

# Designing for Mouldability

VOLUME 1: A RAPID INJECTION  
MOULDING REFERENCE GUIDE FOR  
PRODUCT DESIGNERS AND ENGINEERS

**proto labs**<sup>®</sup>

ADDITIVE MANUFACTURING  
CNC MACHINING  
INJECTION MOULDING

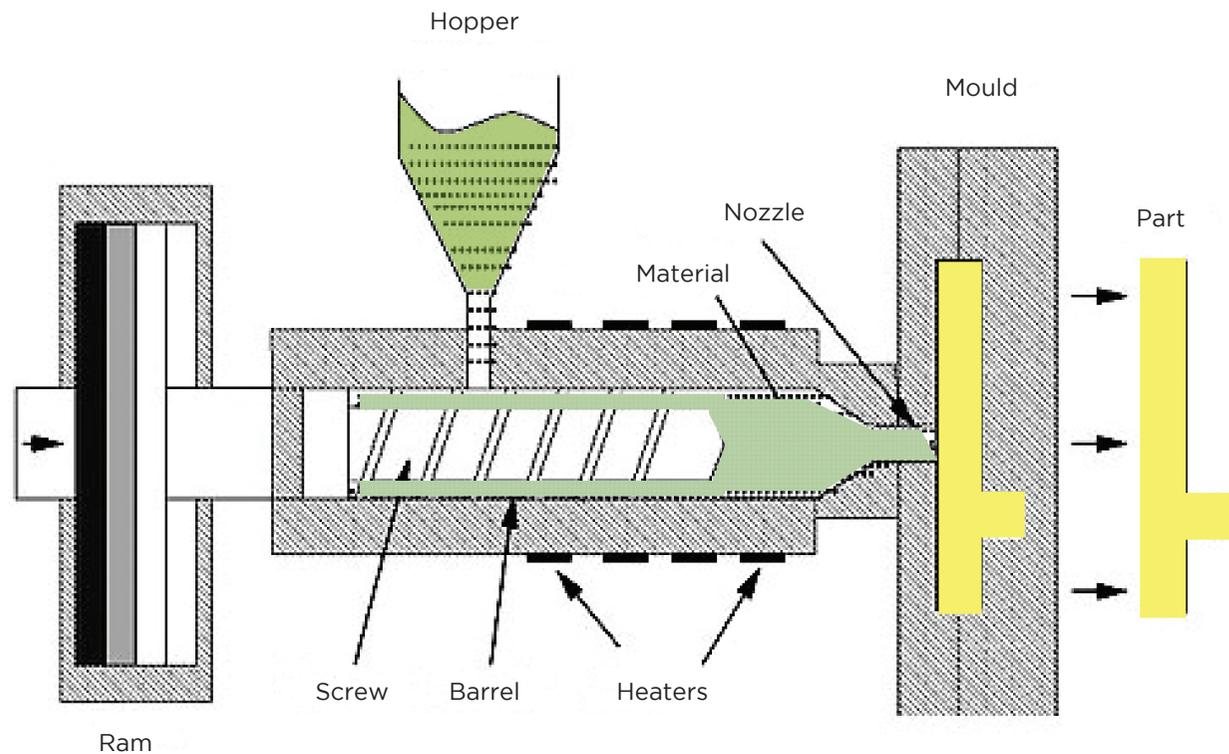
**CPD**  
CERTIFIED  
The CPD Certification  
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**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

# What is injection moulding?

- 1 The hopper is loaded with the plastic stock material.
- 2 A heated barrel is used to melt the beads into a molten form.
- 3 A screw apparatus is used to inject the polymer into a mould.
- 4 The part cools and solidifies.
- 5 The mould is opened and the part ejected.



**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## What is Rapid Injection Moulding?

**Rapid mould fabrication**

- Moulds are made from aluminium
- They are 3-axis CNC milled
- Selective use of electrical discharge machining (EDM)
- Parts in 1 to 15 business days
- Side-action and hand load insert capabilities
- Simple overmoulding capabilities



## Applications of Rapid Injection Moulding

- Refine your design with real moulded prototype parts
- Functional testing in product development cycle
- Test multiple materials
- Try multiple versions
- Make quick iterations
- Bridge tooling
- Low-volume production
- 25 to 10,000 parts
- Support for production line shutdowns
- Crash development project

