesives are fast replacing the traditional practices of mechanical fasteners and liquid adhesives. There are hundreds of pressure-sensitive adhesives with unique characteristics and features suited for a multitude of applications. In addition to providing long-term durable bonds, die-cut adhesives also bond irregular surfaces and dissimilar substrates with great ease. They provide strength throughout the part and not just at the point of attachment. With little to no downtime for curing, assembly is quick and easy by simply peeling off a release liner and attaching the two required substrates together.

Die-cut tapes can also reach places where it might be difficult to utilize mechanical fasteners. Imagine installing a cooling fan in a small hand-held electronic device. Not only it is easier to just peel off a liner and attach the fan with a small die-cut piece of tape, but you can also dampen the noise and vibration of the fan by employing a tape with high viscoelasticity.

Some key benefits of die-cut adhesives include:

- Ability to bond irregular surfaces and incompatible substrates
- Ideal replacement for mechanical fasteners, liquid adhesives, and O-rings
- Reduce manufacturing processing time and cost
- Ability to withstand outdoor conditions, UV exposure, fluctuating temperature, etc.
- Create permanent bonds
- Enhance aesthetics and sleek appearance
- Improve durability and performance

However, when bonding two surfaces together, there are several factors that need to be considered, including surface tension, surface energy, texture of the substrate, bond strength, bond line, product design, chemical and environmental requirements, and product application. Some of the widely employed die-cut adhesives are seen below.

1) Laminating Adhesives

Laminating adhesives are pressure-sensitive adhesives that can see 30% strength at application, 40% in the next hour, 60% in 4 hours, 90% in 24 hours, and 100% in 72 hours. The initial 10% strength is enough to move the part ahead in the production line, thus eliminating any bottlenecks during manufacturing. Some laminating adhesives might also require a primer to enhance adhesion and increase strength when adhering to a very low surface energy substrate.

The most widely used clear primers are typically made for metals and plastics. Glass surfaces require a specialized optically clear primer. Most laminating adhesives are UV-resistant and chemical resistant, some of them are also flame resistant. Laminating adhesives can be broadly classified into the following categories:

A) Double Coated Tapes - Double coated tapes are tapes with adhesives on both sides, separated by a polyester carrier. Depending on your specific application, there are numerous tapes to select from to attach smooth or slightly textured substrates together. The key characteristics of double-coated tapes include:

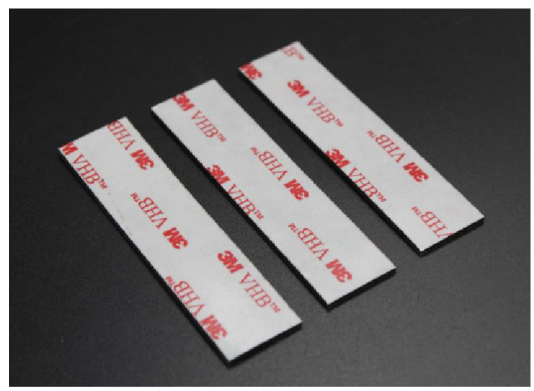
- Can hold up to 10 pounds of strength per square inch
- Thickness range: 4 to 8mm approximately

B) Transfer Tapes - With pressure-sensitive adhesive on one side, topped with a release liner and no carrier, transfer tapes are highly effective in bonding dissimilar substrates. Their unique characteristics include:

- Can hold up to 10 pounds of strength per square inch
- Thickness range: 2 to 5mm approximately

2) High Bond Tapes

High bond tapes are structurally strong closed-cell foams that can bond smooth or slightly textured surfaces. Unlike double-coated tapes that have a polyester carrier, high bond tapes have pressure-sensitive adhesive on both sides separated by a foam carrier. They are perfect for application where high strength and adhesion are essential.



VHB Tapes

High bond tapes are more durable and can hold up to 800 pounds per square inch of strength in tensile. In addition to low outgassing, these tapes work well below the water surface. Due to their viscoelasticity properties, high bond tapes are also great for sound damping solutions.

