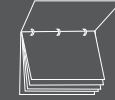




Print.

Format: Landscape
Page Size: Fit to page



Bind and save.

Bind in presentation
format for future reference

Designing for Moldability

A Quick-Reference User Guide for Rapid
Injection Molding for Engineers and Designers

• 2nd edition •

Real Parts. Really Fast.

protomold®

proto labs

Proto Labs, Inc. 5540 Pioneer Creek Drive, Maple Plain, MN 55359 877.479.3680

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What is injection molding?

- ❶ The hopper is loaded with the plastic stock material.
- ❷ A heated barrel is used to melt the beads into a molten form.
- ❸ A screw apparatus is used to inject the polymer into a mold.
- ❹ The part cools and solidifies.
- ❺ The mold is opened and the part ejected.

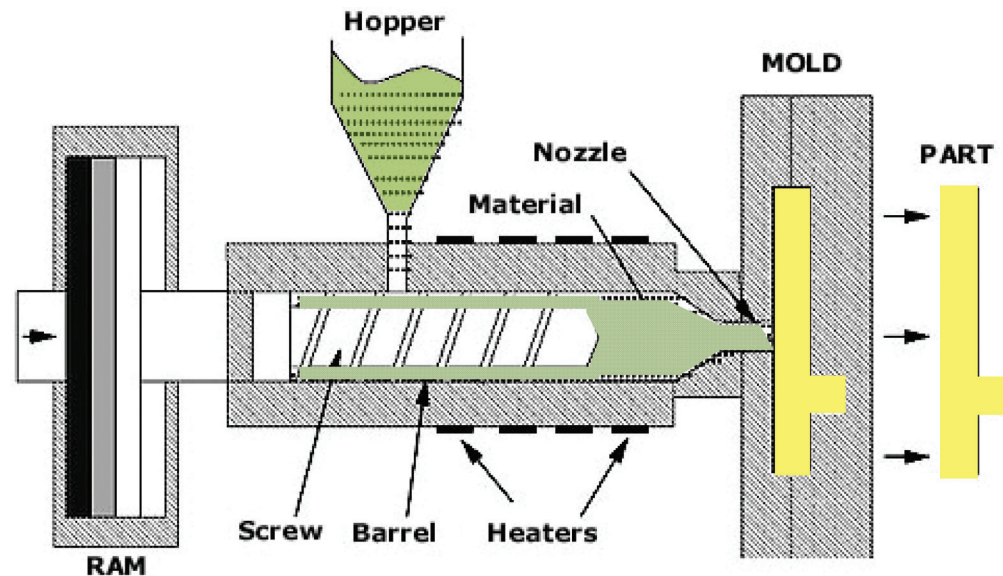


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What is rapid injection molding?

Rapid mold fabrication

- Molds are made from aluminum
- They are 3-axis CNC milled
- Selective use of electrical discharge machining (EDM)

There are limits to complexity

- Rapid Injection Molding is not suitable for overmolding
- Not suitable for inserts
- Number of side actions at the parting line
- No internal threads

Fast real injection molded plastic parts

- CAD to plastic as fast as 1 day
- Standard delivery 10–15 business days

Applications of Rapid Injection Molding

Prototypes. Refine your design with real molded parts

- Functional testing in product development cycle
- Test multiple materials
- Try multiple versions

Bridge tooling

- Production parts until production mold is ready

Low to medium volume production

- 25 to thousands of parts
- Just-in-time parts, use your cash for something other than inventory

