AN INTRODUCTION TO

THERMOFORMING

PLACON®

Simply Better Packaging®

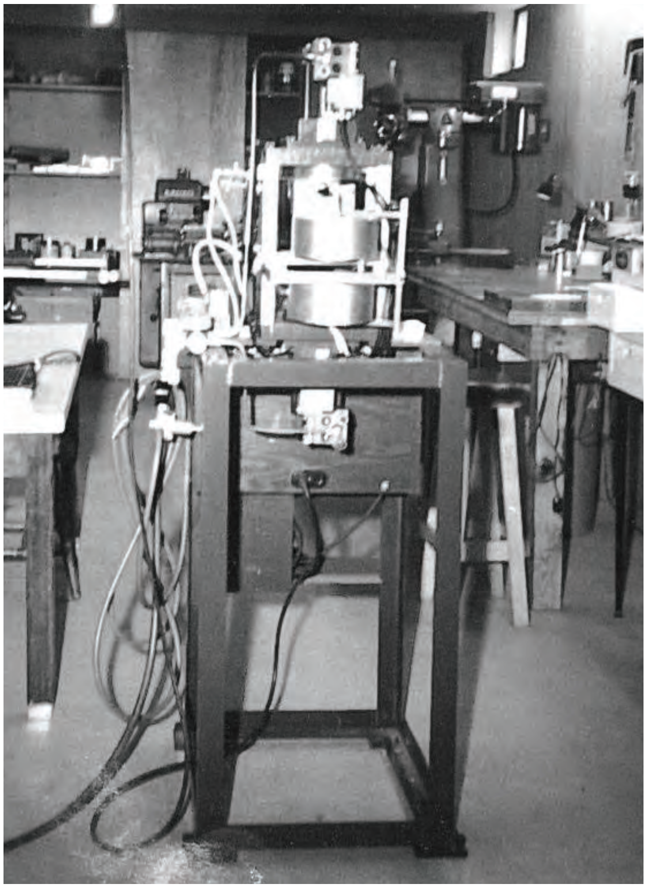
Over 55 Years of Thermoforming Experience

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

Simply: we make it simple to bring your product to market with our turn-key process.

Better: our award-winning design and engineering teams will deliver the best packaging solution for your product.

Packaging: our sustainable thermoforming practices, including but not limited to post-consumer recycled plastic, a net-zero waste facility, and solar powered buildings, ensure your package is responsibly made.



Our first thermoforming machine, pictured above, was used to make jewelry boxes.

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

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

Locations:

- Corporate Headquarters | Madison, WI
- Medical Center of Excellence | Elkhart, IN
- Injection Molding | West Springfield, MA
- Plymouth, MN
- Wilson, NC

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.

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 plastic hardens and forms the desired part. The molded plastic parts are then trimmed and inspected for quality.

