REGAL PLASTIC SUPPLY COMPANY

PLASTICS REFERENCE HANDBOOK

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Regal Plastic Supply Company,
a division of Regal Supply Company
Established in 1954, Regal Plastic Supply Company is considered one of the foremost pioneers in the plastic distribution industry. Throughout the years, the innovative “customer-oriented plan for success” thinking has become a credible trademark our customers rely on. Fortifying that philosophy, Regal introduced its Plastic Materials Reference Guide in 1984. As products and industries continue to evolve, so does this compilation of technical data. We view providing our customers with tools for effective planning and purchasing as important as meeting product “supply and demand”. You will find this guide an invaluable reference source for researching or finding the answer pertaining to your plastic application. The product information contained herein covers the most commonly used materials; it does not reflect our total capacity.

True customer service is a thought process not developed overnight. Our experience and stability in the industry gives Regal the opportunity to assist you in your plastics endeavors as you utilize staff who are accessible, knowledgeable and resourceful with regard to all inquiries.

We invite you to visit the Regal Plastic Supply Company location in your vicinity. All locations maintain generous inventories of plastic sheet, rod, tube, film, and numerous finished products.

Regal Plastic Supply Company thanks all of our customers for their patronage over the years. We will continue in our efforts to provide the best in JIT inventory and personal service. Plastic is in your future and Regal Plastic Supply Company is your best source.

Sincerely yours,

Regal Plastic Supply Company

National Association
Administrative Offices and Distribution Centers

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405-495-7755
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Visit Regal Plastic Supply Company on the Worldwide Web:
www.regalplastic.com
The Origins of Plastic Materials

INTRODUCTION

Crude Oil
Naphtha

Olefins

Aromatics

Crude Oil
Naphtha

Propylene
Butadiene

Ethylene

Propylene Oxide

Cumene
Paraxylene

Toluene
Xylene

Benzene

Cyclohexane

Alkylamines
Low density polyethylene
Polyvinyl chloride
Polytetrafluoroethylene
Ethylene oxide derivatives
Plasticizers
Polypropylene
Polyurethanes
Resins
Petrol
Phenol
Phenolic derivatives
Acetone
Acrylics
Adipic acid
Nylon salt
Nylon
Pure terephthalic acid
Polyester Film
INTRODUCTION

Preface

Introduction

PLASTIC-(per Webster)- “Any numerous organic, synthetic, or processed materials that are high molecular weight polymers.”

Polymers are a tribute to man’s creativity and inventiveness. They are truly man-made materials. Like any other material, they have their origins in nature, in such basic chemical elements as carbon, oxygen, hydrogen, nitrogen, chlorine, and sulfur. These elements in turn are extracted from the air, water, gas, oil, coal, or even plant life.

It was man’s inspiration to take these elements and combine them, via various chemical reactions, in an almost unending series of combinations, to produce the rich variety of materials we know today as plastics.

The possibilities of combining chemical elements to create plastics with different properties are almost endless. It is this diversity that has made plastics so applicable to such a broad range of end uses and products today.

In the Beginning

Given this kind of versatility and the role that plastics play in modern living, it’s surprising to realize that a little over a century ago there was no such thing as commercial plastic in the United States. During the 1850’s and 60’s, developmental work was going on with hard rubbers and cellulose materials, but the U.S. plastics industry officially dates its beginnings back to 1868, when a product called Celluloid was created as the first commercial plastic in the U.S. The development was in response to a competition sponsored by a manufacturer of billiard balls. It came about when a shortage developed in ivory from which the billiard balls were made, and the manufacturer sought another production method. Celluloid was one of the materials considered, and the U.S. plastics industry was born.

As has been typical of new plastic materials ever since, Celluloid quickly moved into other markets. The first photographic film used by Eastman was made of celluloid: producing the first motion picture film in 1882. The material is still in use today under its chemical name Cellulose nitrate, for making products like eyeglass frames.

Forty years were to pass before the plastics industry took its second major step forward. In 1909, Dr. Leo Hendrik Baekeland introduced Phenol formaldehyde plastics (or Phenolics as they are more popularly known), the first plastic to achieve world wide acceptance.

The third big thrust in plastics development took place in the 1920’s with the introduction of Cellulose acetate, ureaformaldehyde, polyvinyl chloride, or Vinyl, and Nylon.

Evolution

In the World War II years of the 1940’s, the demand for plastics accelerated, as did research into new plastics that could aid in the defense effort.
By the start of the 1950’s plastics were on their way to being accepted by designers and engineers as basic materials, along with the more conventional ones.

Nylon, Teflon, Acetal, and Polycarbonate became the nucleus of a group in the plastics family known as the engineering thermoplastics. Their outstanding impact strength and thermal and dimensional stability enabled them to compete directly with metals. This group has grown since then to include a number of new plastics, as well as improved variations of older plastics that could similarly qualify for inclusion.

**The Monomers & Polymers**

Many plastics are derived from fractions of petroleum or gases that are recovered during the refining process. For example: ethylene monomer, one of the more important feedstocks, or starting materials for plastics, is derived in a gaseous form from petroleum refinery gas, liquefied petroleum gases, or liquid hydrocarbons. Although petroleum gas derivatives are not the only basic source used in making feedstocks for plastics, they are among the most popular and economical in use today. Coal is another excellent source in the manufacturing of feedstocks for plastics.

From these basic sources come the feedstocks we call monomers. The monomer is subjected to a chemical reaction known as polymerization; it causes the small molecules to link together into ever increasingly long molecules. Chemically, the polymerization reaction gas turns the monomer into a polymer, and thus a given type of plastic resin.

**The Product as We See It**

The polymer or plastic resin must next be prepared for use by the processor, who will turn it into a finished product. In some instances, it is possible to use the plastic resin as it comes out of the polymerization reaction. More often, however, it goes through other steps which turn it into a form that can be more easily handled by the processor and processing equipment. The more popular forms of resin for processing are pellet, granule, flake, and powder.

