AN INTRODUCTION TO THERMOFORMING

Over 50 Years of Thermoforming Experience

Placon provides high-quality, custom thermoformed packaging solutions for consumer, industrial, food, and medical products.

With over 50 years of thermoforming design and manufacturing experience, you can trust that Placon's award-winning design and engineering teams will deliver the best packaging solution for your product no matter what industry you are in. Using state of the art design software and a collaborative new product innovation process, our team specializes in delivering a distinctive package that will meet your business objectives on time and within budget.

Placon has a reputation in the industry for delivering the highest quality products.
We offer:

- ISO9001 certification
- ISO13485 certification (Elkhart, IN)
- ISO14001 compliant
- AIB certification (Madison, WI)
- SQF certification (West Springfield, MA)
- GMP compliant

We have multiple clean rooms to serve you:

- Elkhart, IN
- Plymouth, MN
- Madison, WI

Team up with us and you'll benefit from:

- More than 250 combined years of design experience with over 700 employees
- Exceptional customer service
- Rapid prototyping and production-quality samples
- In-house tooling and matched-metal thermoforming
- Validation process expertise with strict quality control standards (for medical packaging)

Continuously setting the bar in plastic packaging solutions, we're committed to quality with a deep integrity in all that we do. We create packaging breakthroughs that inspire better engagement between people and products.

Table of Contents




WHAT IS THERMOFORMING?

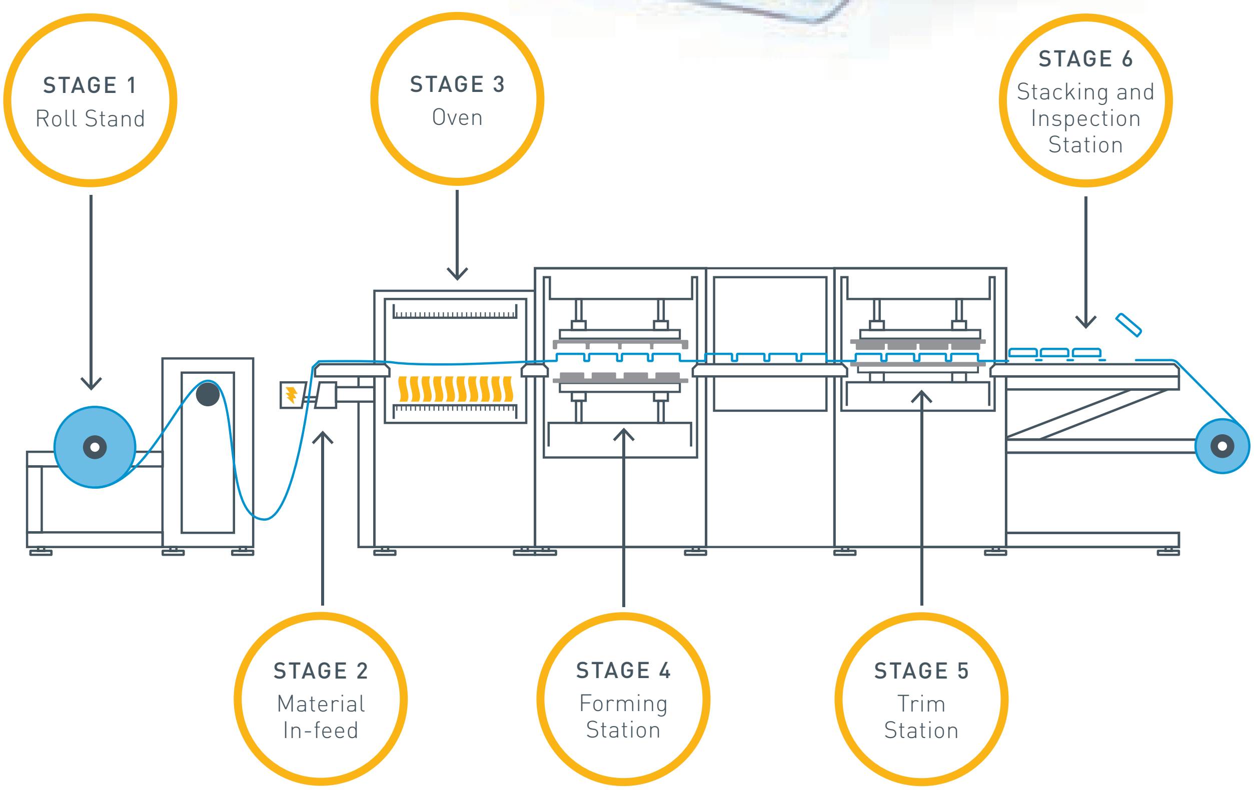
Thermoforming is a process that involves heating a flat sheet of plastic until it is soft enough to mold. Once it reaches the right temperature, the sheet advances to the form section. The sheet is pulled into the mold with a vacuum. The plastic hardens and forms the desired part. The molded plastic parts are then trimmed and inspected for quality.