The main characteristics of VHB tapes include:

- High viscoelasticity
- Strong adhesion (can hold up to 800 pounds per square inch of strength in tensile)
- Enhance sealing from moisture and water
- Withstand outdoor conditions including UV exposure, humidity, and fluctuating temperatures
- Thickness range: 0.15 to 3mm approximately

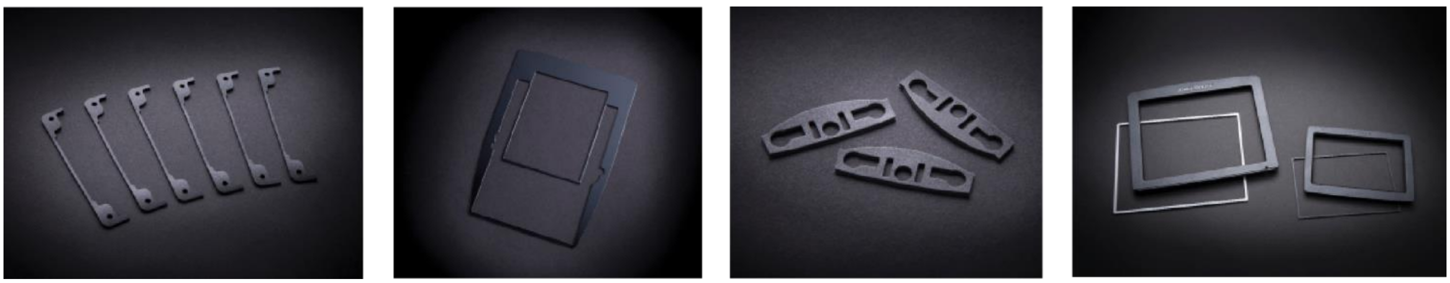
GASKETING, SEALING, AND GAP FILLING

A gasket is a piece of material, cut into a specific shape, which is inserted between two surfaces to provide a mechanical seal. Gaskets, employed for different purposes such as sealing and gap-filling, can be formed using various materials including rubber, silicone, foam, foil, sponge, and plastic.

The main function of a gasket includes:

- Prevent entry of dust, moisture, and liquid
- Adhere two layers or components together
- Provide a cushion or fill up the space between two mating surfaces
- Mitigate noise and vibration

A gasket can create two types of seals - permanent and temporary. Permanent gasketing comes into the picture when we intend to permanently mate two surfaces together, without ever separating them again. Imagine a



Examples of gaskets, spacers, and gap fillers

gasket used in an electronic tablet to seal out moisture and dust that would never be opened or taken apart. High bond tapes are a great candidate when looking at permanent gaskets.

Traditionally, O-rings have been extensively used in sealing applications to keep out moisture, chemicals, and dust. However, a bond created with high bond tape can easily last over a period of 35 years without deteriorating in strength or performance. Hence, high bond tapes are a great alternative to O-rings as they do not deform, crack, age, or dry out in a few years. On the other hand, a temporary or removable gasket is required when we need a seal to prevent dust and moisture from entering the device, but also need to open and close the seal frequently. Polyurethane foams and silicones are often used for temporary gasketing.

Depending on specific needs, any of the die-cut components seen in the previous chapters can be cut into the required shape to form a gasket. A few factors that go into consideration while selecting the right materials and shape of the gasket include the outgassing properties of the material, flammability requirements, resistance to chemicals and moisture, properties of the two mating surfaces, environmental conditions, and desired sealing effectiveness.

THE BOYD ADVANTAGE

Bringing together the perfect synergy between material science expertise, experience, and engineering, Boyd can provide you with the most comprehensive die-cutting solutions and fabrication services in the industry. With our ISO 9001 registered facilities, Boyd can manufacture components that meet your needs quickly, economically, and precisely - from prototypes to million-quantity production runs.

Boyd manufactures components with or without pressure sensitive, conductive, or non-conductive adhesives. We also provide scored, folded, and/or formed components, supplied in sheets, rolls, or individual pieces to conform to varied requirements.