Panic situations

- Production line shutdown
- Crash development projects

Markets that use Rapid Injection Molding

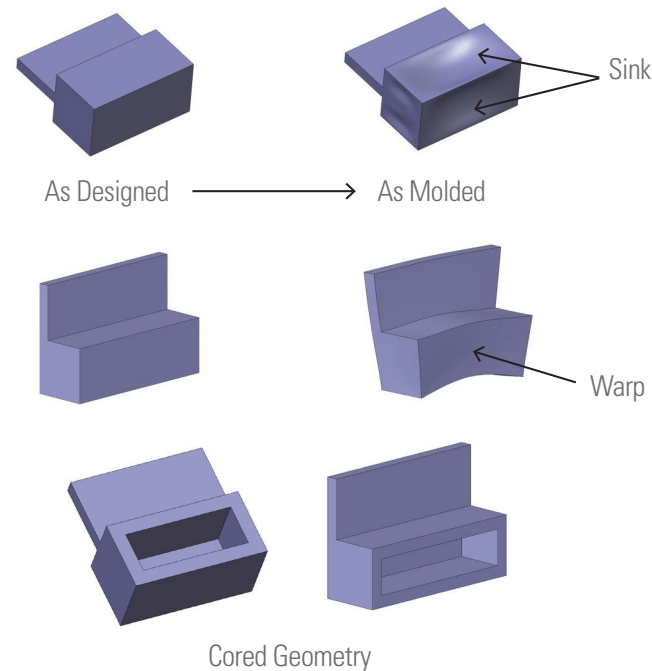
- Medical
- Consumer Products
- Automotive
- Appliance
- Electronics
- Other high volume parts

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Up Against the Wall (Thickness)

The most important design requirement for getting good molded parts: maintain constant wall thickness.

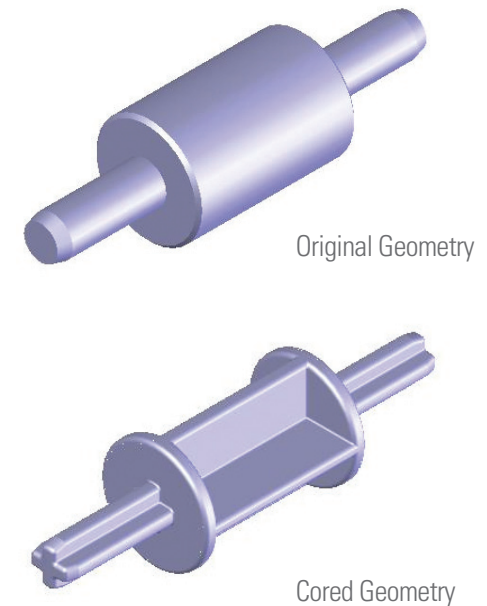


*** Tip:** Good injection molded part design relies on a consistent wall thickness to minimize the potential for warped or distorted parts.

A Core Issue

Core out parts to eliminate thick walls.

- You get the same functionality in a good molded part.



*** Tip:** Unnecessary thickness can throw off part dimensions, reduce strength and necessitate post-process machining.

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Let's Get Absolute

Recommended absolute wall thickness by resin.

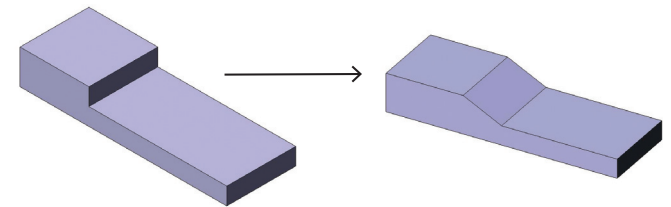
Resin	Recommended Wall Thickness (Inches)
ABS	0.045–0.140
Acetal	0.030–0.120
Acrylic	0.025–0.150
Liquid crystal polymer	0.030–0.120
Long-fiber reinforced plastics	0.075–1.000
Nylon	0.030–0.115
Polycarbonate	0.040–0.150
Polyester	0.025–0.125
Polyethylene	0.030–0.200
Polyphenylene sulfide	0.020–0.180
Polypropylene	0.025–0.150
Polystyrene	0.035–0.150

Note: these are general guidelines, subject to part geometry and molded construction. Large parts shouldn't be designed with the minimum wall thickness.

*** Tip:** Protomold's general rule for wall thickness is 0.040–0.140.

A Warped Personality

Eliminate sharp transitions which cause molded-in stress.



Design 3D structures that support themselves.