THE ADVANTAGES OF THERMOFORMING

Thermoforming has many advantages over other plastic processing procedures, including:

- Low-cost tooling
- Quick and inexpensive prototyping
- Shorter production lead times
- Custom designs that are easy to modify
- Ability to produce both large and small parts
- Ability to produce parts with superior stress crack resistance, high impact strength, and good rigidity

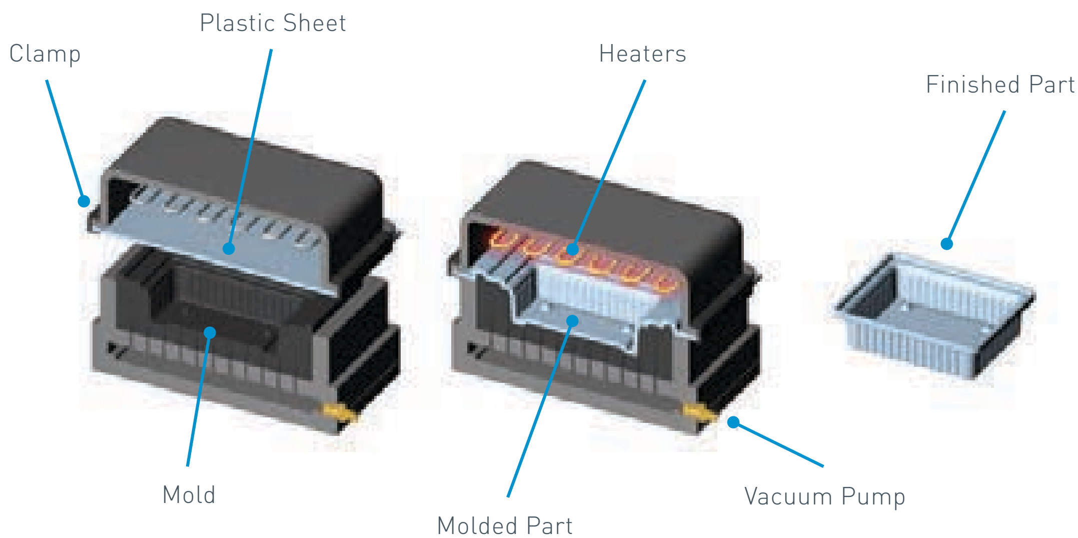
STAGES OF THERMOFORMING



TYPES OF THERMOFORMING

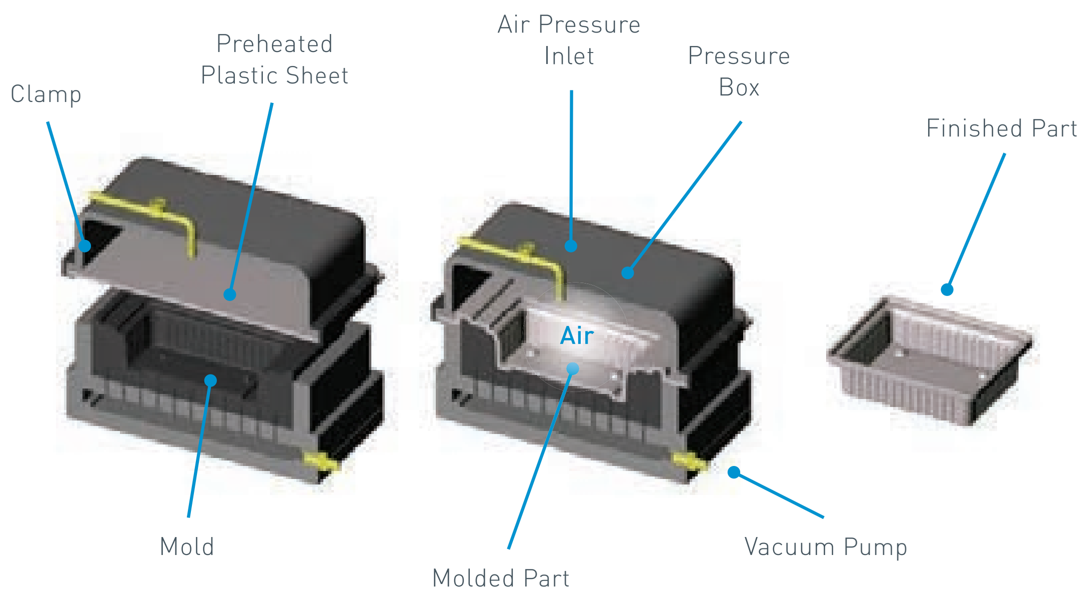
VACUUM FORMING

A vacuum pulls the heated plastic down into the mold.



PRESSURE FORMING

Combining the strength of a vacuum and air pressure, pressure forming pushes the plastic into the mold which allows for thicker sheets and finer details.



LIGHT GAUGE THERMOFORMING

Light gauge parts are made of material that is thinner than .060" and supplied on a roll. These parts are bendable, compact, and able to be sterilized. Some product examples include:

- Blisters
- Clamshells (fold-overs)
- Medical device trays
- Display trays
- Insert trays
- Diagnostic trays
- Fast food trays
- Fragility packaging trays

HEAVY GAUGE THERMOFORMING

In general, parts that come from material thicker than .060" are considered heavy gauge. These thick materials come in sheet form and help create sturdy, firm enclosures. Some examples of heavy gauge thermoforming products are:

- Automobile and aircraft parts
- Agricultural and truck parts
- Office equipment
- Heavy-duty trays
- Tote boxes and pallets
- Signs

THE STATE OF THE INDUSTRY

Technological advances in materials, tooling, and equipment allow thermoforming companies to offer improved products. Parts can now have undercuts, deep draws, and minimal draft while retaining high efficiency and quality levels. Furthermore, various materials such as barrier and high temperature plastics increase the opportunities and applications of the thermoforming industry.