**Markets that use Rapid Injection Moulding**

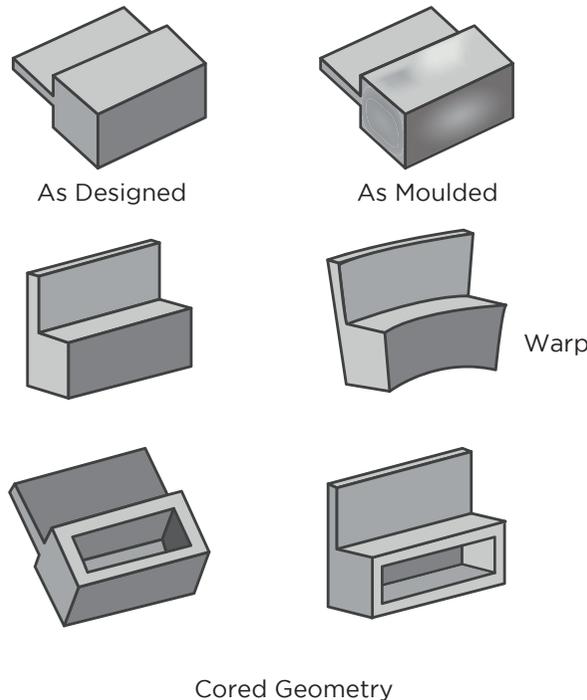
- Medical
- Automotive
- Electronics
- Aerospace
- Consumer Products
- Appliance
- Lighting
- Marine

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Up Against the Wall (Thickness)

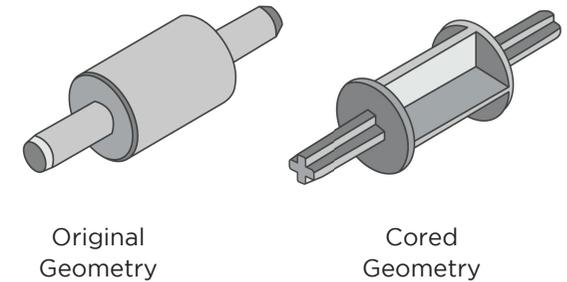
The most important design requirement for getting good moulded parts: maintain constant wall thickness.



**Tip:** Good injection-moulded part design relies on consistent wall thickness to minimise 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 moulded part.



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

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Let's Get Absolute

Recommended wall thickness by resin.

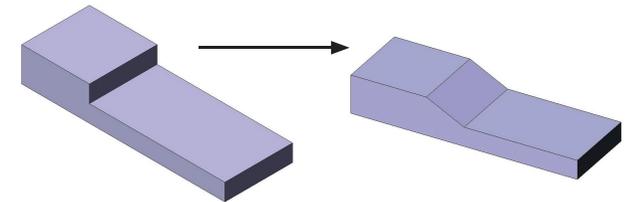
Resin	Recommended Wall Thickness (mm)
ABS	1.14 - 3.50
Acetal	0.64 - 3.05
Acrylic	0.64 - 3.81
Liquid crystal polymer	0.76 - 3.05
Long-fibre reinforced plastics	1.90 - 2.54
Nylon	0.76 - 2.92
Polycarbonate	0.11 - 3.81
Polyester	0.64 - 3.17
Polyethylene	0.76 - 5.08
Polyphenylene sulfide	0.51 - 4.57
Polypropylene	0.64 - 3.81
Polystyrene	0.89 - 3.81

**Note:** These are general guidelines, subject to part geometry and moulded construction. Larger parts shouldn't be designed with the minimum wall thickness.

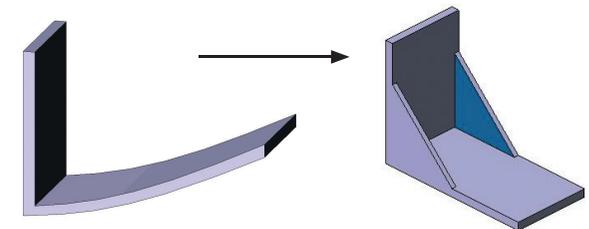
**Tip:** Proto Labs' general rule for wall thickness is 1mm - 3.5mm.

## A Warped Personality

Eliminate sharp transitions that cause moulded-in stress.



Design 3D structures that support themselves.