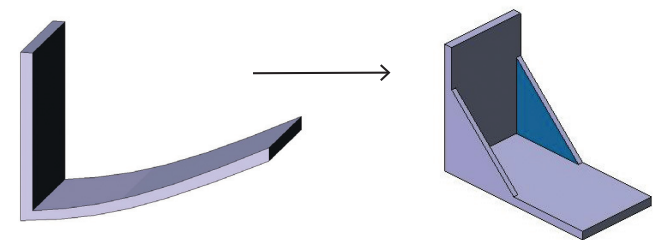


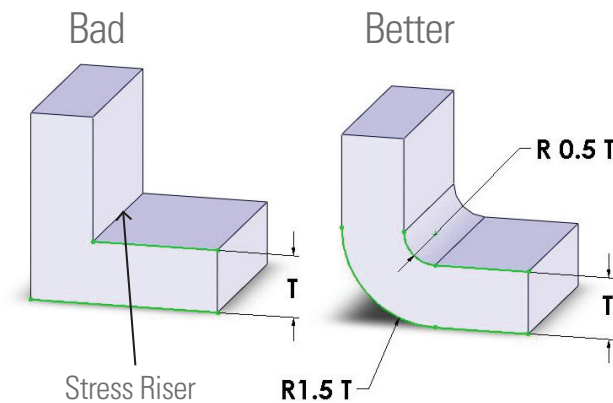
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Get the Stress Out

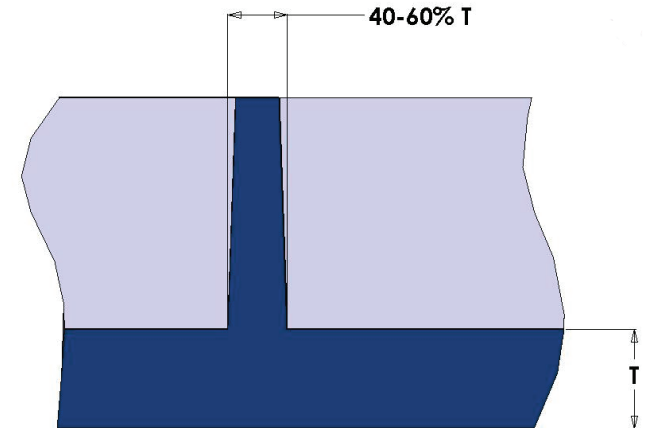
Sharp corners weaken parts.

- They cause molded-in stress from resin flow.
- They form a stress riser in your application.



Give 'em a Good Ribbing

To prevent sink, ribs should be no more than 60% of the wall's thickness.



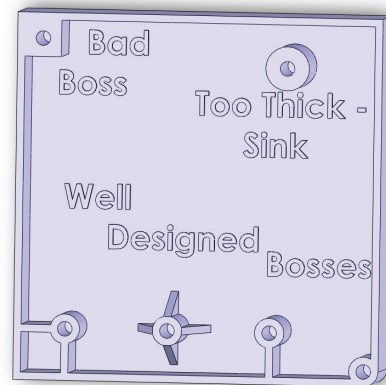
* **Tip:** If Protomold asks for greater wall thickness on your 40–60% T wall, consider increasing your T wall to compensate for this increased thickness to reduce the risk of sink.

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Thin Bosses are In

- Don't create thick sections with screw bosses.
- Thick sections can cause sink and voids in your part.



Get Drafted

Draft (slope the vertical walls) as much as possible—this makes it easier to eject parts without drag marks or ejector punch marks. You get better parts, faster.

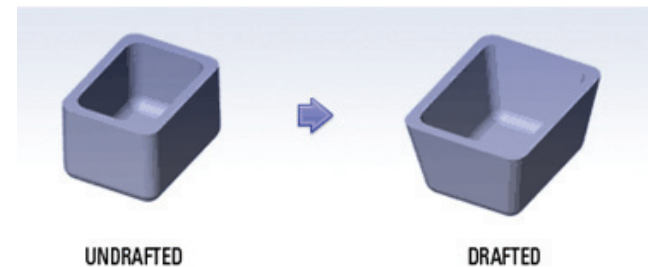
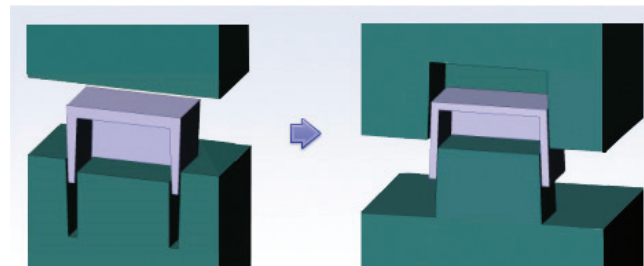


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Core-cavity

When you draft, use core-cavity instead of ribs if you can. It allows you to have constant wall thickness rather than walls with a thick base. We can mill molds with better surface finish and deliver better parts faster.



