BO-MER
Custom Manufacturing

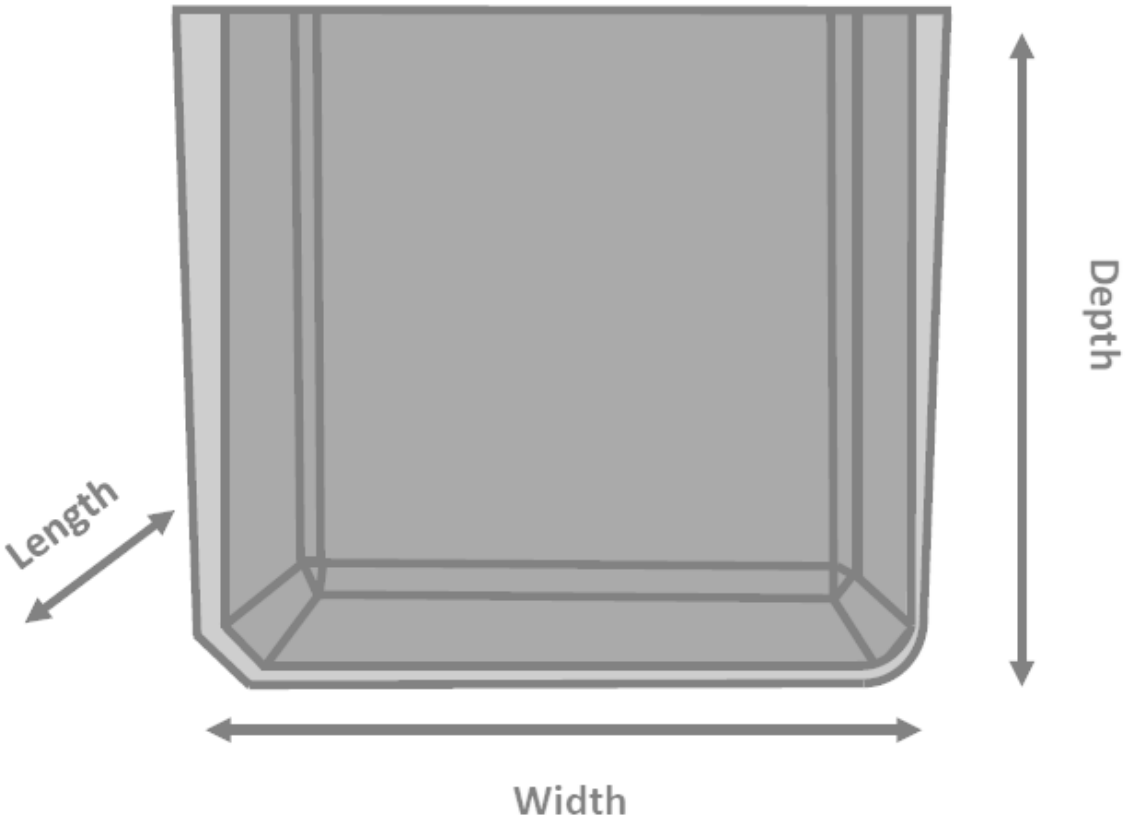
THERMOFORMING DESIGN GUIDE

THERMOFORMING

Thermoforming is a process where an extruded sheet of plastic is heated to a specific forming temperature, formed to the shape of a male or female mold, and then trimmed to fit the desired, detailed finished product. It involves far less tooling and investment than other plastic molding processes, making it an advantageous means of production. Types of thermoforming include; vacuum forming, pressure forming, drape forming, membrane press forming, and free forming. Vacuum forming creates a vacuum between the part and the mold to hold the desired shape as the part cools. Pressure forming uses a vacuum on the mold side of the part and air pressure on the other side of the part to hold the parts shape. Drape forming holds the thickness of the plastic by removing the vacuum and allowing gravity to hold the part against the mold. Membrane press forming is a drape forming with a vacuum. Free forming allows for clarity of the part because the part never touches the mold.

DRAW RATIO

A Draw Ratio is a relationship between the surface area of the part and the area of the base used to find the gauge of plastic you need to make the part. Thermoforming stretches a heated part over or into a mold, creating thin areas that get thinner the more a part is stretched.



$$\frac{\text{Surface Area}}{\text{Base of Part}} = \text{Draw Ratio}$$

$$\frac{lw + 2ld + 2wd}{lw} = \text{Draw Ratio}$$

$$\text{Draw Ratio} \times \text{Finish Gauge} = \text{Minimum Start Gauge}$$

$$\frac{lw + 2ld + 2wd}{lw} \times \text{Finish Gauge} = \text{Minimum Start Gauge}$$

SHARP ANGLES

Creating sharp corners in a part comes at the cost of weakening the final product. Certain techniques can be used to strengthen those corners.

Chamfer

- Turn one corner into multiple, less sharp corners.

Material

- Material properties will affect how sharp a corner can be held by a part. For example, ABS holds a much sharper corner than polycarbonate.

Process

- Choosing a thermoforming process that benefits your design the greatest is an important factor. Pressure forming can make much sharper corners than vacuum forming.