In the hands of the processor, these solids are generally subjected to heat and pressure. They are melted, forced into the desired shape (sheets, rods, and tubes) and then allowed to cure into a finished product. Resins are most readily available in their natural color, but by adding coloring agents, most any color can be achieved during the processing.

Plastics are a family of materials, not a single material. Each has its own distinct and special advantages.

Each day brings new plastic compounds, and new uses for the old compounds.
## INTRODUCTION

### Chronology of Plastic

<table>
<thead>
<tr>
<th>DATE</th>
<th>MATERIAL</th>
<th>ORIGINAL TYPICAL USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1868</td>
<td>Cellulose Nitrate</td>
<td>Eye Glass Frames</td>
</tr>
<tr>
<td>1909</td>
<td>Phenol-Formaldehyde</td>
<td>Telephone Handsets</td>
</tr>
<tr>
<td>1926</td>
<td>Alkyd</td>
<td>Electrical Bases</td>
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<tr>
<td>1926</td>
<td>Alklyl-Formaldehyde</td>
<td>Terminal Boards</td>
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<tr>
<td>1927</td>
<td>Cellulose Acetate</td>
<td>Tooth Brushes, Packaging</td>
</tr>
<tr>
<td>1927</td>
<td>Polvinyl Chloride</td>
<td>Raincoats</td>
</tr>
<tr>
<td>1929</td>
<td>Urea-Formaldehyde</td>
<td>Lighting Fixtures</td>
</tr>
<tr>
<td>1935</td>
<td>Ethyl Cellulose</td>
<td>Flashlight Cases</td>
</tr>
<tr>
<td>1936</td>
<td>Acrylic</td>
<td>Brush Backs, Displays</td>
</tr>
<tr>
<td>1936</td>
<td>Polvinyl Acetate</td>
<td>Flash Bulb Lining</td>
</tr>
<tr>
<td>1938</td>
<td>Cellulose Acetate Butyrate</td>
<td>Irrigation Pipe</td>
</tr>
<tr>
<td>1938</td>
<td>Polystyrene or Styrene</td>
<td>Kitchen Housewares</td>
</tr>
<tr>
<td>1938</td>
<td>Nylon (Polyamide)</td>
<td>Gears</td>
</tr>
<tr>
<td>1938</td>
<td>Polvinyl Acetal</td>
<td>Safety Glass Interlayer</td>
</tr>
<tr>
<td>1939</td>
<td>Polvinylvilene Chloride</td>
<td>Auto Seat Covers</td>
</tr>
<tr>
<td>1939</td>
<td>Melamine-Formaldehyde</td>
<td>Tableware</td>
</tr>
<tr>
<td>1942</td>
<td>Polyester</td>
<td>Boat Hulls</td>
</tr>
<tr>
<td>1942</td>
<td>Polyethylene</td>
<td>Squeezable Bottles</td>
</tr>
<tr>
<td>1943</td>
<td>Fluorocarbon</td>
<td>Industrial Gaskets</td>
</tr>
<tr>
<td>1943</td>
<td>Silicone</td>
<td>Motor Insulation</td>
</tr>
<tr>
<td>1945</td>
<td>Cellulose Propionate</td>
<td>Automatic Pens and Pencils</td>
</tr>
<tr>
<td>1947</td>
<td>Epoxy</td>
<td>Tools and Jigs</td>
</tr>
<tr>
<td>1948</td>
<td>Acrylonitrile-Butadiene-Styrene</td>
<td>Luggage</td>
</tr>
<tr>
<td>1949</td>
<td>Allylic</td>
<td>Electrical Connectors</td>
</tr>
<tr>
<td>1954</td>
<td>Polyurethane or Urethane</td>
<td>Foam Cushions</td>
</tr>
<tr>
<td>1956</td>
<td>Acetal</td>
<td>Automotive Parts</td>
</tr>
<tr>
<td>1957</td>
<td>Polypropylene</td>
<td>Safety Helmets</td>
</tr>
<tr>
<td>1957</td>
<td>Polycarbonate</td>
<td>Appliance Parts</td>
</tr>
<tr>
<td>1959</td>
<td>Chlorinated Polyether</td>
<td>Valves and Fittings</td>
</tr>
<tr>
<td>1962</td>
<td>Phenoxy</td>
<td>Bottles</td>
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<tr>
<td>1962</td>
<td>Polyalloymer</td>
<td>Typewriter Cases</td>
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<tr>
<td>1964</td>
<td>Ionomer</td>
<td>Skin Packages</td>
</tr>
<tr>
<td>1964</td>
<td>Polyphenylene Oxide</td>
<td>Battery Cases</td>
</tr>
<tr>
<td>1964</td>
<td>Polymide</td>
<td>Bearings</td>
</tr>
<tr>
<td>1964</td>
<td>Ethylene-Vinyl Acetate</td>
<td>Heavy Gauge Flexible Sheeting</td>
</tr>
<tr>
<td>1965</td>
<td>Parylene</td>
<td>Insulating Coatings</td>
</tr>
<tr>
<td>1965</td>
<td>Polysulfone</td>
<td>Electrical/Electronic Parts</td>
</tr>
<tr>
<td>1970</td>
<td>Thermoplastic Polyester</td>
<td>Electrical/Electronic Parts</td>
</tr>
<tr>
<td>1973</td>
<td>Polybutylene</td>
<td>Piping</td>
</tr>
<tr>
<td>1975</td>
<td>Nitrile Barrier Resins</td>
<td>Containers</td>
</tr>
</tbody>
</table>
The information contained herein provides product data, suggestions, and guidelines we believe to be reliable. They are offered in good faith but without any guarantee, as conditions, type of product, and methods of product use are beyond our control.

Regal Plastic Supply Company makes no warranties either expressed or implied and expressly disclaims any implied warranty of fitness for a particular purpose or procedure.

**Sufficient verification and testing to determine the suitability for their own particular purpose of any information or products referred to herein, is strongly recommended.**
Polycarbonate extruded sheets are used for a wide variety of applications. These sheets can be tinted and cold-formed to tight radii (as low as 100 times the material thickness) or thermo-formed to complex shapes.