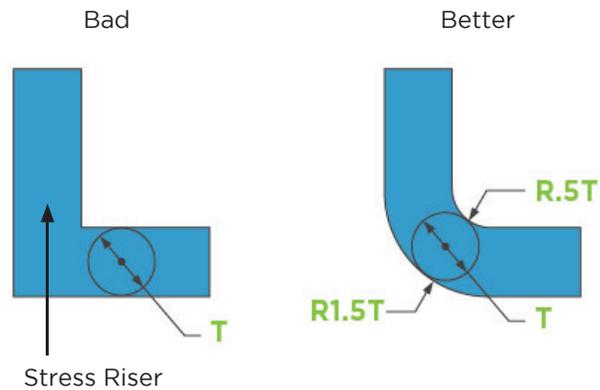
**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Get the Stress Out

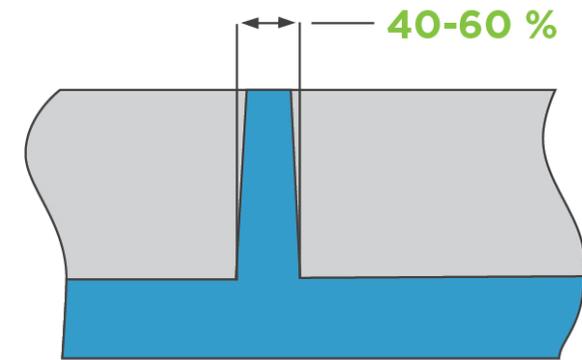
**Sharp corners weaken parts.**

- They cause moulded-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.



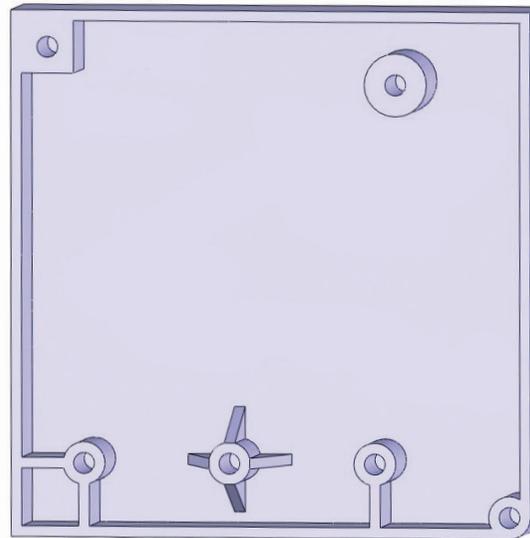
**Tip:** If Proto Labs asks for greater wall thickness on your 40-60% T-wall, consider increasing your T-wall to compensate for this increased thickness to reduce the risk of sink.

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
<b>Bosses</b>	<b>7</b>
<b>Draft</b>	<b>7</b>
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Good and Bad Bosses

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

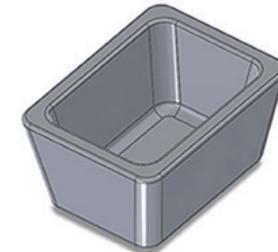


## Don't Be a Draft Dodger

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.



Undrafted



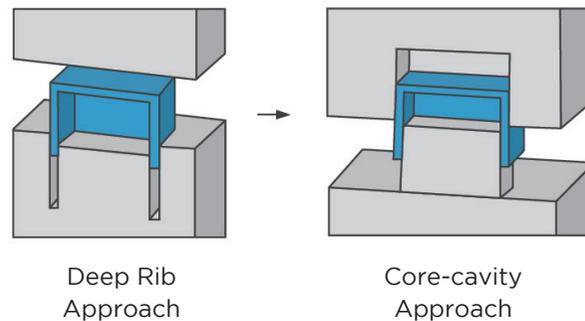
Drafted

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## 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 moulds with better surface finish and deliver better parts faster.



**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 50mm of depth. From 50mm to 101mm of depth, either 3 degrees of draft or a minimum of 3mm thickness may be required.

## Texture

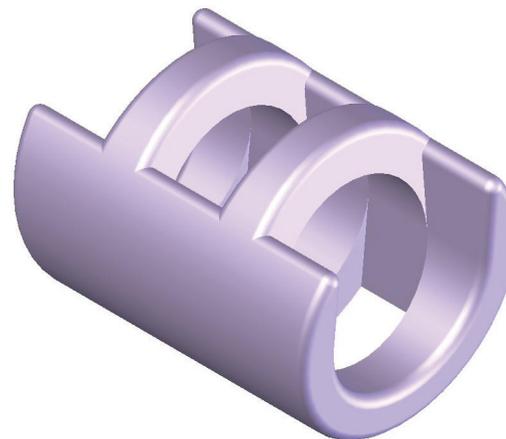
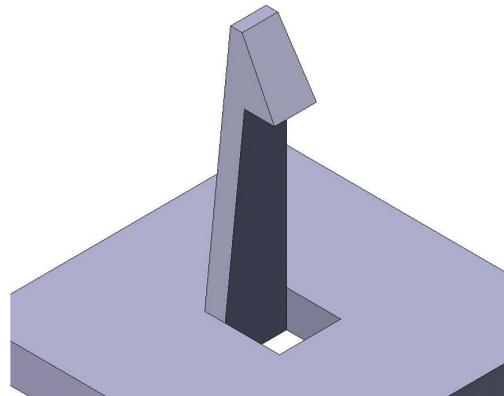
Proto Labs can add bead-blast texture to the mould for your parts. Light texture requires 3 degrees of draft minimum on vertical walls. Medium texture requires 5 degrees.