Thermoformed products have a wide variety of uses and are therefore used in most industries. Major industry users include food, medical, automotive, cosmetic, hardware, housewares, construction, audio/visual, appliance, transportation, office equipment, computer, games, toys, military, and electronics.

COMMONLY USED MATERIALS

Practically all thermoplastic materials can be thermoformed. The most common plastics include:

- PVC
- PETG
- APET/RPET
- HIPS
- HDPE
- PC
- PP
- Antistatic
- Conductive

The materials listed here are the majority of materials we use in products for our customers. If your project requires a specialty material, we'll find it for you.

PVC — POLYVINYL CHLORIDE

Pros:

- Inexpensive
- Excellent formability
- Chemical, corrosion, and moisture resistant
- High impact strength
- Can be flexible or rigid
- Good de-nest characteristics

Cons:

- Angel hair, carbon particles, and gels sometimes present
- Environmental concerns
- Only ETO sterilization
- Longer cycle times

PETG/RPETG — POLYETHYLENE TEREPHTHALATE GLYCOL-MODIFIED

Pros:

- Very clear
- Good formability
- High impact strength
- Fast cycle times
- Low amounts of angel hair
- ETO & radiation sterilization
- Chemical resistant

Cons:

- Poor de-nesting (unless coated in silicone)
- Greater cost
- Brittle in heavier gauges

APET/RPET — AMORPHOUS PET/RECYCLED PET

Pros:

- Good clarity
- Chemical resistant
- Good impact strength
- Temperature resistant
- Good formability
- Cheaper alternative to PETG

Cons:

- Poor de-nest characteristics
- Poor low temperature impact

HIPS — HIGH IMPACT POLYSTYRENE

Pros:

- Inexpensive
- Excellent formability
- Recyclable
- ETO and radiation sterilization
- Good impact strength

Cons:

- Hard to control angel hair
- Can fracture at sharp corners
- Poor clarity

HDPE — HIGH DENSITY POLYETHYLENE

Pros:

- Easy to de-nest
- Impact resistant
- Low amounts of angel hair
- Chemical resistant
- High tensile strength
- Higher yield
- Non-toxic

Cons:

- Poor clarity
- Longer cycles
- Only ETO sterilization
- Does not retain shape well—tendency to warp
- Higher tolerances necessary

PP — POLYPROPYLENE

Pros:

- Inexpensive
- Easy to de-nest
- Chemical resistant
- Impact resistant
- Low amounts of angel hair
- Forms detail undercuts well

Cons:

- Lower tensile yield strength
- High tendency to warp
- Susceptible to UV degradation

PC/LEXAN® — POLYCARBONATE

Pros:

- Very clear
- High impact strength
- Temperature resistant
- ETO, gamma, and dry heat sterilization

Cons:

- Expensive
- Difficult to de-nest
- Scratches easily
- High tooling cost

See tables on pages 26–27 for more information.

CONDUCTIVE/ANTISTATIC PRODUCTS

We can accommodate your needs for conductive or antistatic materials.

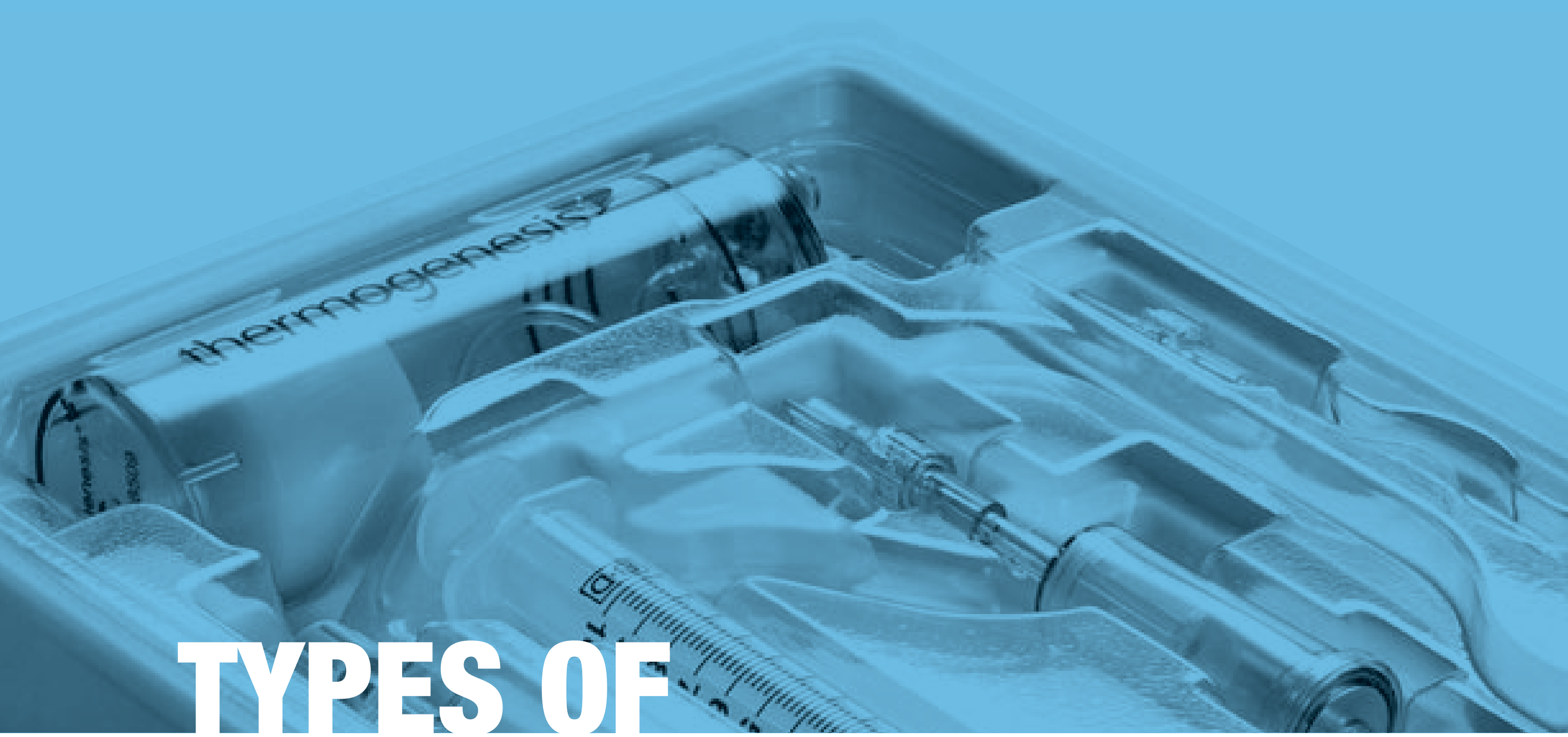
Our main **CONDUCTIVE MATERIAL** is HMS-1000C. While it is carbon impregnated and therefore unclear, it does have high impact strength, good formability, and good de-nest characteristics.