Polycarbonate sheets have 250 times the impact strength of glass, and 30 times the impact of acrylic. They have 40% better thermal efficiency than glass, and lower maintenance costs than both glass and acrylic.

**LEXAN® Sheet**

LEXAN sheet is manufactured by and is a registered trademark of the General Electric Company.

Manufactured by extruded method, LEXAN sheet is available in a wide range of special formulations to meet specific physical requirements and applications.

There are three categories of LEXAN sheet: Monolithic, Profile, and Laminated.

- **Monolithic sheets** are solid extruded sheets, Figure A.
- **Profile sheets** are multi-walled, Figure B.
- **Laminated sheets** are a composite of LEXAN sheet and a mar-resistant sheet bonded together with a resin interlayer film, Figure C.

**Typical end uses for the desired properties innate in polycarbonates** are:

- Automotive instrument panels
- Boat hatch covers
- Bowls and cutting wheels for food processors
- Business machine housings
- Computer disk packs
- Connectors
- Door and window hardware
- Face plates
- Food-service wear
- Grills for fans and air conditioners
- Indoor and outdoor lighting diffusers
- Kidney dialysers
- Meter covers
- Microwave wear
- Milk and baby bottles
- Patio door thresholds
- Power-tool housings
- RV windshields
- Safety and vandal-resistant windows for schools, banks, public buildings, gas stations, trains, and armored cars.
- Safety and prescription eyewear
- Safety helmets
- Skylights and outdoor signs
- Solar cell covers
- Storage modules
- Telephone finger wheels
- Terminal block
- Vacuum-cleaner impellers and housings
LEXAN® Sheet

| LEXAN® 9440 Sheet | An uncoated polycarbonate sheet, the LEXAN 9440 sheet offers high impact protection, thermoformability, transparency, and dimensional stability. Developed to meet the requirements of specialty applications such as food handling/contact, medical device/apparatus, and other cleanroom needs, this sheet meets USP-VI criteria and FDA food additive regulation 21 CFR 177.1580. Available in clear, it is both paintable and printable as well as vacuum, pressure, twin sheet, and drape formable. |
| LEXAN® Sheet for Signs | |

LEXAN® 9034 Sheet

The LEXAN 9034 sheet is a general purpose, polycarbonate glazing sheet, possessing excellent light transmission qualities and high impact strength. With no added abrasion protection or UV resistance, this sheet is thermoformable, easily cold-formable and energy efficient.

Typical end uses include:
- machine guards
- sound panels
- utility glazing material

LEXAN® 9030 Sheet

LEXAN 9030 sheet is a clear, general purpose, polycarbonate with the same basic properties as the Lexan® 9034 sheet. This sheet can be colored, tinted, painted, printed and is formable by vacuum, pressure, twin sheet, and drape methods.

Typically used for:
- machine guards
- lenses

LEXAN® CTG Sheet

This sheet offers excellent impact resistance, optical clarity, and abrasion resistance. Two-sided hard-coated LEXAN CTG sheet is easily fabricated and can be drape formed to simple curvatures. It is typically used for applications such as:
- face shields
- safety glasses
- goggles

LEXAN® FMR Sheet

LEXAN FMR sheet is a clear, two-sided, hard-coated product offering excellent impact resistance, optical clarity, and abrasion resistance. With the ability to be cold-formed or heat-drape formed to soft radii, LEXAN FMR sheet is typically used for:
- motorcycle windscreens
- race car windshields
- industrial conveyor covers
Typical end uses include:
- restrooms
- locker rooms
- industrial window glazing
- breezeways
- carports
- patios

LEXAN® Sheet for Signs
LEXAN sheet for signage offers a large selection of colors, sizes, finishes and weights. Designed for backlit pole signs, groundmounts, canopies, and fascias, LEXAN sheet has 30 times the impact strength of acrylic and 10 times the impact strength of modified acrylic.

<table>
<thead>
<tr>
<th>Performance Capability</th>
<th>LEXAN S-100</th>
<th>LEXAN S-300</th>
<th>LEXAN SGC-100</th>
<th>LEXAN SG-300</th>
<th>LEXAN SG-404</th>
<th>LEXAN MR10</th>
</tr>
</thead>
<tbody>
<tr>
<td>High impact resistance</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Formability</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Add UV resistance</td>
<td></td>
<td></td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
</tr>
<tr>
<td>Available in colors</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Available in spools</td>
<td></td>
<td></td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
</tr>
<tr>
<td>Matte finish on one side</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
</tbody>
</table>

*See your plastic distributor for details on limited warranties.

LEXAN® ColorQuik™ Sheet
This product is a pre-laminated sign material offering durable 3M™ Scotchcal™ translucent film applied to impact-resistant LEXAN sign white polycarbonate sheet. Providing enhanced color consistency and durability, this product reduces the need to paint sign blanks and can eliminate the manual application of color film as the key base color.

LEXAN® MR10 Sheet
with Margard® II UV and Abrasion-Resistant Coating
Designed to be the most UV / abrasion-resistant polycarbonate available, this sheet is virtually unbreakable, easily maintained without marring, hazing, or yellowing, and exhibits high light transmission. Recommended for high-traffic and high-impact areas, typical applications are:
- educational institutions
- psychiatric hospitals
- storefronts and windows
- low-level physical attack areas
- entrance doors and patios
- hurricane protection
- railings
- sound barriers

LEXAN® XL10 Sheet
Designed for sloped glazing and overhead applications, this lightweight, thermoformable sheet is virtually unbreakable with high insulation values and one-sided UV resistance.
Applications include:
- skylights
- barrel vaults
- covered walkways
- canopies

LEXAN® PROTECT-A-GLAZE® 90318 Sheet
Considered the most economical of the LEXAN sheet product line, Protect-A-Glaze is a translucent, pebble finished sheet which displays excellent light transmission and impact resistance. This sheet has no UV resistance.
LEXAN® S-100 Sheet
This clear, extruded polycarbonate sheet is designed for:
- interior signage
- exterior signage
- flat sign faces
- formed sign faces
- backlit pole signs
- pole signs groundmounts
- canopies
- building fascias
- electronic message sign covers

The LEXAN S-100 sheet has a polished surface on both sides with a glossy finish. Compatible with most decorating and forming methods, it is available in transparent and custom colors.