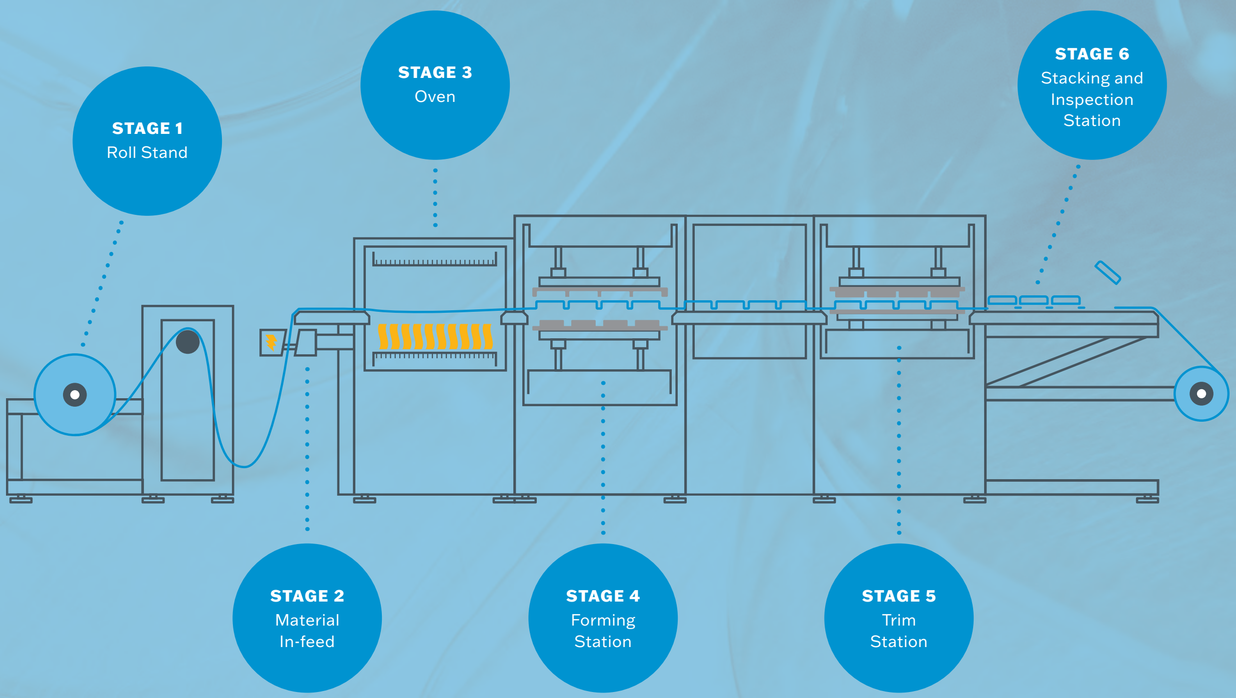
THE ADVANTAGES OF THERMOFORMING

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 rigidity

Our founder, Tom Mohs, collaborated with Jere Irwin to bring innovations in thermoforming on matched metal trim technology

