WHITE PAPER

Designing Reusable Packaging That Earns Its Keep

A practical guide to corrugated plastic fabrication for packaging engineers and buyers

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Executive Summary

Packaging is the easiest line item to underspend on and the most expensive to underspend on. A returnable tote that fails at trip 40 instead of trip 400 does not cost ten times more. It costs every minute the line stopped, every damaged part inside it, and every replacement cycle the buyer has to manage.

The math of reusable packaging is simple. Total cost divided by total trips. A $35 corrugated plastic tote that runs 500 cycles costs $0.07 per trip. A $4 cardboard box that runs once costs $4.00 per trip, plus disposal, plus the labor to break it down. The cheap box is not cheap.

This paper is for the packaging engineer or buyer who has already made the decision to move to reusable plastic and now has to spec it well. It covers what corrugated plastic actually is, the five design decisions that drive performance, the fabrication processes that turn a sheet into a part, and the application-specific tradeoffs for totes, dunnage, dividers, and trays. It closes with an RFQ checklist so the first quote you get back is a real one.

1. What Corrugated Plastic Actually Is

Corrugated plastic, sometimes called coroplast or fluted polypropylene, is a twin-wall sheet of polypropylene with vertical ribs running between two flat faces. The structure is the same idea as corrugated cardboard. The material is polymer instead of paper. It does not absorb water. It does not delaminate. It does not produce dust. It flexes without cracking down to about minus 20 degrees Fahrenheit.

Sheets come in gauges from 2mm to 10mm. Most reusable packaging lands between 4mm and 6mm. Thinner sheets are used for printed signage and short-life dunnage. Thicker sheets are used for heavy totes, structural dividers, and applications where stack load matters.

Standard sheets are stocked in a range of colors at most converters. Specialty grades exist for static-sensitive electronics (ESD and conductive), cleanroom environments, flame retardance, and UV exposure. Specifying the grade up front matters. A 4mm natural sheet and a 4mm ESD sheet look identical and cost different.

HOW CORRUGATED PLASTIC COMPARES TO ALTERNATIVES

Material	Typical life (trips)	Weight	Moisture	Tooling cost	Unit cost
Corrugated plastic	100 to 1,000+	Low	None	Low	Medium
Cardboard	1 to 5	Lowest	Fails	None	Lowest

Material	Typical life (trips)	Weight	Moisture	Tooling cost	Unit cost
Wood crating	5 to 20	Highest	Warps	Medium	Medium
Foam (EPP, EPE)	10 to 100	Low	None	High	Medium
Injection-molded plastic	1,000+	Heavy	None	Very high	High

> *The honest read: corrugated plastic sits in the middle on durability and at the bottom on tooling cost. That combination is why it dominates returnable packaging for medium-volume programs where the engineering changes every 18 months and a $30,000 injection mold cannot be justified.*

2. The Five Design Decisions That Drive Performance

Every reusable packaging part comes down to five decisions. Get all five right and the part runs for years. Get one wrong and you are buying replacements.

Decision 1: Gauge

Gauge is the sheet thickness. Below 4mm, the part flexes too much for reusable handling. Above 6mm, it gets heavy and harder to fold and weld cleanly. The middle ground is where most totes and dividers live.

A useful rule: pick gauge to match the worst case load and handling, not the average case. Most failures happen when a tote gets stacked off-center, dropped from waist height, or loaded heavy with the corners unsupported. Design to the bad day.

Decision 2: Flute Direction

The flutes inside the sheet run in one direction. Strength along the flutes is roughly 4 to 6 times higher than across them. This matters in two places.

First, stacking. A tote stacked on its corners gets compression load down through the side walls. The flutes in the walls should run vertically. If they run horizontally, the walls buckle.

Second, folding. The sheet folds cleanly across the flutes and resists folding along them. Fold lines in a die-cut blank have to be oriented across the flutes. A part designed without thinking about flute orientation will not fold flat, or it will crack on the first fold.

Decision 3: Joining Method

Three options. Each has a place.

- Sonic welding fuses two sheets of compatible plastic by vibrating them at ultrasonic frequency. Fast, clean, and permanent. Good for high-volume assembly of dividers, partitions, and tray seams. No fasteners and no consumables.
- Flat welding, sometimes called hot-plate welding, melts the surface of two sheets and presses them together. Slower than sonic but works on parts that are too big or too irregular for a sonic horn. Kiva runs a proprietary flat welding setup in-house for large totes and structural panels.
- Mechanical fasteners (rivets, snaps, knock-down hardware) are the right call when the part needs to be assembled by the end user, when the design has to be field-serviceable, or when the geometry has too many angles for a weld fixture. Knock-down totes shipped flat and assembled at the line are usually mechanically fastened.