	HMS–1000C
Surface Resistivity (#/sq.)	
at 0.125"	1x104
at 0.060"	5x104
at 0.030"	3x105

For **ANTISTATIC MATERIAL**, we have a few more options:

- PVC (topical)—high impact strength, excellent formability, good clarity, and good de-nest characteristics
- APET/RPET (topical)
- HIPS (topical)
- PETG (topical or embedded)—high impact strength, good formability, excellent clarity, poor de-nest characteristics

	PVC: SCM280/94	PVC: ASM280/14	APET: ASEKPET/56
Surface Resistivity (W/sq.)			
12% RH:	3x10^{12}	1x10^{11}	1x10^{10}
50% RH:	1x10^{11}	1x10^{10}	1x10^{9}
Surface Resistance (W)			
12% RH:	3x10^{12}	1x10^{10}	1x10^{9}
50% RH:	3x10^{12}	1x10^{9}	1x10^{8}
Static Decay ± (5KV to 0.05KV)			
12% RH:	3.0 sec	0.1 sec	0.1 sec
50% RH:	0.1 sec	0.02 sec	0.02 sec



TYPES OF STERILIZATION

ETO — ETHYLENE OXIDE

Ethylene Oxide gas infiltrates packages in order to kill any microorganisms living in the product.

- Process: The gas is pumped into a 120°F chamber with the product inside. After two hours, the chamber is flushed clean and the product is sterilized.
- Suitable for most materials; especially appropriate for those that can't withstand heat.
- Quarantine for parts on residuals.

GAMMA RAY — IRRADIATION

The quick gamma sterilization process exterminates microorganisms through the use of radiation.

- Process: The products are loaded into carriers and receive Cobalt 60 radiation. The radiation damages DNA and other components of any living cells, killing the cells and therefore sterilizing the product.
- Compatible with many materials.
- All sides need exposure to the source of radiation.
- Commonly used for sterilization of disposable medical equipment.

E-BEAM — ELECTRON IRRADIATION

Electron beam processing makes use of electrons to kill any microorganisms living in the product by breaking the chains of their DNA.

- Process: Similar to the gamma sterilization process, the E-beam process fires electrons at the product. Electron beams utilize an on-off method, which provides a higher dose rate and requires less exposure time. The E-beams are, however, less penetrating than gamma rays.
- Compatible with most materials.
- No quarantine required afterwards.

AUTOCLAVE

Autoclaves are machines that use steam and pressure to eliminate most microorganisms.

- Process: The products are placed inside an autoclave, which floods them with steam heated anywhere from 250°F to 275°F. Generally, a holding time of 15 minutes is required at 250°F or 3 minutes at 275°F. Then the products are cooled slowly.
- Used for Propylene & Lexan® (PC).
- Not for heat-labile materials.

DRY HEAT/CURING

Dry heat sterilization utilizes hot air with minimal amounts of water vapor in it to remove microorganisms from the product. The heat kills organisms by causing their proteins to deform.

- Process: The object is heated through either the gravity convection process or the mechanical convection process. In either method, the outside surface of the item absorbs heat from the heated air around it, and then passes the heat inward until the whole object reaches the target temperature. The item is heated for 2 hours at 320°F or 1 hour at 340°F.
- Used for Crystallized PETE and high heat Lexan®.
- Not for heat-labile materials.

See table on page 25 for more information.