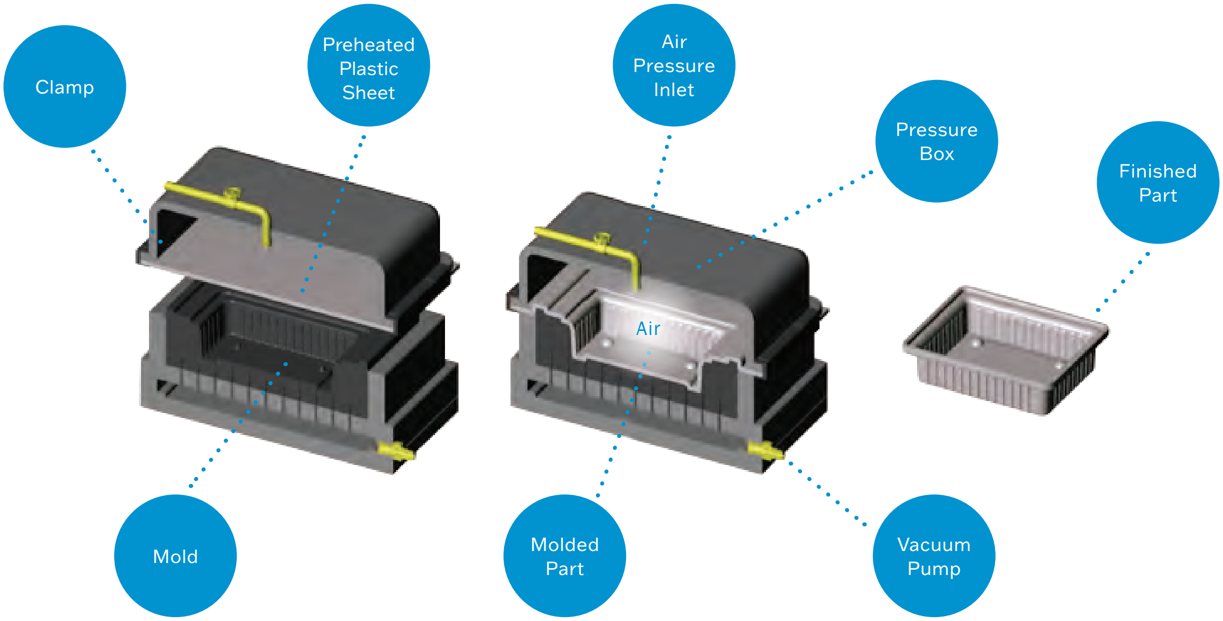
STAGES OF THERMOFORMING



TYPES OF THERMOFORMING

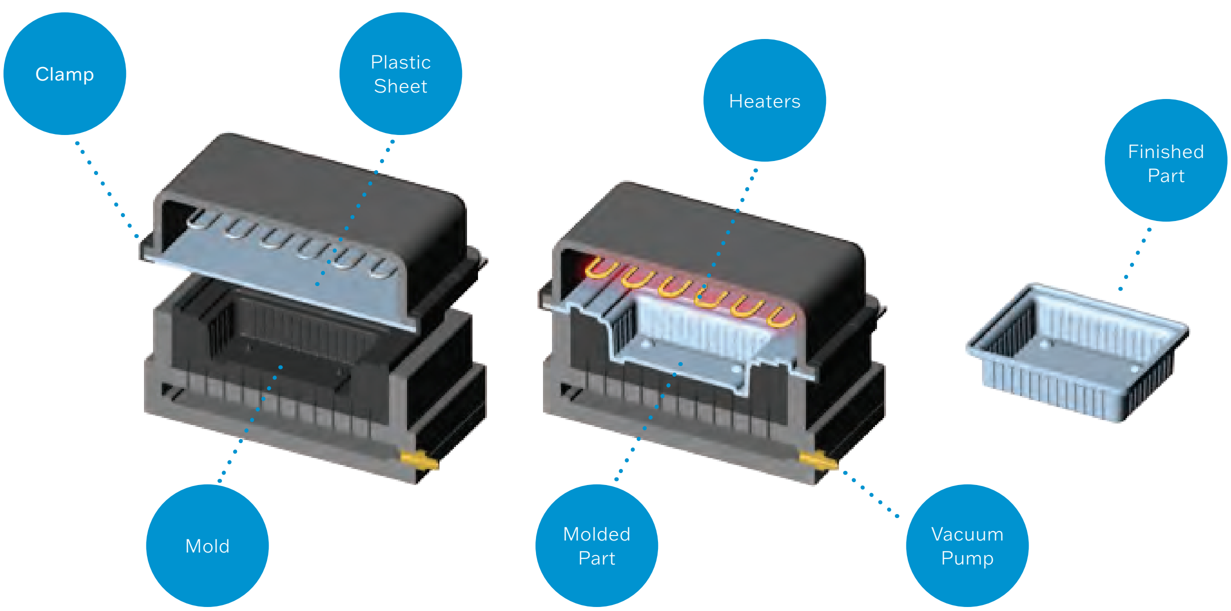
PRESSURE FORMING (PLACON PROCESS)

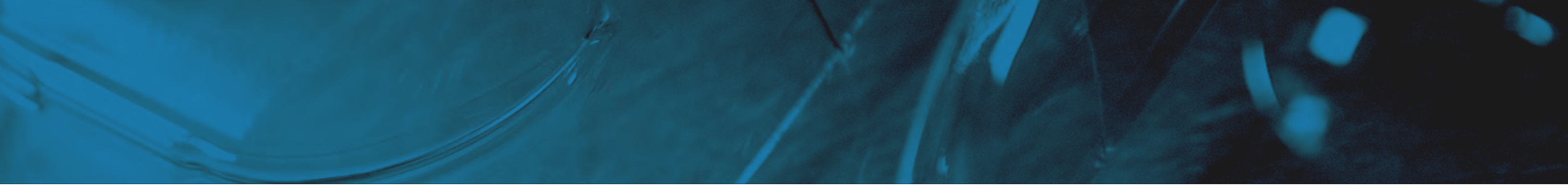
Combining the strength of a vacuum and air pressure, pressure forming pushes the plastic into the mold which allows for thicker sheets and finer details.



VACUUM FORMING

A vacuum pulls the heated plastic down into the mold.





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.

LEADING THE WAY IN SU

STAINABLE PACKAGING

A CLOSED LOOP PROCESS

We are at the cutting edge of environmentally conscious packaging materials with our EcoStar material. EcoStar is a food grade, post-consumer recycled PET material that is made from curbside-collected bottles and thermoforms and is recyclable. Commitment to recycling PET by reclaiming plastic bottles and plastic thermoforms and turning them back into consumer packaging is how we make simply, better, packaging. Reuse, recycle and replastic is our vision to get the most out of plastic.