LEXAN® S-300 Sheet
This extruded polycarbonate sheet differs from the LEXAN S-100 sheet only in the surface texture. The LEXAN S-300 sheet has a matte first surface and a polished second surface.

**NOTE:** LEXAN S-100 and LEXAN S-300 sheets are not recommended for applications requiring high abrasion resistance or for outdoor signs that are predominantly white or where color shift is objectionable.

LEXAN® SGC-100 Sheet
Available in clear only, this co-extruded polycarbonate sheet is polished on both sides with a glossy surface and UV resistant on one side. Easily formed and decorated, typical uses include:
- second surface decorated outdoor signs
- light or white screened / decorated signs
- flat or formed sign faces
- backlit or opaque pole signs
- groundmounts
- canopies
- building fascias
- electronic message sign covers

**NOTE:** LEXAN SGC-100, LEXAN SG-300, and LEXAN SG-404 sheets are not recommended for applications requiring high abrasion resistance. The solar grade treated surface must face outward.

### LEXAN® SG-300 Sheet
This extruded polycarbonate sheet has polished / matte sides with UV resistant surface treatment on one side. Available in clear, transparent, and opaque custom colors, the suggested applications are the same as the SGC-100 sheet.

### LEXAN® SG-404 Sheet
A pigmented translucent sheet, UV resistant on one side, glossy on both, LEXAN SG-404 sheet can be easily formed and decorated. UL recognized as an electrical enclosure material in channel letter diffuser applications, the sheet is available in standard and custom colors. Applications include:
- first-surface decorated outdoor signs
- signs where color shift is not acceptable
- flat signs
- formed signs
- backlit pole signs
- opaque pole signs
- groundmounts
- price signs
- canopies
- fascias
- channel letters

### SG-404 Average Light Transmission Values

<table>
<thead>
<tr>
<th>Color</th>
<th>.118 gauge</th>
<th>.177 gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2051 Blue</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>L2114 Blue</td>
<td>1.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>L2283 Red</td>
<td>13%</td>
<td>8.5%</td>
</tr>
<tr>
<td>L2793 Red</td>
<td>3.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td>L2108 Green</td>
<td>1.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>L7328 White</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>L2119 Orange</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>L2037 Yellow</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>L2025 Black</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
LEXAN® MR10 Sheet

This LEXAN sheet has a Margard® II surface which keeps the material from marring and hazing while preventing graffiti from sticking. UV and abrasion resistant, LEXAN MR10 sheet resists yellowing, breakage, weathering and coating failure. With a glossy surface finish on both sides, this sheet is typically used for applications such as:

- flat, non-decorated applications where abrasion resistance is required
- menu board covers
- directory fronts
- display panels
- glazing for high traffic areas and high security areas

**NOTE:** LEXAN MR10 sheet should be used for flat, transparent applications only. Paint, adhesives and other materials commonly used in the sign industry will not adhere to the highly mar-resistant surface of the sheet. If a second surface decorated application is desired, a one-side, hard-coated LEXAN MR10 sheet is available.

LEXAN® THERMOCLEAR® Sheet

LEXAN Thermoclear sheet is a multi-walled polycarbonate sheet with a UV-protected surface and exceptional strength. LEXAN Thermoclear sheet is available in extruded lengths up to 39 feet, however edge-to-edge cambering (slight arching) of up to 1/4” does occur approximatley every 10 feet. Consult with your nearest Regal Plastic Supply Distributor when considering an application utilizing long lengths. Suggested LEXAN Thermoclear sheet sign application uses:

- flat architectural fascias
- canopy signs

---

### Standard Colors

<table>
<thead>
<tr>
<th>Number</th>
<th>Clear</th>
<th>White</th>
<th>Bronze</th>
<th>Opal</th>
</tr>
</thead>
<tbody>
<tr>
<td>112</td>
<td>825075</td>
<td>5109</td>
<td>825074</td>
<td></td>
</tr>
<tr>
<td>Light Transmission (Avg.)</td>
<td>80%</td>
<td>20%</td>
<td>50%</td>
<td>40%</td>
</tr>
</tbody>
</table>

For further product information, please refer to page 52.
LEXAN® SHEET

LEXAN® THERMOCLEAR® Sheet

Designed for energy efficient, thermal glazing, LEXAN Thermoclear sheet is a multi-wall polycarbonate sheet with vertical interior ribbing.

Possessing high impact strength and light transmission, and are weather and UV resistant. Weighing only 15% of double-pane glass, LEXAN Thermoclear sheet insulates up to 40% better than single-pane glass, and transmits up to 83% of visible light. Weather and UV resistant with high impact strength and light transmission, this sheet can be cold-formed on site (up to 175 times the material thickness) and meets major building codes.

Applications include:
- industrial roofs and sidewalls
- shopping center and football stadium roofing
- greenhouses and sunrooms

LEXAN® Dripgard™ Sheet

With basic properties identical to the Thermoclear® sheet, the LEXAN Dripgard sheet has an added coating on the inner surface which reduces the formation of condensation droplets. Designed for glazing applications in which dripping water is a problem, typical end uses are:
- commercial greenhouses
- sunrooms
- swimming pool enclosures
- industrial roofs

LEXAN® Corrugated Sheet

Used anywhere fiberglass panels would be considered, LEXAN Corrugated sheet has 20 times the impact strength of fiberglass. Transmitting up to 90% of visible light, LEXAN Corrugated sheet is UV resistant, lightweight, and easily cold-formable.

NOTE: Corrugated enclosures must be vented. For high wind load applications, 24" on center is required, 36" on center is acceptable for applications requiring less loading.