SEALING TECHNIQUES

RADIO FREQUENCY HEAT SEALING

Radio frequency heat sealing utilizes radio frequency (RF) energy to heat the plastic. This method takes less time to heat the material than a plain heat sealer, and, since plastic heated with RF energy cools down quicker as well, the plastic will be safer to handle, come off the machine more quickly, and maintain its shape better.

BLISTER SEALS

Blister sealing uses heat to seal a thermoformed part to some type of reinforced backing material, like laminated cardboard. This type of packaging allows the consumer to see the product without opening its packaging.

HEAT STAKING

The process of heat staking involves connecting two components by creating an interference fit between them. One plastic part has a protrusion that fits into a hole on the other part. Then the plastic is heated and softened, and the two components get locked together.

UV ADHESIVE

This simple sealing procedure makes use of a wet adhesive that is either manually or automatically applied to a transparent surface and sent through a UV curing tunnel. There is no need for pressure, heat, or tooling, and the package comes out of the tunnel completely secured.

PRODUCT DEVELOPMENT

QUOTE (2–4 DAYS)

We begin with an assessment of your packaging needs through meetings and analysis. From there, our engineers can create a packaging concept.

PROTOTYPING (2–5 DAYS)

Once this design is approved, we move to developing prototype tooling which we use to create prototype packaging. The prototype packaging is then presented for your approval.

PRODUCTION TOOLING (3–5 WEEKS)

When the packaging meets your final approval, we create the production tooling and, when you are ready, begin creating your product in our production facility.

FIRST ARTICLES (3–5 DAYS FROM RECEIPT OF TOOLING)

The final product is complete and shipped from our production facility.

QUOTE

What we need from you for a quote:

- Idea/Product you need packaged
- 3D product files (if available)
- Rough sketch/Concept drawing

Your quote will contain:

- Prototype price
- Production tooling price
- Part price

PROTOTYPING

CAD Drawing:

- Computer generated model
- General Dimensions (length, width, depth, etc.)

CAD Rendering:

- Colored, 3D
- Computer generated
- For marketing presentations

We have a vast array of prototyping options available. We offer REN, Red board, Aluminum and 3D Rapid Prototyping. We can customize the technology to your project need based on part design, timeline and quantity needed. Our prototypes can be used for marketing and management presentations, extensive testing, ship testing, or customer focus groups. Let us select the right technology to meet your objectives.

PRODUCTION TOOLING

Mold Materials:

- Aluminum

Cutting Method Materials:

- Steel rule die
- Heated steel rule die
- Forged die
- Matched metal trim

Plug Assist Materials:

- Syntactic foam
- Nylon
- Aluminum

Miscellaneous Materials:

- Cooling plate
- Stripper
- Pressure box
- Cut-out striker
- Stacker

Male vs. Female Tooling:

Tooling can be either male or female. Male tooling involves parts that are formed ON the mold and have to get pulled off upon removal. Female tooling, on the other hand, involves parts formed IN the mold that must be taken out upon removal. Despite being male or female, the mold can be either above or below the sheet of plastic during forming.

MALE vs. FEMALE

Least expensive form of tooling; multiple cavity applications	Typically more costly than male
Limited surface detail (none on outside surface)	Sharp exterior detail and definition
Thicker corners	Bottom corners may be thin
Draft required to facilitate part removal from mold	Minimal draft required in most cases
Higher gloss on outside surface	Higher gloss on inside surface
Spacing between parts is greater	Ability to space parts closer together

FIRST ARTICLES

Our sales and engineering team will work closely with you to understand your time constraints and do everything possible to meet or exceed your expectations.

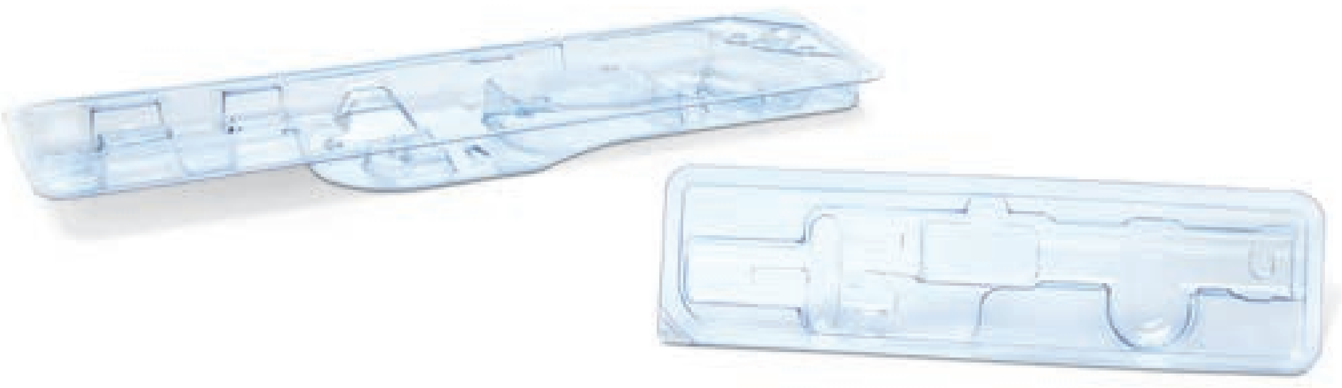
MACHINERY AND PRODUCTION PROCESS

1. *Plastic Sheet is fed through the machine*
2. *Sheet gets heated to forming temperature*
3. *Sheet is formed using vacuum and pressure*
4. *Product is trimmed using appropriate trim method*
5. *Product advances and is inspected for quality*
6. *Web scrap is wound up at the end of the machine for recycling*

MANUFACTURING ENVIRONMENT

GENERAL MANUFACTURING AREA

At our Plymouth facility, we've standardized our tooling so any mold can work in any press. Our proprietary master tooling system allows the majority of our change-overs to be done without tools in minutes. In Madison, our in-house extrusion capabilities allow us to retain complete control over the entire process. We pride ourselves in being a zero waste facility.