- ISO 9001 facility
- 70,000 square foot recycling facility
- Follows GMP and Lean Manufacturing Principles
- FDA Letter of Non-Objection (LNO) for direct food contact
- SCS Global Services certified for 75 & 100% post-consumer recycled PET material

CERTIFIED RECYCLED CONTENT™ SCS GLOBAL SERVICES

MINIMUM 75% RECYCLED CONTENT POST-CONSUMER

RECYCLED OVER 4 BILLION BOTTLES SINCE INCEPTION

PROCESSES ROUGHLY 120,000 LBS OF BOTTLES A DAY

PROCESS ENOUGH FLAKE TO SAVE 75,000 BARRELS OF OIL PER YEAR

COMMONLY USED MATERIALS

For over 30 years we have used recycled plastic in our PET thermoforms; and in 2011 we opened our own 70,000 sq. ft recycling facility to fulfill our vision of a closed-loop system. We create the highest-quality, post-consumer recycled PET rollstock, branded as EcoStar®. If RPET is not best suited for your packaging needs we have the ability to thermoform many other materials and source whatever you desire.

ECOSTAR® APET/RPET — POST-CONSUMER RECYCLED PET/AMORPHOUS 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

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

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

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

HIPS — HIGH IMPACT POLYSTYRENE

Pros:

- Inexpensive
- Excellent formability
- Recyclable
- High impact strength
- ETO & radiation sterilization
- Cheaper alternative to PETG

Cons:

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

PVC — POLYVINYL CHLORIDE

Pros:

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

Cons:

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

BARGERGARD

Pros:

- High-abrasion resistance
- Impact- and cut-resistant
- Ideal for rough inserts and needles
- Can be formed, die-cut, and welded
- Compatible with ethylene oxide (EtO), gamma, and eBeam sterilization
- Won’t break down with UV sterilization
- Cost effective for small runs

Cons:

- Not compatible with Gas Plasma sterilization
- Not recyclable
- Not automation friendly
- Little to no clarity

TYVEK LIDDING

Pros:

- Adheres strongly to PETG trays
- Porous makeup allows for sterilization methods to pull through the fibrous material
- Communicate important messages with three-color print capabilities
- Add lift tabs to double-barrier trays making it easy for the user to lift inner tray without compromising sterilization
- Suitable for both EtO and radiation
- Strong, tear resistant

Cons:

- Doesn't protect against water or oxidization
- Not re-sealable
- Not easily recyclable
- Expensive
- Limited in sizes

FOIL

Pros:

- Best used in applications where sterilization happens prior to lid sealing
- Strong oxygen barrier as foil is non-porous
- Adheres to PETG Trays
- Excellent light, moisture, and oxygen barrier

Cons:

- No printing capabilities directly on foil
- Not compatible with APET or RPET
- Not compatible with EtO
- Shorter shelf-life than Tyvek

BACKER CARDS

Pros:

- Simple designs keep instruments safely separated and contained altogether
- Made with HDPE
- Lower-cost alternative to tray tooling
- Flexible, but more rigid than Bardergard
- Economical and environmentally conscience
- Compatible with EtO, Gamma, and E-Beam

Cons:

- Does not protect against sharp or abrasive objects
- Not as rigid as PETG
- Limited abilities for custom shaping
- Not economical for high volume

ADDITIVES

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"	1 x 104
at 0.060"	5 x 104
at 0.030"	3 x 105

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. Can be flexible or rigid

	PVC: SCM280/94	PVC: ASM280/14	APET: ASEKPET/56
Surface Resistivity (#/sq.)			
12% RH:	3 x 10^{12}	1 x 10^{11}	1 x 10^{10}
50% RH:	1 x 10^{11}	1 x 10^{10}	1 x 10^{9}
Surface Resistance (W)			
12% RH:	3 x 10^{12}	1 x 10^{11}	1 x 10^{9}
50% RH:	3 x 10^{12}	1 x 10^{9}	1 x 10^{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