DIMENSIONAL STABILITY

Coeficients of Thermal Expansion

<table>
<thead>
<tr>
<th>Building Material</th>
<th>Inches/Inch/°F</th>
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</thead>
<tbody>
<tr>
<td>Glass</td>
<td>.0000050</td>
</tr>
<tr>
<td>Aluminum</td>
<td>.0000129</td>
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<tr>
<td>LEXAN Sheet</td>
<td>.0000375</td>
</tr>
<tr>
<td>Acrylic</td>
<td>.0000410</td>
</tr>
<tr>
<td>Steel</td>
<td>.0000063</td>
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</tbody>
</table>

*Registered Trademark of Consolidated Aluminum
**IMPACT STRENGTH**

LEXAN sheet has 30 times the impact strength of acrylic. Cell cast acrylic tests impact resistance at 2 to 3 ft. - lbs. Modified acrylic tests at 10 to 20 ft. - lbs. maximum. Refer to Drop Dart Test diagram below.

**SERVICE TEMPERATURE**

Remaining rigid and resisting warpage at a heat deflection temperature of 270°F @ 264 psi, LEXAN sheet also maintains its impact properties down to -40°F.

**ULTRA-VIOLET LIGHT TRANSMISSION***

All grades of LEXAN® sheet are essentially opaque at all wavelengths below 385 nanometers, making LEXAN sheet excellent for protecting art objects, display merchandise and fabrics from damaging effects of UV light.

**SOUND TRANSMISSION**

LEXAN Monolithic Sheet

**WEIGHT**

* All grades of LEXAN® sheet are essentially opaque at all wavelengths below 385 nanometers, making LEXAN sheet excellent for protecting art objects, display merchandise and fabrics from damaging effects of UV light.
PRODUCT COMPLIANCE CODES

<table>
<thead>
<tr>
<th>Code</th>
<th>Major Model Building Codes (BOCA, ICBO, SBC and Dade County)</th>
<th>MR10 Sheet</th>
<th>9034 Sheet</th>
<th>XL10 Sheet</th>
<th>Thermoclear Sheet</th>
<th>LEXGARD Laminates</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Approved Light Transmitting Plastic</td>
<td>X</td>
<td>X</td>
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<td>Burglary-resistant glazing per UL 972 Min. thickness .060”</td>
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<td>Safety glazing material for architectural applications</td>
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<td>Approved Light Transmitting Plastic</td>
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<td>X</td>
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</tbody>
</table>

**GLAZING**
Designing with LEXAN sheet requires consideration of and planning for its thermal expansion and flexibility. The following charts and tables are provided to help determine possible application design.

**Rabbet Depth Detail**

Sheet Thickness, Edge Engagement*, Expansion Allowance** and Rabbet Depth***
(Based on ± 50°F temperature shift from installation)

<table>
<thead>
<tr>
<th>Glazing Dimensions</th>
<th>LEXAN Sheet Thickness (use short dimension)</th>
<th>Edge Engagement (use long dimension)</th>
<th>Expansion</th>
<th>Contraction</th>
<th>Total Rabbet Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>25&quot; - 36&quot;</td>
<td>.118’</td>
<td>5/16’</td>
<td>1/32’</td>
<td>1/32’</td>
<td>3/8”</td>
</tr>
<tr>
<td>37&quot; - 48&quot;</td>
<td>.177’</td>
<td>1/2’</td>
<td>1/16”</td>
<td>1/16”</td>
<td>5/8”</td>
</tr>
<tr>
<td>49&quot; - 60&quot;</td>
<td>.236’</td>
<td>5/8’</td>
<td>3/32”</td>
<td>3/32”</td>
<td>13/16”</td>
</tr>
<tr>
<td>61&quot; - 72&quot;</td>
<td>.375’</td>
<td>3/4”</td>
<td>3/32”</td>
<td>3/32”</td>
<td>15/16”</td>
</tr>
<tr>
<td>73&quot; - 96&quot;</td>
<td>.500’</td>
<td>7/8”</td>
<td>1/8”</td>
<td>1/8”</td>
<td>1 1/8”</td>
</tr>
<tr>
<td>97&quot; - 120&quot;</td>
<td>.500’</td>
<td>1”</td>
<td>5/32”</td>
<td>5/32”</td>
<td>1 5/16”</td>
</tr>
</tbody>
</table>

*Based on 40 PSF design load. **Trim the sheet by the amount indicated in the expansion column. ***Expansion + contraction + edge engagement = Total Rabbet Depth.
DRY SYSTEMS

When sheet expansion may exceed sealant limitations, resulting in application (i.e., sloped, curved skylights) failure, dry glazing should be considered. Gaskets for dry glazing applications should be EPDM, silicone, or neoprene. Individual gasket manufacturers should be contacted to verify the correct use of their products with polycarbonate sheet.

Note: PVC gaskets typically are not compatible with polycarbonate.

DUAL

In dual-glazed window systems, double-channeled sash units, and for overglazing and backglazing, it is important to always allow for the greater flexibility and expansion of Lexan® sheet.

WET SYSTEMS

Only high-grade silicone sealants and fully-cured butyl tapes are recommended.
DRY SYSTEMS

In applications where sheet expansion might exceed the sealant limitations, dry glazing systems provide a workable solution. In dry systems, the rubber gaskets are snapped into the glazing strips and thereby allowing free movement of the sheet during expansion and contraction.

**Note:** PVC gaskets typically are not compatible with polycarbonate.

WET SYSTEMS

Commonly used in applications such as carports, warehouses, conservatories and similar glass replacement situations.

Silicone sealants are the glazing compound normally recommended for Thermoclear sheet.

**Note:** Amino or Benzamid curing silicone sealants are not compatible with LEXAN sheet and result in micro-cracks under stress.