CLEAN ROOM

Placon has three clean rooms for medical device packaging — located in Elkhart, IN, Plymouth, MN and Madison, WI. Our ISO class 8 or 100,000 clean rooms are certified to meet or exceed the stated class conditions. The temperature and humidity are controlled and the air is repeatedly filtered in order to protect your medical device packaging from airborne contamination. Quality checks are completed per specifications.

Acronym Index

ABS: Acrylonitrile-Butadiene-Styrene
ASA: Acrylic-Styrene-Acrylonitrile
BMC: Bulk Molding Compound
CA: Cellulose Acetate
CAB: Cellulose Acetate-Butyrate
CAD: Computer-Aided Design
CAE: Computer-Aided Engineering
CAM: Computer-Aided Manufacturing
CAP: Cellulose Acetate Propitionate
CD: Compact Disc
CIM: Computer Integrated Manufacturing
CN: Cellulose Nitrate
CP: Cellulose Proitionate
CPET: Crystallized Polyethylene Terephthalate
CPVC: Chlorinated Polyvinyl Chloride
CRT: Cathode Ray Tube
CTFE: Chlorotrifluoroethylene
DAP: Diailyl Phthaiate
EAA: Ethylene Acrylic Acid
EC: Ethyl Cellulose
EMI: Electro-Magnetic Interference
EPS: Expandable Polystyrene
EVA: Ethylene Vinyl Acetate
EVOH: Ethylene Vinyl Alcohol
FEP: Fluoro(ethylene-propylene) Copolymer
FR: Flame Retardant
FRP: Fiberglass Reinforced Plastics
HDPE: High-Density Polyethylene
HIPS: High-Impact Styrene
HMW-HDPE: High-Molecular Weight-High-Density Polyethylene
IM: Injection Molding
LDPE: Low-Density Polyethylene
LLDPE: Linear Low-Density Polyethylene
MDI: Methylene Diisocyanate
MPPO: Modified Polyethylene Oxide
OPET: Oriented Polyethylene Terephthalate
OPP: Oriented Polypropolene
PA: Polyamide
PAI: Polyamideimide
PAN: Polyacrylonitrile
PBT: Polybutylene
PC: Polycarbonate
PE: Polyethylene
PET: Polyethylene Terephthalate
PMMA: Polymethyl Methacylate
POM: Polyacetal
PP: Polypropylene
PPE: Polyphenylene Ether
PPS: Polyphenylene Sulfide
PS: Polystyrene
PSO: Polysulfone
PTFE: Polytetrafluoroethylene
PUR: Polyurethane
PVA: Polyvinyl Acetate
PVB: Polyvinyl Butyral
PVC: Polyvinyl Chloride
PVdC: Polyvinylidene Chloride
PVdF: Polyvinylidene Flouride
PVF: Polyvinyl Fluoride
RIM: Reaction Injection Molding
RP: Reinforced Plastics
RTM: Resin Transfer Molding
SAN: Styrene Acrylonitrile
SBR: Styrene-butadiene Rubber
SMA: Styrene Maleic Anhydride
SMC: Sheet Molding Compound
SPE: Society of Plastics Engineers
SPI: The Society of the Plastics Industry
SPPF: Solid Phase Pressure Forming (Thermoforming)
TFE: Tetrafluoroethylene
TPE: Thermoplastic Elastomer
TPO: Thermoplastic Olefin
UHMWHDPE: Ultra High-Molecular Weight-High-Density Polyethylene
VCM: Vinyl Chloride Monomer

Glossary

AIR POCKET: Air trapped between the mold and plastic sheet.

CHILL MARK: Visible flow marks in the formed plastic article that result from too low of a plastic forming temperature.

DEPTH OF DRAW: Linear distance as measured from the top to bottom of a formed part.

DRAFT ANGLE: Incline used in the design of mold surfaces to help with part release from mold. Draft angles become more important in the male molds than in female molds.

DRAPE FORMING: Plastic sheet is heated and then placed over a positive mold. Vacuum is drawn through vacuum holes in the positive mold to complete the forming process.

FORM TOOLING: Upper and lower tooling that imparts the finished part shape to a plastic film material.

FORMING RATIO: The ratio of the part height to depth. This gives an indication of what the final part wall thickness will be in relation to starting sheet thickness. (A.K.A. Draw Ratio)

MOLD RADIUS: Circular arcs machined into the mold tooling to improve material flow and part wall uniformity.

MOLD SPACING: Measured center distance between multiple mold forms in the x-y plane.

MOLD UNDERCUT: Negative draft or taper that causes removal interferences between the formed part and mold geometry. This condition can make stripping of part from the mold more difficult.

