

# The Institute For Competitive Product Design

## *Plastic Injection Molding Part Design*

Related to ABS is SAN. This material is missing the butadiene rubber component causing the plastic to be hard, rigid and transparent. It has good chemical resistance, dimensional stability, ease of processing, and clarity. Compared to ABS it has higher tensile and flexural strengths but lower notched izod values.

Polystyrene is a leading low cost thermoplastic. It is characterized by clarity, hardness, good colorability and ease of processing. It tends to be brittle, and has low heat resistance and poor solvent resistance. The impact resistance can be improved by adding small amounts of rubber to create impact polystyrene.

### **BLENDS AND ALLOYS:**

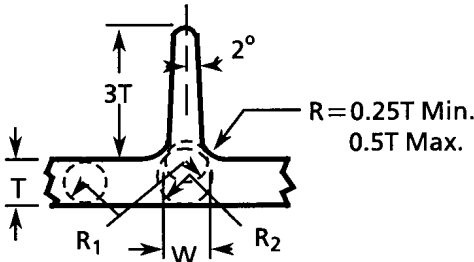
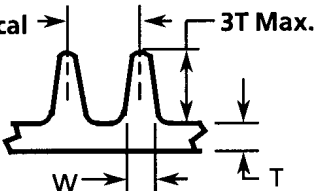
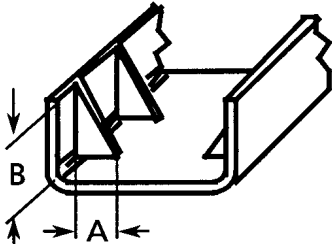
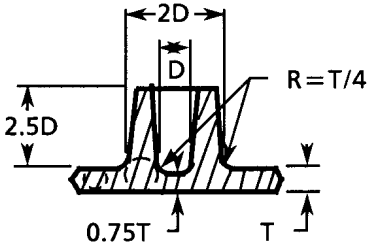
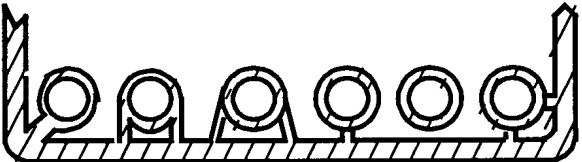
Currently there are over 24,000 plastics including over 500 different types of alloys and blends. The definition of an alloy is: it is a polymer system composed of 2 resins that are mutually compatible with strong intermolecular forces. Each of the two resins have a single glass transition temperature with a single phase. A blend has better properties than its constituents, which are an average of its constituents. A blend has two discrete phases and two glass transition temperatures. For successful blending the two resins need to be compatible. Many times the words alloy and blends are used interchangeably and it is often difficult to distinguish the difference. One of the best known blends is PPO with PS known as Noryl, or PPE with PS known as Prevex. These materials are true alloys. They have good heat and impact properties, are insensitive to moisture, and are good against many chemicals. Another example of a popular blend is the ABS/PC plastic resin. This blend has the properties of heat resistance, easier processability, and low temperature impact strength. Three companies make this material, Borg-Warner, Dow, and Mobay. This material is used on top cases or cosmetic accessories because it does not have some of the processing problems that ABS exhibits such as plate-out in the molds.

### **A SAMPLE OF PLASTIC BLENDS AND ALLOYS:**

<u>ALLOY OR BLEND</u>	<u>KEY PROPERTIES</u>	<u>SUPPLIER</u>	<u>TRADE</u>
PPO / PS	Heat resistance, toughness, improved processing, low cost, low moisture absorption	G.E. Plastics	Noryl
Noryl / ABS	Heat and chemical resistance, good flow, lower cost, low temperature impact.	Monsanto Borg-Warner	Triax Elemid
Nylon / elastomers	Improved toughness and fatigue resistance, chemical and heat resistance.	Du Pont Celanese Wilson	Zytel ST Nylon 7000 Fiberfil TN
PPE / PS	Toughness, heat resistance, improved processing, low cost, low moisture absorption.	Borg-Warner	Prevex
PPO / Nylon / GTX	High temperature resistance, chemical resistance, lower moisture absorption, dimensional stability.	G.E. Plastics	Noryl
ASB / PC	Heat resistance, processability, low temperature	Borg-Warner	Proloy

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## Plastic Injection Molding Part Design

Subject	Rule
Rib Design	<p><math>R_1 \approx R_2</math></p>  <p><math>W \text{ max.} = 0.5T</math>; Non-reinforced Crystalline Thermoplastic</p> <p><math>W \text{ max.} = 0.6T</math>; Non-reinforced Amorphous Thermoplastic</p> <p><math>W \text{ max.} = 0.75T</math>; Reinforced Thermoplastic and Struct. Foam</p>
Rib Height & Spacing	<p><math>3 \times W \text{ Min.}; &gt; 15\text{mm Typical}</math></p> 
Gussets	<p><math>B = 2 \text{ to } 5 \times A</math></p> 
Boss Design	
Boss Attachment	