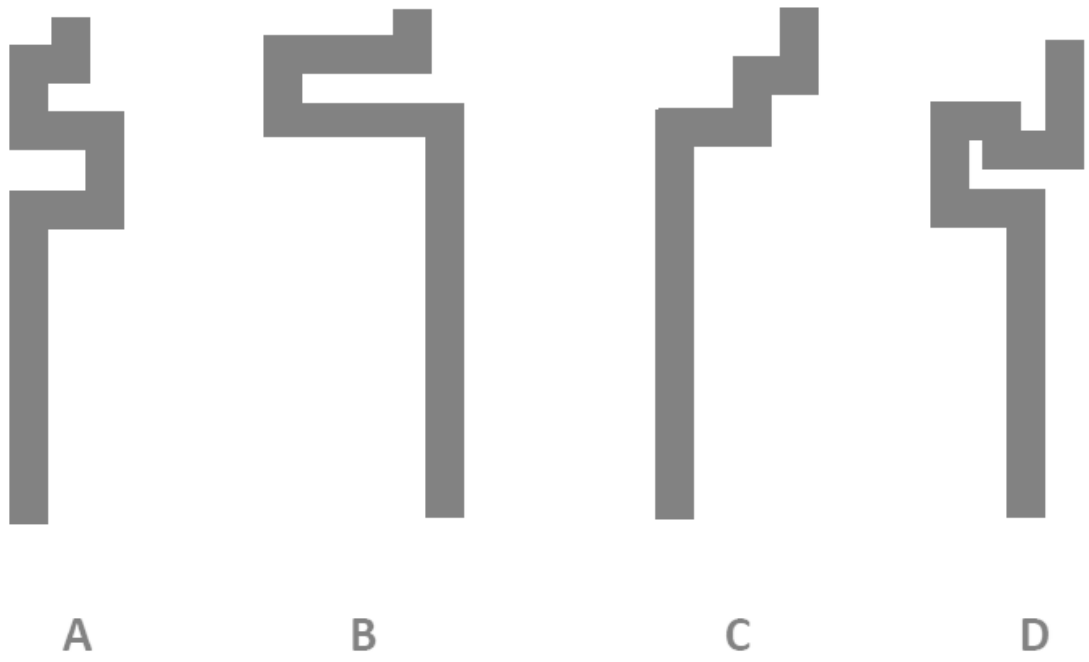
Radii

- Be aware that deeper parts need larger corner radii to accommodate the thin areas created by stretching the part.

Molded Corner Radius	
Depth of Part (in)	Minimum Radius (in)
0.000”- 3.000”	0.015”- 0.125”
3.001”- 6.000”	0.125”- 0.250”
6.001”- 12.000”	0.25” or more
Depth of Part (mm)	Minimum Radius (mm)
0.000- 76.200	.381- 3.175
76.201- 152.400	3.175-6.350
152.401- 304.800	6.350 or more

UNDERCUTS

Understanding undercuts in thermoforming design is important, since they can add significant value to the end product. Benefits of undercuts include increased strength, fastening points, snap fits, and hidden trimmed edges. It is much less expensive to pressure form an undercut, rather than injection mold the feature. Most undercuts require a movable part of the mold to create the feature. Small undercuts made with the right material can occasionally make the part shrink away from the mold, making removal much easier.



A Double Undercut

B Too Deep and Narrow

C Perimeter Undercut

D No Way to Release the Part

Make sure to...

- Include undercuts in draw ratio calculations.
- Step back undercuts that meet at a corner.
- Plan for parting line from mold.
- Ask about the abilities and limitations of different processes.

DRAFT ANGLES

Industry Standard

- 1.5° to 2° for vertical drafts on female features (mold around part).
- 4° to 6° for vertical drafts on male features (part around mold).
- 0° to negative drafts are possible but require special accommodations.

Corrugated Ribs, Louvers, and Vents

- Louvers and ribs are helpful for many designs. Be aware that too many of them close together can create thinning in the part. A good suggestion is to keep the depth and spacing of ribs the same value.

Components and features can be added to thermoformed parts for a variety of reasons; added strength, rigidity and mounting features are common. These are typically made from PVC and adhered to the thermoformed part as needed.

TOLERANCES

All Linear Tolerance (Inches)

All dimensions taken from molded/tooled side.

Molding/Forming: All tolerances based on using machined temperature-controlled tooling.

- ±0.02 for the first 12, 0.001 each additional inch taken from molded side.
- 0.06 surface profile tolerance from mold side
- ±2° all angles.

Trim:

- ±0.005 hole diameters, and slot widths up to Ø1.0, ±0.001 for each additional 0.125.
- ±0.02 molded feature to trim feature for the first 12, ±0.001 each additional inch taken from molded side.
- ±0.015 trimmed edge to holes/slots.
- ±0.010 trimmed hole patterns.
- ±0.015 all other trimmed features.
- 0.125 minimum all machined inside radii.

Rib / Post Assembly

- ±0.03 molded feature to assembled feature for the first 12, ±0.0015 each additional inch taken from molded side.

All Linear Tolerance (Millimeters)

All dimensions taken from molded/tooled side.

Molding/Forming: All tolerances based on using machined temperature-controlled tooling.

- ±0.5 for the first 305, 0.03 each additional 25 taken from molded side.
- 1.53 surface profile tolerance from mold side.
- ±2° all angles.

Trim:

- ±0.13 hole diameters, and slot widths up to Ø25, ±0.03 for each additional 3.
- ±0.5” molded feature to trim feature for the first 305, ±0.03 each additional 25 taken from molded side.
- ±0.38 trimmed edge to holes/slots.
- ±0.25 trimmed hole patterns.
- ±0.38 all other trimmed features.
- 3.18 minimum all machined inside radii.

Rib / Post Assembly

- ±0.75 molded feature to assembled feature for the first 305, ±0.038 each additional 25 taken from molded side.

Tolerances may need to be modified depending on process and/or part geometry

(i.e. mold construction, part material)

NOTES

The above illustrates some of the industry standards in thermoforming and are not set in stone.

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