Deep Rib Approach

Core-cavity Approach

*** Tip:** This option is faster and less expensive to manufacture.

Deep (Milling) Impact

Draft the part as much as possible. This allows us to make deeper features for you. Draft allows us to reduce tool chatter and cosmetic defects when milling deep walls. If you can fit it in, use 1 degree of draft or more. On core-cavity designs, try to use 2 degrees or more. A rough rule of thumb is 1 degree of draft for each of the first two inches of depth. From 2 to 4 inches of depth, either 3 degrees of draft or a minimum of 1/8" thickness may be required.

Texture

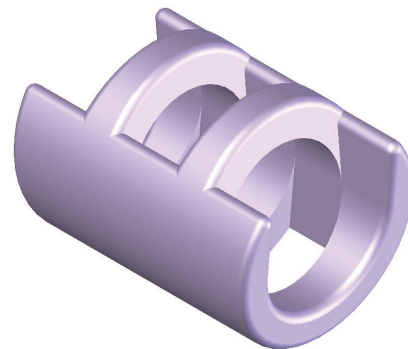
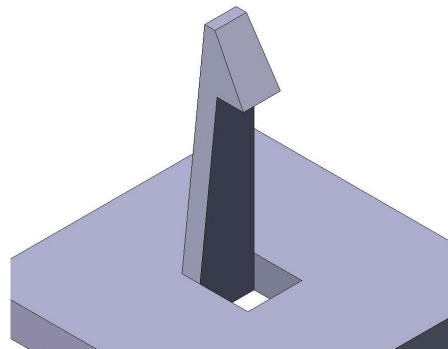
Protomold can add bead blast texture to the mold for your parts. Light texture requires 3 degrees of draft minimum on vertical walls. Medium texture requires 5 degrees.

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Straight (Pull) Shooter

Sliding shutoffs are your friend—these features can be made in a straight-pull mold. They do require 3 degrees of draft, but save significant money over side actions.



Just a Side Action

Side actions can form undercuts on the outside of your part. Undercuts must be on or connected to the parting line. They must be in the plane of the parting line. Protomold can do up to 8 side actions per part.

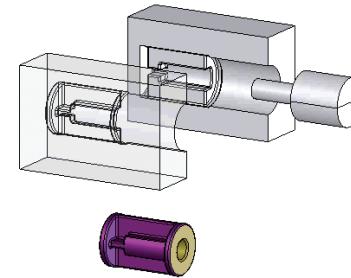
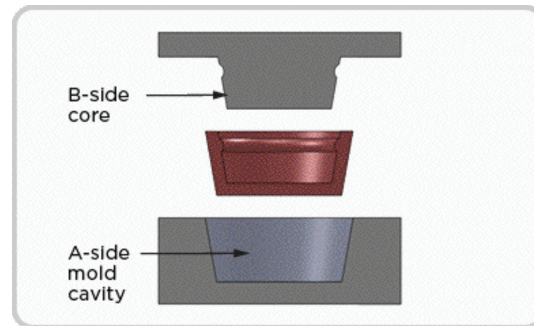


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Bumpoff

A “bumpoff” is a small undercut in a part design that can be safely removed from a straight-pull mold without the use of side actions. Bumpoffs can be used to solve some simple slight undercuts, but are sensitive to geometry, material type, and orientation.



*** Tip:** Mold can be made core-cavity, allowing room for the part to “bumpoff” after the mold opens.

Pickouts

A pickout is separate piece of metal that is inserted into the mold to create an undercut. It is ejected with the part, then removed by the operator and re-inserted in the mold.

*** Tip:** Using a pickout overcomes many shape and positioning restrictions, but is more costly than sliding shutoffs, or using a side action.