oxystar®

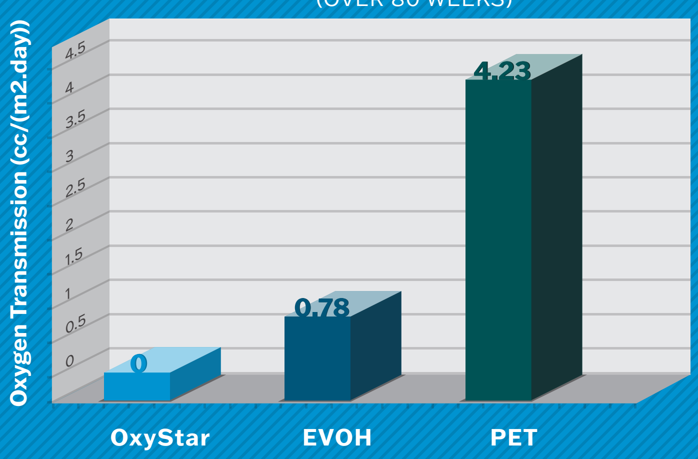
HOW OXYSTAR WORKS:

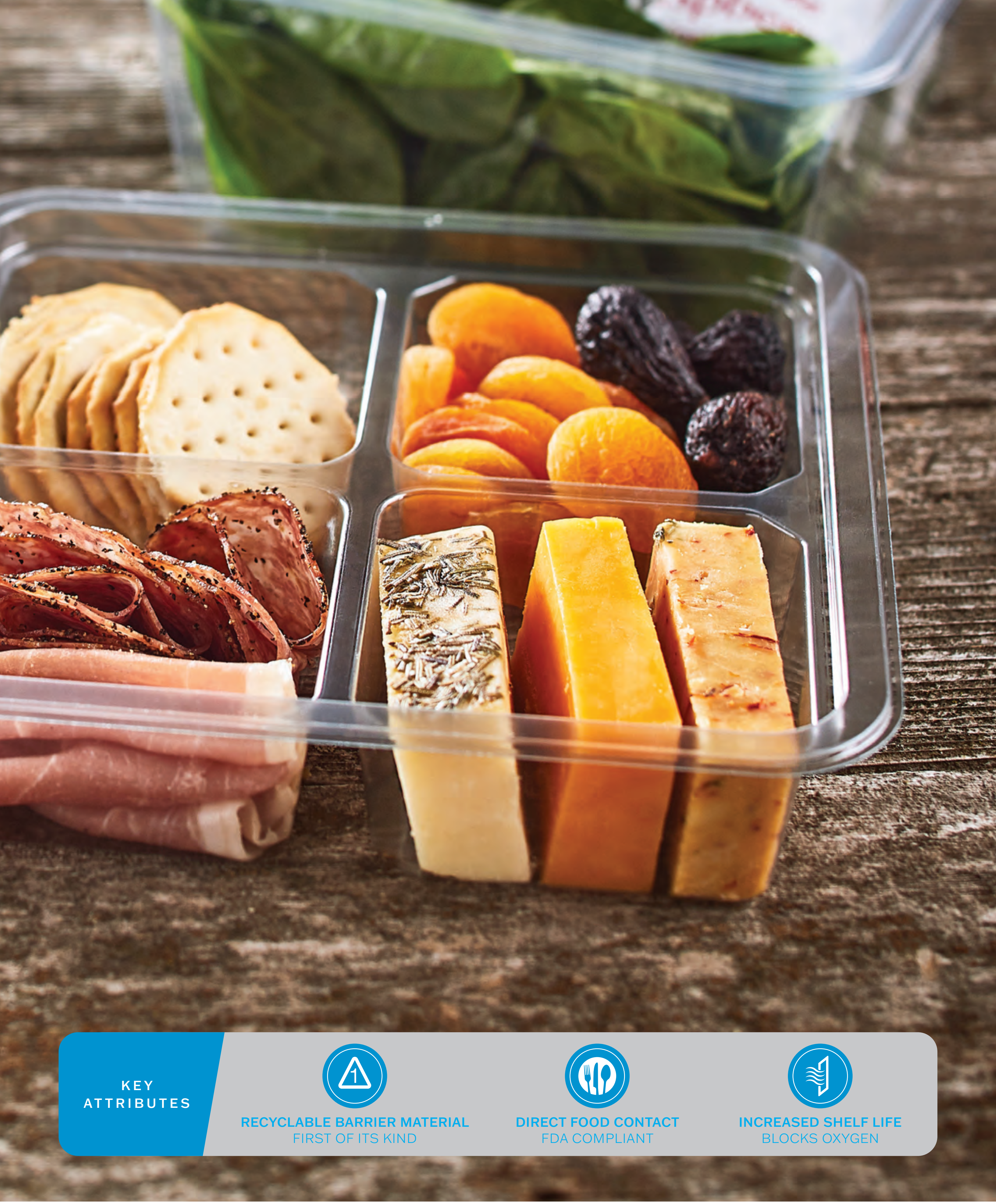
OxyStar barrier material utilizes a multilayer PET with an oxygen scavenging agent. PET has a naturally low oxygen transmission rate (OTR) and this construction slows down the flow of oxygen molecules through the package from the outside. Once the scavenger agent finds an oxygen molecule, it attaches to it and binds the oxygen within the sidewall of the package to keep your product fresh and lasting longer.