**For recommended sealants, gaskets, and tapes refer to table on adjacent page or contact your nearest Regal Plastic Supply Distributor.**
### LEXAN® Sheet / Laminates for Glazing

#### PRODUCT AVAILABILITY

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>GAUGES</th>
<th>WIDTHS</th>
<th>LENGTHS</th>
<th>COLORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEXAN XL10 Sheet</td>
<td>.093”, .118”, .177”, .236”, .375”, .500”</td>
<td>48” min. 96” max.</td>
<td>150” max.</td>
<td>Clear, Grey, Greylite, Bronze, and Light Green</td>
</tr>
<tr>
<td>LEXAN MR10 Sheet</td>
<td>.118”, 177”, .236”, .375”, .500”</td>
<td>48” min. 72” max</td>
<td>96” max.</td>
<td>Clear, Grey, Greylite, Bronze, and Light Green</td>
</tr>
<tr>
<td>LEXAN 9034 Sheet</td>
<td>.118”, .177”, .236”, .375”, .500”</td>
<td>48” min. 96” max, depending on gauge</td>
<td>150” max.</td>
<td>Clear, Gray, Greylite, Bronze, and Light Green</td>
</tr>
<tr>
<td>Thermoclear Multi-Wall Sheet</td>
<td>6mm, 8mm, 10mm, 16mm</td>
<td>36’, 47.25’, 48’, 71.25’, 72’ and 83’</td>
<td>96” min. 51” max.</td>
<td>Clear, Bronze, Dark Bronze, White, Opal and custom colors</td>
</tr>
<tr>
<td>LEXAN Protect-A-Glaze Sheet *</td>
<td>.118”, .177”, .236”</td>
<td>48” - 72”</td>
<td>up to 144”</td>
<td>Clear and Bronze</td>
</tr>
<tr>
<td>LEXAN Corrugated Sheet</td>
<td>.033”</td>
<td>27” and 51”</td>
<td>96” - 480”</td>
<td>Clear, Gray, Opaque, Forest Green, White and Bronze</td>
</tr>
<tr>
<td>LEXGARD Bullet-Resistant Laminates</td>
<td>.250” to 1.25”</td>
<td>60” max.</td>
<td>96” max.</td>
<td>Clear, Grey, and Bronze</td>
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</tbody>
</table>

* = Custom gauges and sizes available  
¥ = Custom sizes and colors available

#### Sealants, Gaskets and Tapes

<table>
<thead>
<tr>
<th>Type</th>
<th>Manufacturer</th>
<th>Product Name</th>
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</thead>
<tbody>
<tr>
<td>Silicone</td>
<td>General Electric Company</td>
<td>Ultrapur Sealant</td>
</tr>
<tr>
<td></td>
<td>Waterford, NY</td>
<td>Silpurf® Sealant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1200® Sealant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000® Sealant</td>
</tr>
<tr>
<td>Gasket/Tape</td>
<td>Norton Company</td>
<td>NORRENE* Foam</td>
</tr>
<tr>
<td></td>
<td>Granville, NY</td>
<td>V-2100 Urethane Series</td>
</tr>
<tr>
<td>Gasket</td>
<td>Tremco</td>
<td>Silicone (70 Durometer)</td>
</tr>
<tr>
<td></td>
<td>Columbus, OH</td>
<td>EPDM (60, 70 Durometer)</td>
</tr>
<tr>
<td>Tape</td>
<td>Tremco</td>
<td>440 Tape</td>
</tr>
<tr>
<td></td>
<td>Cleveland, OH</td>
<td></td>
</tr>
<tr>
<td>Butyl Tape</td>
<td>PTI</td>
<td>303, 606</td>
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<td>Dayton, OH</td>
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<td></td>
<td>Schnee-Morehead</td>
<td>Isocryl 5600 Series</td>
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<td>Irving, TX</td>
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<tr>
<td>Aluminum / Mesh Tape</td>
<td>DRG Sellotape</td>
<td>Sellotape BV Vent Tape</td>
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<td>Utrecht, Holland</td>
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<tr>
<td>Vent Tape</td>
<td>3M</td>
<td>Tape 394, 3294</td>
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<td></td>
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<tr>
<td></td>
<td>ITP</td>
<td>Muerifire AD 3429</td>
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<tr>
<td></td>
<td>Annapolis, MN</td>
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*Registered Trademark of Norton
## LEXAN® Sheet for Signs