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## Plastic Injection Molding Part Design

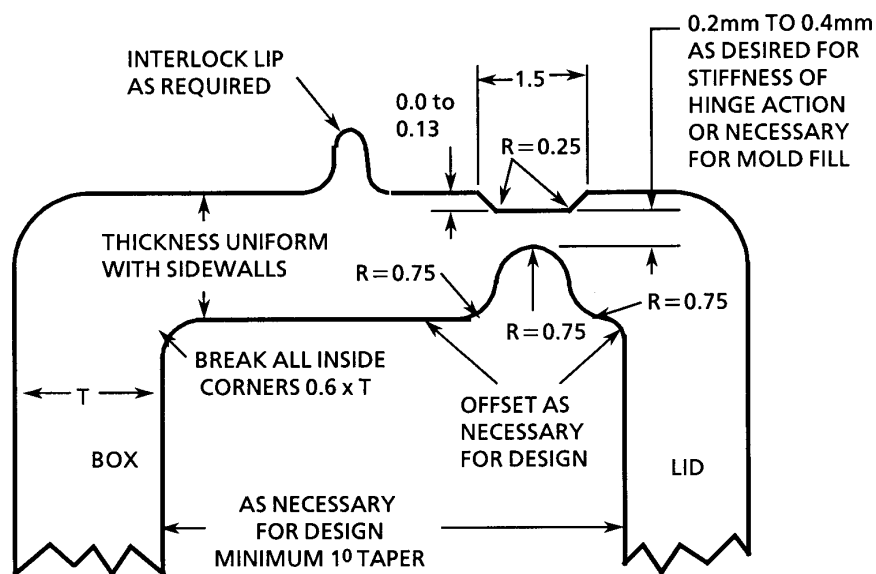
### MOLDED IN HINGE DESIGN

Crystalline materials are best suited for molded-in hinge designs. In particular, polypropylene has been successfully applied to many hinge applications. When crystalline materials are stressed in an appropriate manner, the molecular structure undergoes orientation. This gives these materials extremely high tensile strengths.

Testing of hinges made with polypropylene have exceeded a million flexes. One hinge unit was flexed at 23°C over a 180° angle 300,000 cycles, then at minus 26°C for 300,000 cycles, and finally at 23°C for 300,000 more cycles without failure.

Many applications may call for only a few hundred flexes or less in a lifetime. Some applications may be as low as one flex, such as a hinge of two parts of an assembly. For these applications many materials can be used by the part designer.

#### Hinge Design



The illustration provides the recommended molded-in hinge design parameters. Note the use of radii to improve flow in the mold and reduce notch sensitivity in the area of the hinge. Observe the suggested use of a radiused restriction. This ensures bending at the thinnest point on a straight line along the centerline of the web.

# The Institute For Competitive Product Design

## *Plastic Injection Molding Part Design*

### Light Pipe Design

Acrylic and polycarbonate are good candidates for applications requiring total light reflection. Their excellent clarity, high index of refraction (polycarbonate 1.586) (acrylic) and ability to be molded to a high gloss, make these resins suitable for applications such as edge-lighted insertment panels and advertising signs.

Critical angle, light transmission, light source location, surface quality and surface treatments are all influential factors which can be optimized for success in the design of a light pipe.

Linear, or straight line light piping, is dependent on a critical angle associated with the material. If the incident light ray exceeds this critical angle, the light will not be piped internally and will escape.

Another requirement for piping light is an extremely smooth surface. Scratches on the surface will reflect the light beam externally. This can be advantageous, however, if selective escape of light is desired. This can be accomplished by roughening or engraving the surface to produce angles greater than the critical angle required for total reflection.

The critical angle can be defined as the incident angle for a light wave which produces a refracted light wave parallel to the material interface. In this case, the interface is plastic resin and air. Any incident wave with an angle greater than this critical angle will be totally reflected internally or piped. If the incident wave angle is less than the critical angle, the light wave will be transmitted into the air.

The critical angle ( $k$ ) for total reflection in polycarbonate resin is calculated from the relation:

$$\sin(k) = N_i / N_d$$

Where  $N_i$  the index of refraction of air (1.0  $\sin 90^\circ$ )

$N_d$  the index of refraction of polycarbonate (1.586)

The critical angle for polycarbonate ( $\sin(k) = 1/1.586 = .6305$ )

Polycarbonate critical angle =  $39.1^\circ$  (note)

Acrylic critical angle =  $42.2^\circ$

note: wavelength of sodium at  $20^\circ$  C, other critical angles will vary with wavelength and temperature.

**To design such a curved light pipe in acrylic or polycarbonate resin, the outside curvature or radius must be at least 3X the pipe diameter or plate thickness. This insures that the majority of the light rays propagating through the pipe will impinge on the surface at angles greater than the critical angle.**

From the critical angle calculation above, the angular bend, the deviation from a straight line ( $180^\circ$  angle) should be  $39^\circ$  or less for polycarbonate.