High-Aspect-Ratio Small Diameter Holes

These holes can be made with steel core pins in the mold. A steel pin is strong enough to handle the stress of ejection and its surface is smooth enough to release cleanly from the part without draft. There shouldn't be any cosmetic effect on the resulting part, if there is, it will be inside the hole where it won't be seen.

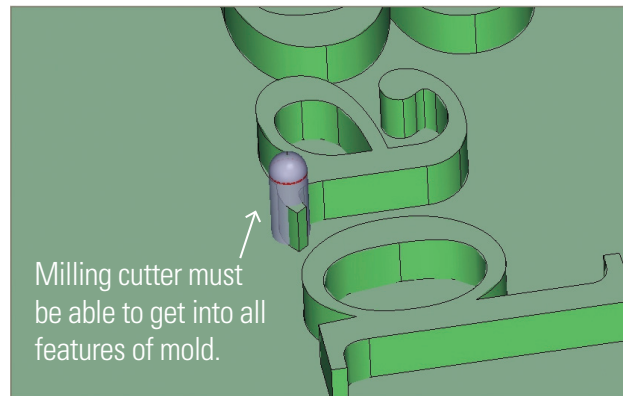
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Watch your Penmanship

Choose a sans serif font where the smallest feature is at least .020" thick. Serif fonts have small tails which are often too small. Text that is raised above the part is better. We cannot polish around it if the text is cut into your part.

- In SolidWorks, Century Gothic 26 point regular font and **16 point bold** create millable text.
- **Comic Sans MS 24 point** also creates millable text.
- For small text, a depth of .010"–.015" often works well to reduce milling cost and improve ejection.



Open the Floodgates

Thin edges restrict flow and can break during gate trimming. We need somewhere thick to gate into your part. There may be alternatives, please contact one of our customer service engineers at 877.479.3680 or customerservice@protolabs.com.

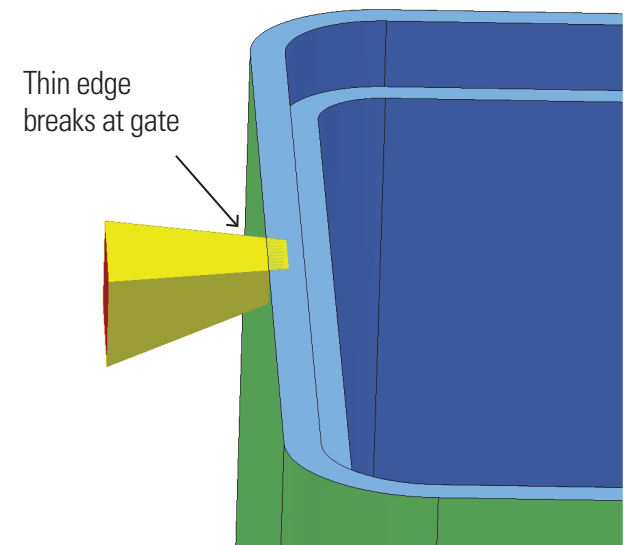


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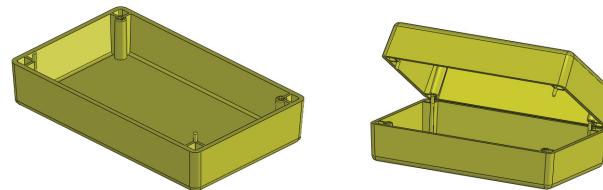
Self-Mating Parts

Identical parts that flip over and mate to themselves are possible and save the cost of a second mold.

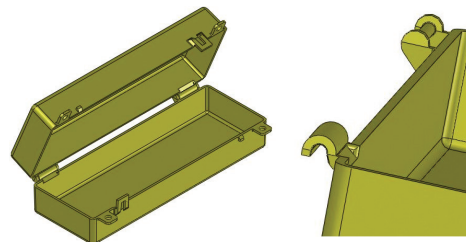
Elements include:

- Peg and hole
- Interlocking rim
- Hooks and latches

Peg and hole/interlocking rim



Hooks and latches



Be Tolerant

- Protomold can hold about ± 0.003 " machining accuracy.
- Shrink tolerance depends mainly on part design and resin choice. It varies from 0.002" per inch for stable resins like ABS and polycarbonate to 0.025" per inch for unstable resins like Santoprene.
- There are techniques for getting the most accuracy out of our process. Please contact a Customer Service Engineer at 877.479.3680 or customerservice@protolabs.com.

