



WHITE PAPER

# When to Thermoform, and How to Design for It

*A practical guide to heavy and light gauge thermoforming for packaging engineers and buyers*

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## Executive Summary

Thermoforming is a family of processes, not a single one. Picking the right one starts with two questions. First, is the part better suited to thermoforming or injection molding? Second, if thermoforming wins, does the part run on a light gauge inline machine or a heavy gauge sheet-fed machine? Get those two answers right and the rest of the design follows.

This paper is for the packaging engineer or buyer scoping a thermoformed part. It walks through the threshold decision against injection molding, the heavy versus light gauge call, and the design rules that govern both. It covers the materials that actually run on a thermoforming line, the realities of tooling and lead time, and the RFQ inputs that turn a vague conversation into a real quote.

The short version: thermoforming wins under roughly 10,000 parts per year, when geometry is one-sided, and when the design is still moving. Injection molding wins above that volume, when geometry needs two-sided detail, and when the part is locked. Most engineering teams should run both processes for different parts in the same product family. Knowing which one to pick is the value.

## 1. Thermoforming or Injection Molding

This is the first decision. It drives tooling cost, lead time, design freedom, and per-part cost. Get it wrong in either direction and the program either pays for a steel mold it never amortizes, or it slogs through three years of unit cost that should have been half.

Thermoforming heats a plastic sheet until it sags, then pulls it down (or pushes it up) against a one-sided aluminum tool. Vacuum or air pressure conforms the sheet to the tool. The part cools, trims, and ejects. The other face is whatever the back of the sheet looks like after it stretched.

Injection molding clamps a two-sided steel mold shut, injects molten resin under high pressure, cools the part, and ejects. Both faces of the part are designed. Walls are uniform. Detail is fine.

### SIDE-BY-SIDE: THERMOFORMING VS. INJECTION MOLDING

Factor	Thermoforming	Injection molding
<b>Tooling cost</b>	\$2,000 to \$30,000 (aluminum, one-sided)	\$30,000 to \$300,000+ (steel, two-sided)
<b>Tooling lead time</b>	2 to 6 weeks	12 to 24 weeks
<b>First-article lead time</b>	4 to 8 weeks from PO	16 to 28 weeks from PO
<b>Per-part cost (low volume)</b>	Wins below ~10,000 parts/year	Higher fixed cost dominates

Factor	Thermoforming	Injection molding
Per-part cost (high volume)	Loses above ~50,000 parts/year	Wins, sometimes by 5x or more
Wall thickness	Thins in the draw direction (50% at deep features is typical)	Consistent, designed-in
Geometry detail	One-sided detail (the side that contacts the tool)	Two-sided detail, fine features, ribs, bosses
Undercuts	Limited without secondary trimming or slides	Designed in with slides, lifters, collapsible cores
Part size	Up to 46 x 54 inches at Kiva, larger possible elsewhere	Typically smaller, driven by press tonnage
Design iteration cost	Low. Rev tooling in weeks for a few thousand dollars.	High. Steel tool revisions are slow and expensive.

*The breakeven sits roughly between 10,000 and 50,000 parts per year, depending on part size, complexity, and tolerance. Below that band, thermoforming almost always wins. Above it, injection molding usually does. The middle is where the design and material drive the call.*

## 2. Heavy Gauge or Light Gauge

Once thermoforming is the right process, the next question is which kind. Heavy gauge and light gauge are different machines, different tools, different cycle times, and different applications. Calling a thermoforming shop without knowing which one you need is fine. Sending a 4 by 4 foot machine guard to an inline thin-gauge line is not.

### HOW LIGHT AND HEAVY GAUGE DIFFER

Factor	Light gauge (thin gauge)	Heavy gauge
Sheet thickness	0.015 to 0.080 inch	0.080 to 0.300 inch (Kiva range)
Typical equipment	Inline thermoformer, roll-fed or sheet-fed	Sheet-fed thermoformer, individual sheets loaded
Cycle time	Seconds per cavity, multi-up tools common	30 seconds to several minutes per part
Volume sweet spot	5,000 to 500,000+ parts per program	100 to 10,000 parts per program
Common applications	Clamshells, blisters, food trays, dunnage cradles, electronics trays, medical pouch trays	Machine guards, equipment housings, medical device trays, automotive interior panels, kiosk skins, large dunnage
Tooling	Aluminum, multi-cavity, often family	Aluminum, single-part, larger footprint