### PRODUCT AVAILABILITY

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>SPOOL THICKNESS</th>
<th>SPOOL WIDTHS</th>
<th>SPOOL LENGTHS</th>
<th>SHEET GAUGES (inches)</th>
<th>SHEET WIDTHS</th>
<th>SHEET LENGTHS</th>
<th>COLORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEXAN ColorQuik™ Sheet</td>
<td>.118&quot;, .150&quot;, .177&quot;</td>
<td>52&quot;</td>
<td>.118 - 504&quot;, .150 - 400&quot;, .177 - 304&quot;</td>
<td>.118&quot;, .150&quot;, .177&quot;</td>
<td>52</td>
<td>36&quot; - 150&quot;</td>
<td>Sunflower Yellow, Green, Red, Cardinal Red, Blue, Bright Blue</td>
</tr>
<tr>
<td>LEXAN S-100 Sheet</td>
<td>.093&quot;, .118&quot;, .150&quot;, .177&quot;</td>
<td>4&quot;, 5&quot;, 6&quot;, 8&quot;</td>
<td>304&quot;, 392&quot;, 400&quot;, 504&quot;, 624&quot;, 800&quot;, 1000&quot;</td>
<td>.060, .080, .093, .118, .125, .150, .177, .236</td>
<td>52, 64, 76, 86, 100&quot;</td>
<td>36&quot; - 150&quot;</td>
<td>Clear*</td>
</tr>
<tr>
<td>LEXAN S-300 Sheet</td>
<td>.093&quot;, .118&quot;, .150&quot;, .177&quot;</td>
<td>4&quot;, 5&quot;, 6&quot;, 8&quot;</td>
<td>304&quot;, 392&quot;, 400&quot;, 504&quot;, 624&quot;, 800&quot;, 1000&quot;</td>
<td>.093, .118, .125, .150, .177, .236</td>
<td>52, 64, 76, 100&quot; **</td>
<td>36&quot; - 150&quot;</td>
<td>Clear*</td>
</tr>
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<td>LEXAN SGC-100 Sheet</td>
<td>.093&quot;, .118&quot;, .150&quot;, .177&quot;</td>
<td>4&quot;, 5&quot;, 6&quot;, 8&quot;</td>
<td>304&quot;, 392&quot;, 400&quot;, 504&quot;, 624&quot;, 800&quot;, 1000&quot;</td>
<td>.093, .118, .125, .150, .177, .236</td>
<td>52, 64, 76, 100&quot; **</td>
<td>36&quot; - 150&quot;</td>
<td>Clear*</td>
</tr>
<tr>
<td>LEXAN SG-300 Sheet</td>
<td>.093&quot;, .118&quot;, .150&quot;, .177&quot;</td>
<td>4&quot;, 5&quot;, 6&quot;, 8&quot;</td>
<td>304&quot;, 392&quot;, 400&quot;, 504&quot;, 624&quot;, 800&quot;, 1000&quot;</td>
<td>.093, .118, .125, .150, .177, .236</td>
<td>52, 64, 76, 100&quot; **</td>
<td>36&quot; - 150&quot;</td>
<td>Transparent* Texture</td>
</tr>
<tr>
<td>LEXAN SG-404 Sheet</td>
<td>.093&quot;, .118&quot;, .150&quot;, .177&quot;</td>
<td>4&quot;, 5&quot;, 6&quot;, 8&quot;</td>
<td>304&quot;, 392&quot;, 400&quot;, 504&quot;, 624&quot;, 800&quot;, 1000&quot;</td>
<td>.093, .118, .125, .150, .177, .236</td>
<td>52, 64, 76, 100&quot; **</td>
<td>36&quot; - 150&quot;</td>
<td>Two shades of red, two shades of blue, yellow, orange, black, white and green.</td>
</tr>
<tr>
<td>LEXAN MR10 Sheet</td>
<td>——</td>
<td>——</td>
<td>——</td>
<td>.118, .177, .236</td>
<td>48&quot;, 60&quot;, 72&quot;, 96&quot;</td>
<td>36&quot; - 96&quot;</td>
<td>Clear, gray, bronze, greylite and green</td>
</tr>
<tr>
<td>LEXAN Thermoclear Sheet</td>
<td>——</td>
<td>——</td>
<td>——</td>
<td>.236, .312, .395&quot;</td>
<td>36&quot;, 48&quot;, 54&quot;, 72&quot;, 83&quot;, 96&quot;, 120&quot;, 144&quot; ¥</td>
<td>Clear, White, and Bronze*</td>
<td></td>
</tr>
</tbody>
</table>

* = Custom colors upon request  
¥ = Custom sizes upon request  
** = 100" wide roll / sheets only available in gauges .125 and higher
LEXAN® Sheet is fabricated using standard procedures and equipment.

**CUTTING**

<table>
<thead>
<tr>
<th>Type</th>
<th>Sheet Gauge</th>
<th>Blade Description</th>
<th>Teeth Per Inch</th>
<th>Blade Speed (feet per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular</td>
<td>1/16&quot; - 3/32&quot;</td>
<td>Hollow Ground Panel Blade</td>
<td>10 - 12</td>
<td></td>
</tr>
<tr>
<td>Circular</td>
<td>1/8&quot; - 1/2&quot;</td>
<td>Triple chip cut carbide blades with alternating bevel and straight teeth.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Band</td>
<td>All Gauges</td>
<td>10 - 18</td>
<td>2500 - 3000</td>
<td></td>
</tr>
</tbody>
</table>

**MILLING AND ROUTING**

When end milling, using a high rotating speed or low feed rate is recommended. Without increased milling speed, a high feed rate isn’t permissible.

Right or left-handed spiral router bits are preferred. Two or three-fluted carbide tipped bits, 3/8" to 1/2" diameter, can also be used. Router (no-load) speeds of 25,000 to 30,000 rpm are suggested.

**SHEARING, PUNCHING, BLANKING**

When shearing polycarbonate sheet, remove the sheared edge by a secondary routing operation to remove high-stress areas. Shear blades should have a 45° angle or less. A clearance of 0.0005" to 0.001" should be maintained between the top and bed blade.

**DRILLING**

Polycarbonate can be drilled using standard high-speed or carbide-tipped twist drill bits.

<table>
<thead>
<tr>
<th>Hole Diameter (in.)</th>
<th>Speed (rpm)</th>
<th>Feed (mils/rev.)</th>
<th>Time (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8</td>
<td>1750</td>
<td>1/2 - 3</td>
<td>25 - 30</td>
</tr>
<tr>
<td>1/4</td>
<td>1000-1500</td>
<td>1 1/2 - 3</td>
<td>30</td>
</tr>
<tr>
<td>3/8</td>
<td>550-1000</td>
<td>1 1/2 - 3</td>
<td>30</td>
</tr>
<tr>
<td>1/2</td>
<td>325-650</td>
<td>3</td>
<td>45 - 50</td>
</tr>
<tr>
<td>3/4</td>
<td>350</td>
<td>3</td>
<td>50 - 60</td>
</tr>
</tbody>
</table>

To minimize the drill’s tendency to pull into the material, the standard twist drill design can be modified by grinding a small flat on the cutting edge as shown below.

**STRIP HEATING AND BENDING**

Strip heating may be used for localized bending of polycarbonate sheet. While heating the entire sheet is not necessary, heating both sides at the bend area yields the best results. The temperature for strip heating should be approximately 315°F. Pre-drying is not necessary for sheets up to 1/8". To eliminate the need for pre-drying for thicker sheets, back-routing or V-grooving may be used. This removes material in the area of the bend where the heat is applied to allow sharper corners and minimize warpage. Radius cutters for back-routing or V-grooving are recommended to minimize high stress areas and ensure high impact strength.
Polycarbonate sheet can be cold bent to tighter curves than is possible with acrylic.

Cold forming may be used for shapes that have a radius of 100 times the material thickness or greater. Bends with radii less than 100 times the material thickness will require heat forming.