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It's Material

When choosing a material for your part, relevant properties might include mechanical, physical, chemical resistance, heat, electrical, flammability, or UV resistance. Resin manufacturers, compounders and independent resin search engines have data online. For resin links, visit www.protomold.com/DesignGuidelines_ResinInformation.aspx#links.

Commodity Resins:
cheap, low to medium properties.

Engineering Resins:
more \$, higher properties.

Colors:
Stock, Semi-Custom, Custom.

Commodity Resins

Polypropylene—soft, tough, cheap, chemical resistant, makes good living hinges

Polyethylene—soft, tough, cheap, chemical resistant

- High Density
- Low Density

Polystyrene—hard, clear, cheap, brittle but can be toughened

Engineering Resins

ABS

- Inexpensive
- Impact Resistant
- Equipment and handheld housings
- Susceptible to sink

Acetal

- More expensive
- Strong
- Good lubricity and machinability
- Very sensitive to excess wall thickness

LCP

- Very expensive
- Very strong
- Fills very thin parts
- Weak knit lines

Nylon

- Reasonable cost
- Very strong
- Susceptible to shrink and warp, particularly glass-filled
- Absorbs water—dimensional and property change

Polycarbonate

- Moderate cost
- Very tough
- Good dimensional accuracy
- Susceptible to chemical stress cracking, voids

Polyesters—PBT, PET

PPS, PSU, PES, PEI

Many, many others

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Select Colors

Stock colors—from the resin vendor are typically black and natural. Natural might be white, beige, amber, or some other color. Semi-custom colors are created when colorant pellets are added to natural resins. For available colors, visit www.protomold.com/DesignGuidelines_ResinInformation.aspx#Colors. There is no added charge for our inventory colors. They are not an exact match and may create streaks or swirls in parts. Custom colors match exactly to a Pantone or color chip. You work with a compounder and provide us the resin. This process is slower and more expensive, but produces a more accurate match.

Resin Additives

(Short) glass fibers are used to strengthen a composite and reduce creep, especially at higher temperatures. They make the resin stronger, stiffer, and more brittle. They can cause warp due to the difference in cooling shrink between the resin and the fibers.

Carbon fiber is used to strengthen and/or stiffen a composite and also to aid in static dissipation. It has the same limitations as glass fibers. Carbon fiber can make plastic very stiff.

Minerals such as talc and clay are often used as fillers to reduce the cost or increase the hardness of finished parts. Since they do not shrink as much as resins do when cooled, they can reduce warping.

PTFE (Teflon) and molybdenum disulfide are used to make parts self lubricating in bearing applications.

Long glass fibers are used like short glass fibers to strengthen and reduce creep, but make the resin much stronger and stiffer. The downside is that they can be particularly challenging to mold parts with thin walls and/or long resin flows.

Aramid (Kevlar) fibers are like glass fiber only not as strong, but less abrasive.

Glass beads and mica flakes are used to stiffen a composite and reduce warping and shrinkage. With high loading they can be challenging to inject.

Stainless steel fibers are used to control EMI (electromagnetic interference) and RFI (radio frequency interference) typically in housings for electronic components. They are more conductive than Carbon fiber.

UV inhibitor for outdoor applications.

Static treatments make resins dissipate static.

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Be the Hero!

- Get real plastic injection molded parts made for your project faster than your competitors.
- Shave days or weeks off the prototyping cycle.
- Save the day in a line-down situation.
- Cut out the middle man—work with a company that has sales and manufacturing on the same campus.

Questions?

Call your Account Manager or a Customer Service Engineer at 877.479.3680.

Protomold is a service of Proto Labs, the world's fastest source for custom CNC machined and injection molded parts.

We offer interactive and highly-illustrated ProtoQuote online quotations, backed up by a streamlined manufacturing system that can ship real injection molded parts in as fast as the next business day.

www.protomold.com

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