The wrong joining method makes a good design fail. A sonic weld on the wrong polymer blend will not hold. A rivet in a high-flex location will work itself loose. Walk through the part with the fabricator before locking the joining decision.

Decision 4: Hardware and Finishing

Most reusable packaging needs at least one of: handles, grommets, strapping, drains, vents, RFID pockets, label windows, or guide pins. The decision is which features to integrate at the fabrication stage and which to add at assembly.

Integrated features (heat-formed handles, die-cut vents, screen-printed labels) cost less per unit and last longer. Bolt-on features (snap-in handles, adhesive labels, riveted grommets) cost more per unit but allow late-stage customization.

For programs with stable artwork and stable spec, integrate. For programs with frequent revisions or customer-specific labeling, modularize.

Decision 5: Regulatory and Environmental Grade

If the part touches static-sensitive electronics, specify ESD or conductive grade. If it enters a cleanroom, specify cleanroom-compatible material and ask about particulate testing. If it sees outdoor UV, specify UV-stabilized resin. If it touches food, specify FDA-grade.

These grades are not interchangeable. ESD sheet is not cleanroom sheet. UV sheet is not food grade. Trying to make a single sheet do everything will either cost more than necessary or fail in service. Spec the grade for the actual environment.

3. How Corrugated Plastic Is Fabricated

There are five fabrication processes that turn a sheet into a packaging part. A serious fabricator runs all five in-house. Outsourcing tooling or print means longer lead times and more revision cycles.

Die-Cutting

A steel rule die is a plywood form with sharp steel blades inlaid along the cut and crease lines. The die goes into a flatbed press and stamps the sheet in one stroke. Die-cutting is the fastest, lowest-per-unit way to make medium and high volume parts. Tooling cost runs from a few hundred dollars for a simple divider to a few thousand for a complex tote blank. Tooling lasts for tens of thousands of cycles.

Use a steel rule die when the design is locked, the volume justifies the tooling, and the geometry is repeatable.

Digital Routing and Cutting

A CNC routing table cuts corrugated plastic with a spinning bit or oscillating blade. No tooling, no dies. The file goes from CAD straight to the table. Slower per part than die-cutting but flexible. A routing table will cut a one-off prototype, a 50-piece short run, or a new revision the same day.

Kiva runs a Gerber M3000 turbo router with a 75 by 120 inch cutting area, and a Pioneer flatbed die-cutter with a 78 by 150 inch bed. Prototypes and revisions go on the router. Production volume goes on the die-cutter. Most programs start on the router and move to the die-cutter once the design is locked.

Sonic Welding

Ultrasonic welding fuses compatible polypropylene sheets in fractions of a second. The horn vibrates at roughly 20 kHz, and the friction heats the contact zone above the polymer melt point. No adhesive, no filler, no curing. The bond is as strong as the parent material when the joint is designed correctly.

Sonic welds are best for inline production: divider crosses, partition assemblies, repeating seams on trays and shippers.

Flat Welding

For seams too long for a sonic horn or geometry that does not fit a fixture, flat welding (hot-plate welding) is the alternative. A heated platen contacts the two pieces, melts the surface, and the parts are pressed together while cooling.

Flat welding is slower than sonic but produces a continuous seam on parts that sonic cannot reach. Kiva developed a proprietary flat welding process in-house for large totes and full-perimeter seams.

Wire Bending and Structural Fabrication

Sometimes the part needs more rigidity than corrugated plastic alone can provide. A bent steel wire frame inside or along the perimeter of a tote or divider adds load capacity, holds geometry under compression, and survives repeated impact without fatigue.

In-house wire bending lets the structural design get tuned to the part instead of forcing the part to fit a standard frame. This matters most on heavy totes, AS/RS-compatible shippers, and dividers that need to hold tolerance under load.

4. Application-Specific Design Notes

The right design depends on the application. Here is what to think about for the four most common categories.

Returnable Totes

The driver: cost-per-trip and stackability. Spec 6mm to 10mm for the body. Run flutes vertically in the side walls. Integrate handles instead of bolting them on. Add a footed base or a die-cut nesting feature so empty totes nest 4-to-1 or 5-to-1 for return shipment. If the tote rides an AS/RS conveyor, verify the base geometry against the conveyor spec before tooling.