WHY USE OXYSTAR:

The distinct advantage of packaging made with OxyStar barrier material is that it carries a #1 resin identification symbol. OxyStar products are compatible with PET recycling and reuse processes to support sustainability goals. OxyStar material has a desired use for meats, cheeses, foods with high vitamin C content and high fat content such as nuts and oils.

OXYGEN TRANSMISSION RATE
(OVER 80 WEEKS)





KEY ATTRIBUTES

RECYCLABLE BARRIER MATERIAL
FIRST OF ITS KIND

DIRECT FOOD CONTACT
FDA COMPLIANT

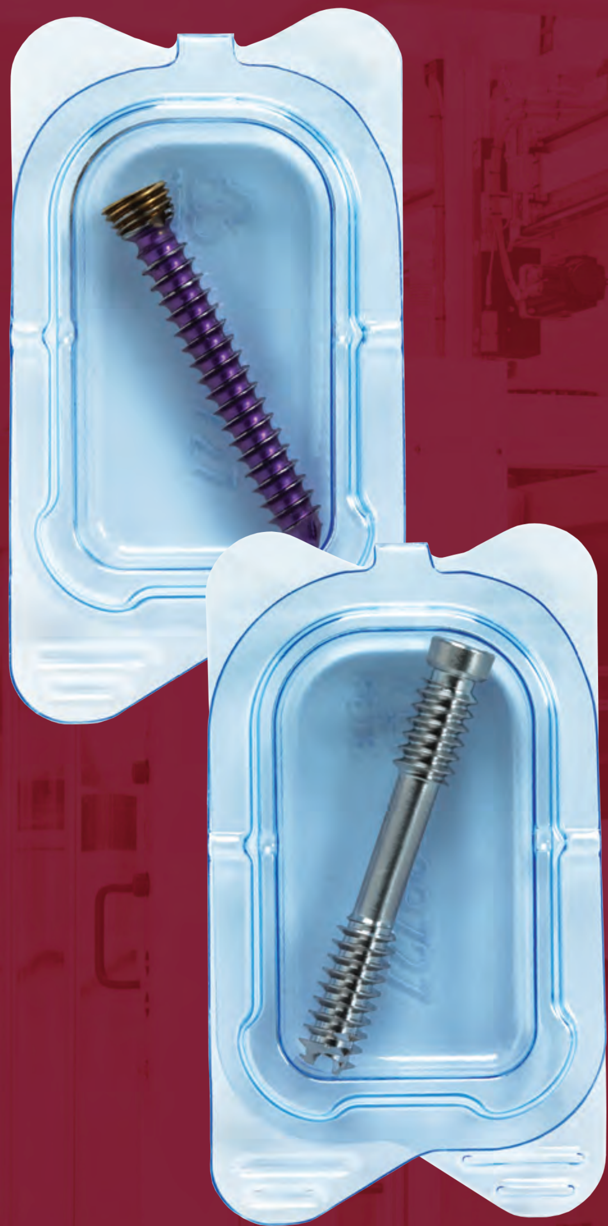
INCREASED SHELF LIFE
BLOCKS OXYGEN

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 — 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 and high heat Lexan®.
- Not for heat-labile materials.

See table on page 28 for more information.

PRODUCT DEVELOPMENT

PROCESS OVERVIEW

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.

PROTOTYPING

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

POSITIVE VS. NEGATIVE TOOLING

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

Positive
Least expensive form of tooling; multiple cavity applications.

Negative
Typically more costly than positive.

Positive
Limited surface detail (none on outside surface).