NEGATIVE MOLD (Female): A cavity that material is drawn into.

PLUG ASSIST: Used in conjunction with mold tooling to help in the control and distribution of material in the finished part. The plug can be shaped to increase or decrease the finished parts wall thickness and material distribution.

POSITIVE MOLD (Male): A protruding shape that material is formed over.

POST MOLD SHRINKAGE: Thermoformed parts shrink after forming when removed from the mold.

PRESSURE FORMING: Technique of applying air pressure to form finished parts. This technique is often used in conjunction with vacuum forming techniques. Pressure can range anywhere from 0 to 500 PSI. Most commonly used pressures range from 0 to 100 PSI.

ENTRAPPED AIR: Visible continuous line marking that surrounds the surface areas of a formed part that did not make contract with mold surface.

SHEET THICKNESS/FILM GAUGE: Measured thickness of the unformed sheet.

THERMOFORMING: Any process in which a sheet of plastic material is heated, brought into contact with a mold and formed into a finished shape.

VACUUM FORMING: Technique of using negative pressure to form a finished part. English unit of measurement is in Inches of Mercury (Hg) or Absolute Pressure (PSIA).

WEBBING: Heated plastic material folds into itself during the forming process. Webbing often shows up in mold shapes that are close together or at sharp corners on rectangular shaped parts.

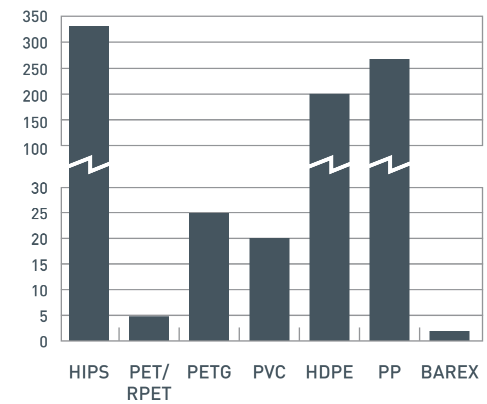
Data Tables

TRANSMISSION PROPERTIES

OXYGEN TRANSMISSION RATE

The amount of oxygen gas that passes through a material over a certain period of time.

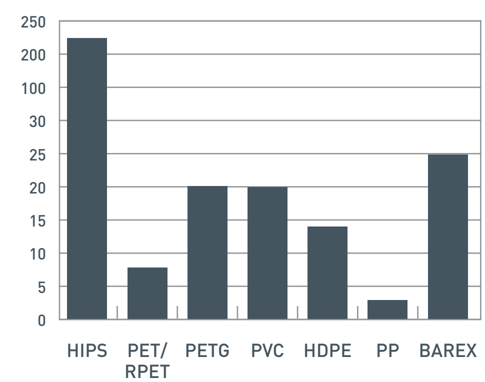
PERMEABILITY 0_2 @ 25°C
(cm³•mill/24 hrs•100 in²•Atm)



MOISTURE VAPOR TRANSMISSION RATE (MVTR)

The amount of water vapor that passes through a material over a certain period of time.

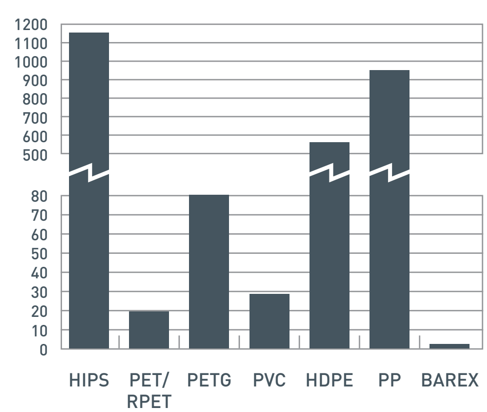
MOISTURE VAPOR TRANSMISSION RATE – MVTR (g•mill/24 hrs•100 in²)



CO2 TRANSMISSION RATE

The amount of carbon dioxide gas that passes through a material over a certain period of time.

PERMEABILITY 0_2 @ 25°C
(cm³•mill/24 hrs•100 in²•Atm)

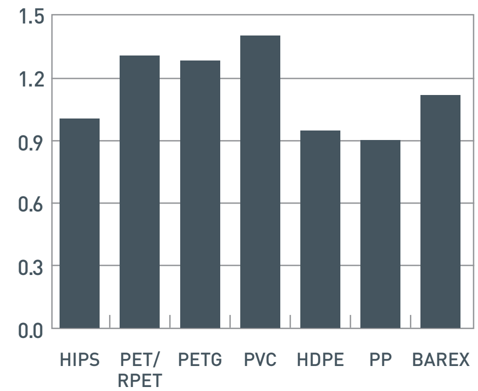


Data Tables

DENSITY (SPECIFIC GRAVITY)

The density (mass per unit volume) of a material is very important. Plastics with lower specific gravities tend to save companies money since the plastic is bought based on weight, but the final product is sold based on the size of the part. So, a lightweight (low density) material will cost less than a high density material, but sell for the same price. See pages 26—27 for specific data values for the plastics.