Dunnage and Part Inserts

The driver: part protection and cycle time. Dunnage cradles need to hold parts in known positions so pick operators do not fumble. Use die-cut pockets with light foam or felt liners for finish-sensitive parts. For heavy parts, use thicker gauge with wire reinforcement around the pocket perimeter.

Avoid one-piece dunnage when the parts vary in size across a family. Modular dunnage (interchangeable inserts in a common tray) costs more up front and pays back the first time the part revs.

Divider Systems

The driver: density and damage prevention. Dividers are typically interlocking crosses or single-axis partitions assembled into a grid. Gauge runs 4mm to 6mm. Sonic welding speeds up assembly when the crosses repeat. For programs with frequent SKU changes, design the grid to be reconfigurable: same outer tray, different insert.

> *A divider system that protects $200 of parts and costs $8 to fabricate is one of the highest-leverage spends in packaging engineering. It is also the spot where a generic catalog product almost never fits.*

Trays and Shippers

The driver: print quality and dimensional accuracy. Trays often carry customer-facing branding. Direct screen printing on corrugated plastic produces durable graphics for thousands of cycles. Digital printing handles short runs and proofs. Both are done in-house at a serious fabricator, so artwork prep, color match, and registration stay under one roof.

For shippers that go to end customers, spec a gauge heavy enough to survive parcel handling. A returnable shipper that comes back damaged is a returnable shipper that does not come back.

5. The Cost-Per-Trip Calculation

This is the only math that matters. Everything else is downstream of it.

Total program cost equals unit cost times quantity, plus tooling, design, freight, storage, and replacements over the program life. Total trips equals quantity times cycles per part over program life. Cost per trip equals total cost divided by total trips.

EXAMPLE: 3-YEAR PROGRAM, 5,000 DELIVERIES PER YEAR

Line item	Cardboard one-way	Corrugated plastic returnable
Unit cost	$4.00	$35.00
Quantity (3-year life)	5,000 (consumed)	100 (cycled)
Cycles per part	1	250
Tooling	$0	$1,800
Design and prototyping	$0	$800
Total 3-year program cost	$20,000	$6,100
Total trips delivered	5,000	25,000
Cost per trip	**$4.00**	**$0.24**

The numbers above are illustrative. Real programs vary. What does not vary is the structure: cardboard wins on unit price and loses on cost per trip by a factor of 10 to 20. Reusable corrugated plastic wins on the only number that matters.

Two caveats.

First, this math assumes the totes actually come back. A returnable program with no return logistics is a one-way program with a higher unit cost. Build the return path before specifying the part.

Second, this math assumes a stable design over the program life. If the part inside the tote revs every 6 months, the dunnage has to be modular or the tooling write-off accelerates.

6. What to Send a Fabricator for a Fast Quote

The fastest quote comes from the most complete RFQ. Here is the checklist.

1	**Part drawing or 3D file.** STEP or IGES preferred. PDF flat patterns acceptable if the geometry is simple.
2	**Material spec or environment.** Example: "Polypropylene corrugated, 4mm, ESD grade" or "indoor warehouse, no static, standard PP."
3	**Quantity and cadence.** First order quantity, annual quantity, expected program life.
4	**Cycle expectation.** How many trips per part over the program life.
5	**Stack and load.** Loaded weight per tote, stack height in service, stack height in storage.
6	**Joining and assembly.** Welded, riveted, knock-down, or customer-assembled.
7	**Hardware.** Handles, grommets, labels, drains, vents, RFID pockets.
8	**Print and color.** Logos, part numbers, color match requirements.
9	**Compliance.** AS9100, ISO 9001, FDA, ITAR, REACH, RoHS.
10	**Lead time target.** First-article date and production ramp.

> *An RFQ with all ten lines gets a real quote in days. An RFQ with three lines gets clarifying questions and delays the timeline.*

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.

CAPABILITIES RELEVANT TO THIS PAPER

- Pioneer flatbed die-cutter, 78 by 150 inch maximum sheet size
- Gerber M3000 turbo router and cutting table, 75 by 120 inch maximum
- 2mm to 10mm corrugated polypropylene stock in a range of colors, held in inventory
- Sonic welding and proprietary in-house flat welding
- In-house steel rule die fabrication and CNC tooling
- Screen printing with UV dryer and Canon 1260GT flatbed digital printing

- Wire bending for structural support
- 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 returnable packaging program coming up, send an RFQ. We will tell you what we would change in the design before we quote it.*

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