- **Strategic partnerships** - Boyd is committed to providing solutions to resolve your unique challenges with our die-cutting capabilities and strategic partnerships. As a Preferred Converter for multiple top-tier suppliers, Boyd can offer custom-engineered solutions to your specific design needs. Our strategic partnerships have enabled us to offer the following benefits to our customers:
    - Access to a wide range of products and technologies
    - Accelerate response time and delivery
    - Competitive pricing
    - High agility during the product development process
    - Customize design and technical solutions

- **Material inventory** - Boyd maintains an extensive material inventory in-house to reduce processing times, while passing volume material pricing on to our customers.

- **Rapid prototyping services** - Boyd's dedicated rapid prototyping services enable customers to assess multiple design considerations with accelerated lead times and reduced costs compared to full production parts. With a lead-time of 2-3 days, our prototyping services utilize stock materials and other "soft tooling" methods before transitioning to hard tooling for production. Special materials and processes can increase lead time.

- **Fabrication equipment** - Boyd offers a range of die-cut fabrication equipment including clamshell presses, laser cutters, plotter/routers, and rotary cutters. We can help you determine the most appropriate method to meet your specific design requirements and production volumes. The table below offers a brief comparison between the different processes, shedding light on their core advantages and limitations.

Equipment	Advantages	Limitations
Clam shell press	• Good for low to medium volume production • Ability to cut multiple types of material under 0.030"	• Not ideal for tighter tolerances

Laser cutter	• Tight tolerance of +/-0.005” • No tooling costs, hence, no lead time for tools • Requires only a small programming charge • Suited for low volume production	• Limited material cutting options (cannot cut metal or vinyl) • Can create burnt edges on polycarbonate • Masking is required before cutting to eliminate burn marks on the part, which can be labor intensive and expensive
Plotter/ router	• No tooling costs, hence, no lead time for tools • Requires only a small programming charge • Suited for low volume production • Easy to make last-minute design changes	• Can only cut small parts (under 2”) • Time-consuming process • Can leave rough edges • Poses limitations on materials and interior cutouts
Rotary cutting	• Suited for high volume production • Low tooling cost • Performs well when “kiss cut” to a liner, not individual pieces	• Loose tolerance of +/-0.015” • Difficult to cut interior holes • Limited to thin materials including polyester, polycarbonate, double coated adhesives, thin foam, and thin aluminum

- **Tooling methods** - The die-cutting process requires cutting material (and usually adhesive) into custom shapes that fit the application. At Boyd, we provide four types of tooling processes including steel rule die, chemical etch die, rotary tooling, and Class-A (steel). Each of these methods is outlined below in greater detail to determine which may be the best fit for your unique project.

Tooling	Advantages	Limitations
Steel rule die	• Inexpensive • Quick turnaround time (3-5 days) • Suitable for wide range of applications	• Loose tolerance of +/-0.015” • Can cut materials thicker than 0.030” only • Short life of the die depending on material
Chemical etch die	• Tighter tolerance of +/-0.007” • Quick turnaround time (5 days) • More durable than steel rule die	• Can only cut material thinner than 0.010” • Short life of the die depending on material

Rotary tooling	• Inexpensive • Suited for high volume production • Medium to long life (over 100,000 hits)	• Loose tolerance of +/-0.015” • Can only cut materials thinner than 0.010” • Typically used for label-type materials
Class-A (steel)	• Precise tolerance of +/-0.005” • Suited for high volume production • Ability to cut all types of materials	• Expensive • Longer lead time (4-6 weeks to build)

WHAT'S NEXT?

Boyd is equipped with the capabilities to provide a range of options for every unique die-cut project need. With decades of manufacturing experience in the medical, aerospace, automotive, and consumer electronics industry, Boyd's engineering team can help resolve your design challenges with an array of die-cut fabrication methods and materials so you can get your product into production and on the market.

If you are looking for quick fixes and improvements to resolve your toughest design challenges, start by contacting Boyd Corporation to learn more about die-cut components.

BOYD CORPORATION

To receive more information, please visit www.boydcorp.com.