Factor	Light gauge (thin gauge)	Heavy gauge
	tools	
<b>Typical tolerance</b>	±0.020 inch on formed features	±0.030 inch on formed features, tighter with secondary trim
<b>Kiva equipment</b>	2 inline thermoformers, max sheet 23.5 x 18.5 inch	4 sheet-fed thermoformers, max sheet 46 x 54 inch

The sheet thickness draws the line, but the real decision is application and volume. A 0.040 inch ABS clamshell at 100,000 units per year is light gauge. A 0.187 inch ABS machine guard at 500 units per year is heavy gauge. The same shop can run both if it has both machine types in-house, which is how most jobs get scoped without ping-ponging between vendors.

### 3. Design Rules That Apply to Both

Thermoforming follows physics, and the physics are the same whether the sheet is 0.030 inch or 0.250 inch. These rules are the difference between a part that runs and a part that fights the tool every cycle.

#### Draft Angle

Thermoformed parts pull off the tool after the sheet cools. Draft is the angle on every vertical wall that lets the part release without sticking or distorting. Minimum draft on a female (cavity) tool is 3 degrees. Minimum on a male (positive plug) tool is 1 degree. Textured surfaces need more, usually 5 to 7 degrees, because the texture grabs the tool.

Zero-draft walls are the most common cause of formed parts that come out warped, scuffed, or stuck. There is no fix in production. The fix is at the drawing stage.

#### Radii

Sharp corners do not exist in thermoforming. The sheet cannot bend tighter than its own thickness. Inside radii should be at least equal to the starting sheet thickness. Outside radii should be 1.5 times the sheet thickness. Larger radii form more easily, distribute stress better, and reduce thinning at the corner.

#### Wall Thinning

Sheets thin as they draw. A 0.187 inch starting sheet drawn 2 inches deep into a narrow pocket can hit 0.080 inch at the bottom corner. Plan for the minimum thickness at the deepest draw point, not the starting thickness. As a working rule, expect the deepest feature to be 40 to 60 percent of the starting gauge.

## Draw Ratio

Draw ratio is how deep a feature is relative to its narrowest opening. For female (cavity) tools, depth should be no more than half the narrowest opening. For male (plug) tools, depth can equal the width. Beyond those ratios, the sheet thins too aggressively and the part fails in service.

## Undercuts

Thermoforming forms over or into a one-sided tool. True undercuts (features that hook under the tool) cannot be molded in. The workarounds: design the undercut as a secondary trim, use a collapsible core or slide on the tool (raises tooling cost), or split the part into two pieces. The right move depends on volume and aesthetics. Talk it through with the fabricator before locking the design.

## Tolerances

Default formed-feature tolerance is  $\pm 0.030$  inch. Trimmed and CNC-machined features can hold  $\pm 0.010$  inch. Hole locations on a CNC-routed trim hold tighter than holes formed into the part. If a feature is critical, plan to trim it after forming.

## 4. Material Selection

Thermoforming runs a wide range of resins. The material drives clarity, impact, chemical resistance, temperature, regulatory compliance, and cost. The right call usually starts with the environment the part lives in, not a preference for a specific resin.

Material	Strengths	Best fit
PETG	Clear, easy to form, food contact	Medical pouch trays, retail blisters, food packaging, displays
RPET / PET	Clear, recycled content, FDA grades available	Food trays, sustainable packaging programs
ABS	Tough, impact resistant, low temp ductile	Machine guards, equipment housings, automotive interior
Polycarbonate	Clear and impact resistant, flame ratings available	Machine guards, displays, ballistic and high-impact covers
HDPE / HMWPE	Chemical resistant, abrasion resistant	Industrial dunnage, chemical handling, wear surfaces
Kydex	Durable, scratch resistant, flame retardant grades	Military, mass transit, medical equipment skins

Material	Strengths	Best fit
Acrylic	Optical clarity, rigid	Displays and signage, light covers
Polypropylene	Chemical resistant, low cost, fatigue resistant	Reusable trays, living-hinge features, chemical handling
PVC	Rigid, flame retardant grades, low cost	Industrial enclosures, signage
Styrene (HIPS)	Low cost, easy to print	Disposable trays, point-of-purchase
ESD / conductive grades	Surface or volume resistivity for static control	Electronics handling, ESD-sensitive parts