Negative
Sharp exterior detail and definition.

Positive
Thicker corners.

Negative
Bottom corners may be thin.

Positive
Draft required to facilitate part removal from mold.

Negative
Minimal draft required in most cases.

Positive
Higher gloss on outside surface.

Negative
Higher gloss on inside surface.

Positive
Spacing between parts is greater.

Negative
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

All of our facilities follow Good Manufacturing Practices (GMP) and in facilities with food packaging, we adhere to Safe Quality Food (SQF) standards as well. 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.

CLEAN ROOM

Placon has three facilities 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 Fluoride
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.

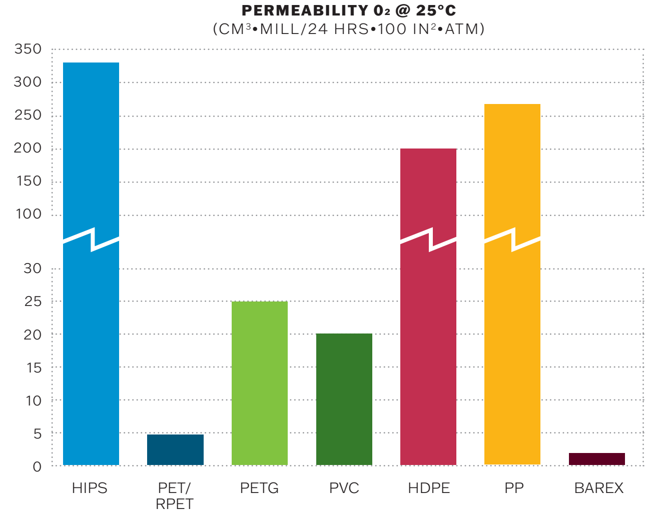
VACUUM FORMING: Technique of using negative pressure to form a finished part. English unit of measurement is in Inches of Mercury (Hg) or Absolute Pressure (PSIA).

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

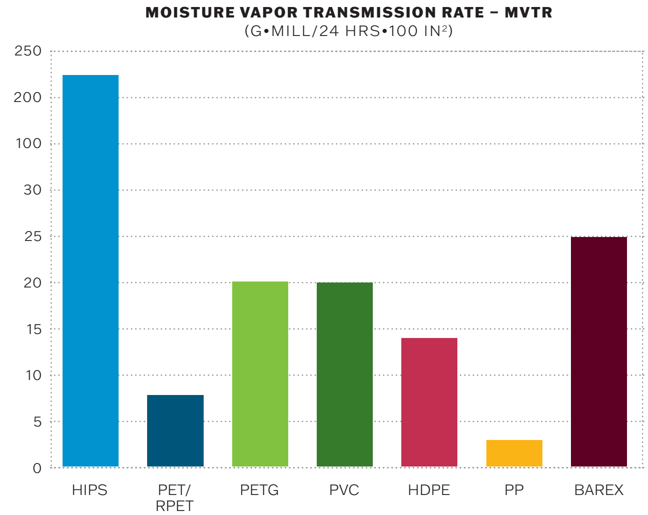
OXYGEN TRANSMISSION RATE

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



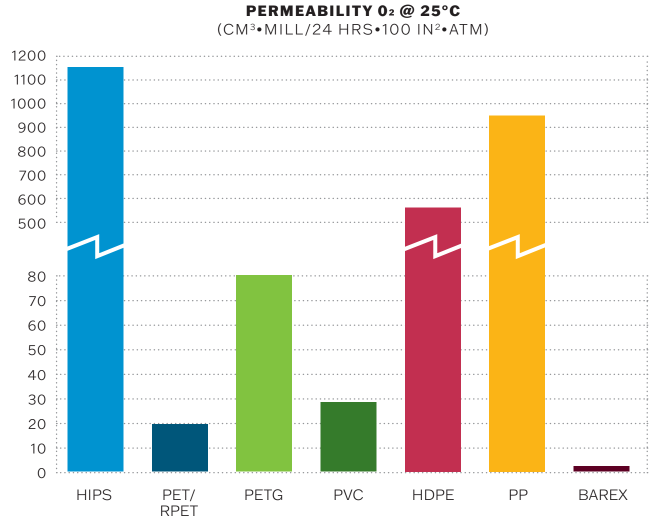
MOISTURE VAPOR TRANSMISSION RATE (MVTR)