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

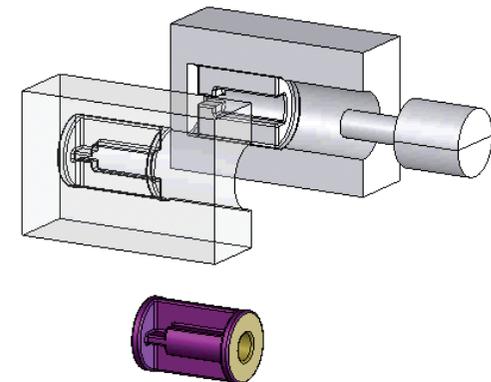
## Straight (Pull) Shooter

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



## Side-Action for Undercuts

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. Undercuts must be connected and perpendicular to the direction the mould is opening.

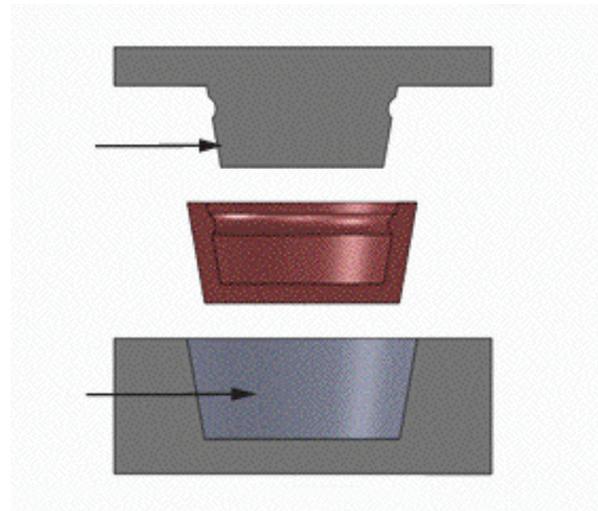


**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Bumpoffs

A bumpoff is a small undercut in a part design that can be safely removed from a straight-pull mould 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:** Moulds can be made core cavity, allowing room for the part to “bumpoff” after the mould opens.

## Pickouts

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

**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 mould. 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.

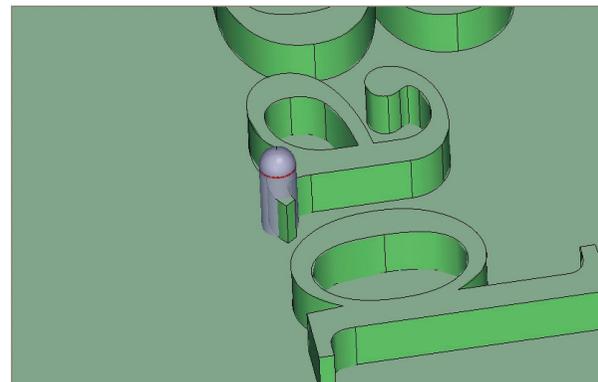
**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
<b>Text</b>	<b>11</b>
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Watch Your Penmanship

Choose a sans serif font where the smallest feature is at least 5.08mm 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.

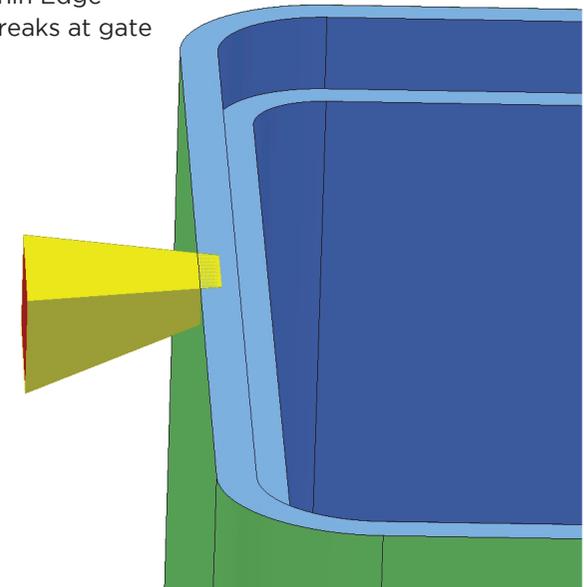
- In SolidWorks, Century Gothic 26 point regular font and 16 point bold create millable text.
- Comic Sans MS 24 point also creates millable text.
- For small text, a depth of at least 5.08mm thick often works well to reduce milling cost and improve ejection.