*Pick the material for the worst case the part will see, then check cost. Specifying a premium resin for an indoor warehouse part is wasted money. Specifying a commodity resin for an aerospace cleanroom is a recall.*

## 5. Cost and Lead Time Reality

The cost story for thermoforming has three numbers: tooling, per-part, and total program cost. Tooling is low (a few thousand dollars to thirty thousand). Per-part runs higher than injection molding at scale. Total program cost is the only number that matters.

Below roughly 10,000 parts per year, the tooling savings outweigh the per-part premium. A program that runs 2,000 heavy gauge equipment housings per year on a \$12,000 aluminum tool delivers parts for years at lower total cost than the same program on a \$180,000 injection mold.

Lead time tells the same story. A new thermoforming tool prints in two to six weeks. A new injection mold runs twelve to twenty four. For a program that needs first-article in eight weeks, thermoforming is the only option that hits the date.

*The most expensive thermoforming program is one that should have been injection molded, and vice versa. Running the numbers up front is cheap. Tooling rework is not.*

## 6. What to Send a Fabricator for a Fast Quote

Same logic as any RFQ: the more complete the package, the faster and more accurate the quote. Here is the thermoforming-specific checklist.

- 1 Part drawing or 3D file.** STEP or IGES preferred. Include the contact surface, since thermoforming detail lives on one side of the part.

2	<b>Material or environment.</b> Pick the resin, or describe the environment (temperature, chemical, ESD, clarity, UV) and let the fabricator recommend.
3	<b>Starting gauge.</b> If known. If not, the fabricator will spec based on part depth and stiffness needs.
4	<b>Quantity and cadence.</b> First order, annual volume, expected program life.
5	<b>Tolerance requirements.</b> Critical dimensions and what tolerance they need. Default thermoforming tolerance is $\pm 0.030$ inch on formed features.
6	<b>Trim and secondary operations.</b> Holes, slots, edge trim, heat staking, inserts, printing, painting, assembly.
7	<b>Cosmetic requirements.</b> Texture, color, finish, surface critical for visible parts.
8	<b>Compliance.</b> AS9100, ISO 9001, FDA, UL94, ITAR, REACH, RoHS, cleanroom.
9	<b>Hardware and assembly.</b> Threaded inserts, ESD bonding, gaskets, foam, fasteners installed at fabrication.
10	<b>Lead time target.</b> First-article date and production ramp.

*Don't know the gauge, material, or trim spec? Send what you have and let the fabricator recommend. A capable shop will quote a few options and explain the tradeoffs. That is faster than sending a blank RFQ that comes back with twelve questions.*

## About Kiva Container Corporation

Kiva Container Corporation is a custom thermoforming and corrugated plastic shop in Anaheim, California. Founded in 1986. AS9100D and ISO 9001:2015 certified. Women-owned. All design, tooling, and production in-house at a single facility.

### THERMOFORMING CAPABILITIES

- 2 inline thermoformers, max sheet size 23.5 by 18.5 inches (light gauge)
- 4 sheet-fed thermoformers, max sheet size 46 by 54 inches (heavy gauge)
- Gauge range 0.015 to 0.300 inches
- Materials run: PVC, RPET, PET, PETG, ABS, styrene, polycarbonate, acrylic, HDPE, PE, HMWPE, Kydex, and a range of ESD and conductive grades
- 3 multi-ton presses for thermoformed part trimming and die-cutting
- In-house aluminum CNC tooling, built on Kiva's own CNC mills
- In-house 3D printing for prototyping and fabrication aids
- In-house screen printing and Canon 1260GT flatbed digital printing
- Hardware and finishing: heat staking, inserts, grommeting, rivets, strapping

- Full design through production cycle, no outsourcing

Most customers are packaging engineers and buyers in aerospace, medical, and material handling. Order profile runs from short prototype runs to repeat production. Custom engineering is the default, not the exception.

*If you have a thermoforming program coming up and you are not sure whether it should be heavy gauge, light gauge, or injection molded at all, send what you have. We will tell you what we would do before we quote it.*

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