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



CO2 TRANSMISSION RATE

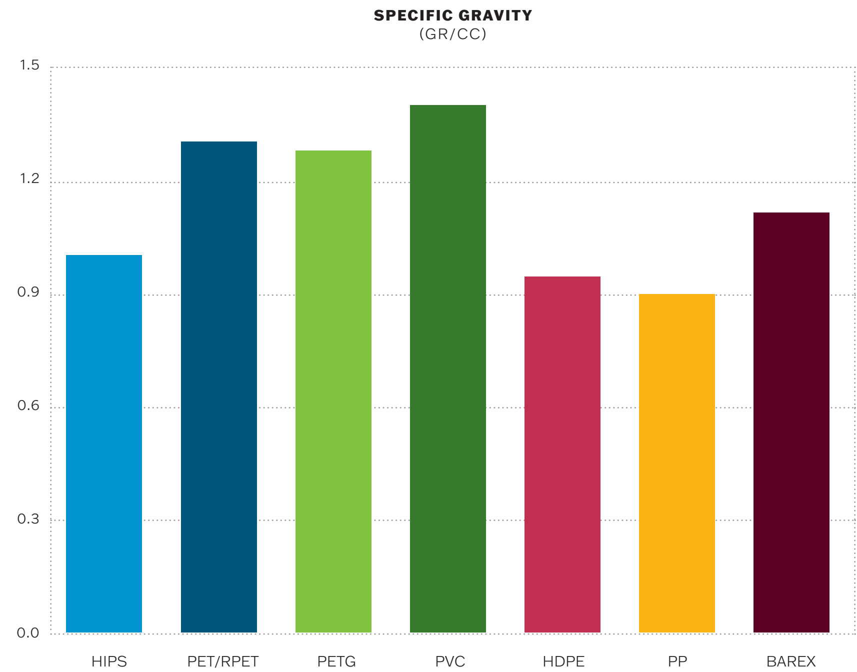
The amount of carbon dioxide gas that passes through a material over a certain period of time.



CALL **800.541.1535** TO PLACE AN ORDER OR VISIT US @ **PLACON.COM**

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.



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″ (in²/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.	415 (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 100in²/24hr/atm	20–25 cc/mil 100in²/24hr/atm	3–10 cc/mil 100in²/24hr/atm
Permeability N_2	1–10 cc/mil 100in²/24hr	10 cc/mil 100in²/24hr	
Permeability CO_2	20–30 cc/mil 100in²/24hr/atm	80–125 cc/mil 100in²/24hr/atm	
Permeability H_2O Vapor	2–4 gm/mil 100in²/24hr	2.5–4.0 gm/mil 100in²/24hr	1.0–4.0 gm/mil 100in²/24hr
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)
1.3–1.35	1.27	1.33	1.27	1.33
2110	2180	2081	2180	2081
Good	Good–Excellent	Good	Good–Excellent	Good
0.5–2.0	0.4–0.8	0.5–2.0	0.4–0.8	0.5–2.0
7,000–8,500	6,900–7,700	7,300–9,000	6,900–7,700	7,300–9,000
100–200	180	200–400	180	200–400
325,000–375,000	250,000–310,000	325,000–370,000	250,000–310,000	325,000–370,000
10,000–12,000	10,000–11,240	12,500–13,300	10,000–11,240	12,500–13,300
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 100in^2/24hr/atm	250–350 cc/mil 100in^2/24hr/atm	160–190 cc/mil 100in^2/24hr/atm	230–300 cc/mil 100in^2/24hr/atm	150–250 cc/mil 100in^2/24hr/atm
		6–7 cc/mil 100in2/24hr/atm	50 cc/mil 100in2/24hr/atm	
	900–1,200 cm3/mil 100in^2/24hr/atm	550–600 cc/mil 100in^2/24hr/atm	1,000 cc/mil 100in^2/24hr/atm	900–1,000 cc/mil 100in^2/24hr/atm
2–4 gm/mil 100in^2/24hr	5–10 gm/mil 100in^2/24hr	2–3 gm/mil 100in^2/24hr	10–15 gm/mil 100in^2/24hr	0.3–0.7 gm/mil 100in^2/24hr
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

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