SPECIFIC GRAVITY (gr/cc)



STERILIZATION TABLE

	STERILIZATION BY		
Material	ETO	Radiation	Autoclave
HIPS	Yes	Yes	No
APET	Yes	Yes	No
RPET	Yes	Yes	No
HDPE	Yes	Sometimes	Sometimes
PP	Yes	Yes	No
PVC	Yes	No	No
PC	Yes	Yes	Yes
PETG	Yes	Yes (2.5 gamma) rad.	No

Data Tables

MATERIAL PROPERTIES

Property of Characteristic	PVC (rigid)	PETG	APET
Specific Gravity (gm/cc)	1.3–1.45	1.27	1.33
Yield for .010" (in^2/lb.)	2080	2180	2081
Clarity	Good–Excellent	Good–Excellent	Good
Haze (%)	3.0–6.5	0.4–0.8	0.5–2.0
Tensile @ Yield (PSI)	6,500–6,700	6,900–7,700	7,300–9,000
Elongation (%)	50–180	180	200–400
Flexural Modulus (PSI)	330,000–480,000	250,000–310,000	325,000–370,000
Flexural Strength (PSI)	12,200	10,000–11,240	12,500–13,300
Hinging	Excellent	Fair–Good	Good–Excellent
Impact Strength	Good–Excellent	Good–Excellent	Good–Excellent
Notched IZOD Impact (ft.lb.@in.@°F)	0.80 @ 73°F 0.6 @ 0°F	1.70 @ 73°F 0.7 @ -40°F	0.59 @ 73°F
Dart Impact (gm@26" Drop @ 73°F) Dart Impact (gm@26" Drop @-20°F)	415 (½)" dia. 345 (½)" dia.	425 (½)" dia. 350 (½)" dia.	
Heat Distort/Deflection Temp (°F)	137–168 @ 264 psi	145 @ 264 psi	145–165 @ 264 psi
Water Absorption in 24hrs. (%)	0.06	0.1–0.3	0.15
Permeability O_2	8–20 cc/mil / 100in^2/24hr/atm	20–25 cc/mil / 100in^2/24hr/atm	3–10 cc/mil / 100in^2/24hr/atm
Permeability N_2	1–10 cc/mil / 100in^2/24hr	10 cc/mil / 100in^2/24hr	
Permeability CO_2	20–30 cc/mil / 100in^2/24hr/atm	80–125 cc/mil / 100in^2/24hr/atm	
Permeability H_2O Vapor	2–4 gm/mil / 100in^2/24hr	2.5–4.0 gm/mil / 100in^2/24hr	1.0–4.0 gm/mil / 100in^2/24hr
Dielectric Constant	2.7–3.1 @ 1MHz	2.4–2.6 @ 1MHz	3.0 @ 1MHz
Thermoforming Range (°F)	275–350	250–350	250–310
Heat Sealing Range (°F)	315–370	275–350	
Mold Shrinkage Rate (in./in.)	0.003–0.004	0.003–0.005	0.002–0.005

RPET	HIPS	HDPE	PC (Lexan)	PP (Coploymer)
1.33–1.35	1.03–1.06	0.91–0.98	1.2	0.9
2110	2580	2900	2123	3000
Good	Poor	Poor	Excellent	Poor–Fair
0.5–2.0	10	10–20	0.4–2.0	0.3–40
7,000–8,500	6,000–10,000	3,200–4,500	9,000–9,500	2,000–4,800
100–200	45–70	600	100–130	100–300
325,000–375,000	200,000–370,000	165,000–200,000	350,000–490,000	160,000–185,000
10,000–12,000	4,000–7,800	2,600–6,000	13,500	3,750–5,400
Good–Excellent	Fair–Good	Excellent	Good	Excellent
Good–Excellent	Fair–Good	Good	Excellent	Excellent
0.7–2.4 @ 73°F	2.1 @ 73°F 1.2 @ 0°F	1.3 @ 73°F	14.0 @ 73°F	7.8 @ 73°F 0.8 @ 0°F
145–180 @ 264 psi	150–190 @ 264 psi	157 @ 264 psi	265–280 @ 264 psi	180–195 @ 264 psi
0.12	0.20	<0.01	0.15	0.01
6–7 cc/mil / 100in²/24hr/atm	250–350 cc/mil / 100in²/24hr/atm	160–190 cc/mil / 100in²/24hr/atm	230–300 cc/mil / 100in²/24hr/atm	150–250 cc/mil / 100in²/24hr/atm
		40–45 cc/mil / 100in²/24hr	50 cc/mil / 100in²/24hr/atm	
	900–1,200 cm³/mil / 100in²/24hr/atm	550–600 cc/mil / 100in²/24hr/atm	1,000 cc/mil / 100in²/24hr/atm	900–1,000 cc/mil / 100in²/24hr/atm
2–4 gm/mil / 100in²/24hr	5–10 gm/mil / 100in²/24hr	2–3 gm/mil / 100in²/24hr	10–15 gm/mil / 100in²/24hr	0.3–0.7 gm/mil / 100in²/24hr
3.0 @ 1MHz	2.5–2.8 @ 1MHz	2.3–2.4 @ 1MHz	2.9–3.0 @ 1MHz	2.2–2.6 @ 1MHz
250–310	260–360	260–430	335–400	270–380
		200–265	400–430	285–400
0.002–0.005	0.004–0.007	0.015–0.030	0.005–0.007	0.010–0.020

The above data is approximate and was compiled from the data sheets of various manufacturers. Placon assumes no liability or responsibility for the accuracy of this information.

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