## 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, so please contact one of our customer service engineers at +44 (0) 1952 683047 or customerservice@protolabs.co.uk.

Thin Edge breaks at gate



**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

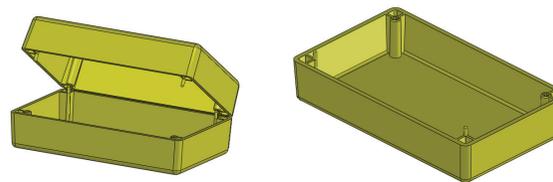
## Self-Mating Parts

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

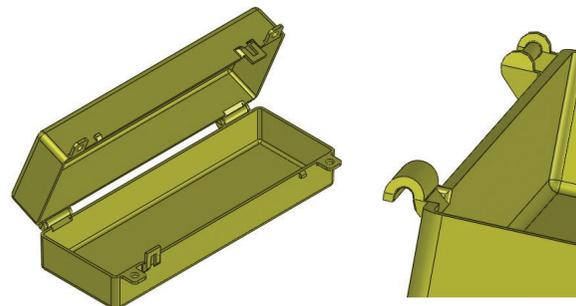
**Elements include:**

- Peg and hole
- Interlocking rim
- Hooks and latches

Peg and hole/interlocking rim



Hooks and latches



## Be Tolerant

Proto Labs can hold about 30.08mm. machining accuracy.

- Shrink tolerance depends mainly on part design and resin choice. It varies from 0.05mm per 25.4mm for stable resins like ABS and polycarbonate to 0.65mm per 25.4mm for unstable resins like TPE.
- There are techniques for getting the most accuracy out of our process. Please contact a customer service engineer at +44 (0) 1952 683047 or [customerservice@protolabs.co.uk](mailto:customerservice@protolabs.co.uk).

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## It's a Material World

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 [protolabs.co.uk/resources#materials](http://protolabs.co.uk/resources#materials).

### 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

#### Colours

No colour-matching, salt/pepper 3% mixture for most stocked colourants, re-compounded material/colourants or customer supplied colourants.

### 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

PBT, PET, PPS, PSU, PES, PEI and many others

**TABLE OF CONTENTS**

What is Injection Moulding?	2
What is Rapid Injection Moulding?	3
Applications of Rapid Injection Moulding	3
Wall Thickness	4
Cored Geometry	4
Recommended Wall Thickness	5
Warp	5
Sharp Corners	6
Ribs	6
Bosses	7
Draft	7
Core-cavity	8
Deep (Milling) Impact	8
Texture	8
Straight-Pull Mould	9
Side-Actions	9
Bumpoff	10
Pickouts	10
Steel Core Pins	10
Text	11
Tab Gate	11
Self-Mating Parts	12
Tolerance	12
Choosing a Material	13
Select Colours	14
Resin Additives	14

## Select Colours

Stock colours from the resin vendor are typically black and natural. Natural might be white, beige, amber or another colour. Semi-custom colours are created when colourant pellets are added to natural resins. For available colours, visit [protolabs.co.uk/resources/molding-materials](https://protolabs.co.uk/resources/molding-materials). There is no added charge for our inventory colours. They may not be an exact match and may create streaks or swirls in parts. Custom colours that need to match an exact Pantone or colour chip need to be compounded with a resin supplier. This process is slower and more expensive, but produces a more accurate match.

### Resin Additives

Short glass fibres 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 fibres. Carbon fibre is used to strengthen and/or stiffen a composite and also to aid in static dissipation. It has the same limitations as glass fibres. Carbon fibre 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 fibres are used like short glass fibres to strengthen and reduce creep, but make the resin much stronger and stiffer. The downside is that they can be particularly challenging to mould parts with thin walls and/or long resin flows. Aramid (Kevlar) fibres are like less-abrasive glass fibres only not as strong.

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 fibres are used to control EMI (electromagnetic interference) and RFI (radio frequency interference) typically in housings for electronic components. They are more conductive than carbon fibre.

UV inhibitor for outdoor applications.

Static treatments make resins dissipate static.

# Questions?

Call your account manager or a customer service engineer at +44 (0) 1952 683047. Proto Labs is the world's fastest digital manufacturing source for custom prototypes and low-volume production parts. Our automated quoting system and proprietary software translate 3D CAD models into instructions for high-speed manufacturing equipment. This enables advanced 3D printing,

CNC machining and injection moulding technologies to produce plastic and metal parts within days. The result is an unprecedented speed-to-market value for product designers and engineers worldwide.

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