### THERMOCLEAR® Sheet

In most cases, Thermoclear sheet fabricates the same as monolithic LEXAN sheet. Specifics on fabrication methods are obtainable from your plastics distributor.

### FORMING

LEXAN sheet may be formed using conventional forming equipment that is capable of quickly transferring the sheet from the heating station to the mold or forming table. The material must be transferred quickly as polycarbonate sheet cools rapidly and becomes form-stable at a higher temperature than other materials.

**Note:** Avoid using separate heating and forming devices.

### PRE-DRYING

Polycarbonate sheet must be dried prior to vacuum forming to prevent moisture bubbles, loss of forming detail and visually unattractive surface. To dry, the sheet is placed in a 250°F oven with a minimum distance of 1” between sheets.

<table>
<thead>
<tr>
<th>Suggested Drying Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (inches)</td>
</tr>
<tr>
<td>.093</td>
</tr>
<tr>
<td>.118</td>
</tr>
<tr>
<td>.150</td>
</tr>
<tr>
<td>.177</td>
</tr>
<tr>
<td>.236</td>
</tr>
</tbody>
</table>

After drying, the sheets may be used for up to 12 hours without re-drying.

### EQUIPMENT

Canopy, Shuttle, or Rotary type conventional vacuum forming equipment is suitable for forming polycarbonate sheet.
Shuttle type ovens either move over the sheet or the sheet moves in and out from between the ovens. The double oven shuttle balances the intensity of the heat, facilitating the forming of undried thin gauge material. Thick material also forms more easily and quickly on double oven type machines.

Rotary type machines normally handle heavier gauge materials easier because of their longer cooling cycles.

Canopy type heaters, utilizing either electric or gas heaters with movable vacuum tables and automatic or manual clamping systems, keep the travel distance of the heated sheet to the tool short and takes place under the heat source.

HEATING CYCLE

Vacuum forming LEXAN® sheet requires a sheet temperature of 350° - 400°F range. When the sheet reaches this forming range, uniform sag occurs. The amount of sag depends on the size and thickness of the sheet. Once uniform temperature has been achieved and proper sag has been determined through a manual cycle, timers or installed electric eyes, can accurately reproduce the condition for part-to-part consistency.

Note: In thicker gauges of LEXAN sheet to ensure a flat flange, the frames should be pre-heated and maintained at 250°F. This can be accomplished by shading the center of the sheet or by adding heaters immediately above the clamps or in the clamps themselves.

SHADING OR SCREENING

This is a technique commonly used to balance out the hot spots in an oven for temperature uniformity and also may be used to control the sag of the sheet.

Heavy-duty metal screening is used to shade the major portion of the clamped sheet leaving several inches along the edges unshaded to allow for cooler areas.

When using shading, heat slowly, especially with thicker gauged sheet. This will prevent gradient heating and provide more opportunity for heat to be conducted to the center of the sheet. Heat should be reduced by lowering the intensity or by moving the sheet away from the heaters.

MOLD MATERIALS AND DESIGN

An advantage of working with polycarbonate is that a variety of mold materials may be used including wood, filled and unfilled polyesters, epoxies and metal.

The following are some general rules to follow in mold design and selection:

- Pre-heat the molds: 200° to 250°F for metal
- Make draft angles as generous as possible for easy part removal: 1) Male molds should have a minimum draft angle of 5° to 7°. 2) Female molds require less - 2° to 3° is usually sufficient.
- Avoid sharp edges on molds. A minimum radius of 1x thickness is required for proper part performance.
• Allow at least 1/16" per foot of part dimension for mold shrinkage.
• Provide sufficient holes for fast removal of all air between the sheet and mold to allow the sheet to form as rapidly as possible. In female molds, provide air evacuation holes at all deep areas, especially around the perimeter of the mold. Keep the diameter of the holes small to avoid marking the sheet. Holes 0.30" to 0.50" in diameter are adequate. Long slots instead of holes may also be used to remove air. Slots are most commonly used in female tooling with a loose bottom insert.
• Trim the flange immediately after forming to reduce part warpage.

AIR-SLIP FORMING
Similar to vacuum snap-back except in air-slip forming the heated sheet is billowed up and the mold rises to meet it.

BILLOW PLUG FORMING
Forming with billow plug is often used to produce thin-wall items with depth-to-diameter draw ratios up to 1.5:1.

DRAPE FORMING
This technique is used to form simple contours. Drape forming over a male or female mold are both acceptable techniques.

FEMALE MOLD VACUUM FORMING
Straight vacuum forming in a female mold is recommended for low-profile parts where deep draw is not a requirement.

FREE BLOWN BILLOW FORMING OF DOMES
This process is used to form domes. The procedures and equipment are the same as vacuum forming with the exception of the mold. Billow forming can be done with positive air pressure (free blown) or negative pressure (vacuum). Here, after sag is reached, the heat source is removed. The pressure box is then lowered to seal air supply pressure. High air pressure is applied and then reduced as the dome is created. When the desired height is achieved, positive air pressure is maintained until the part cools. Remove and trim.

FREE DRAWN VACUUM DOME FORMING
In this type of forming, when desired sag is reached, the plastic is removed from the heat source, placed on a vacuum seal box and vacuum pressure is applied. Using an electric eye or microswitch will assure consistency of dome depth. A small amount of vacuum pressure should be retained until dome sets up. Remove and trim.

PLUG ASSISTS
The thinning of material in deep-mold cavities can be overcome by use of plug assists designed for fast penetration.

SNAP-BACK VACUUM FORMING
Vacuum forming with snap-back can reduce starting sheet size, aid material distribution and minimize chill marks.

KEY THERMOFORMING POINTS
• Pre-dry LEXAN sheet before forming (remove protective masking before pre-drying).
• Suggested heat sources - calrod, nichrome wire, gas, infrared, quartz, and ceramic.
• Pre-heat the clamp frames. Cold clamp frames will act as a heat-sink and draw the heat away from the edges of the LEXAN sheet. Ideal clamp frame temperature is between 200° - 250°F.
• Pre-heat the molds.
• Heat metal molds to 200° - 250°F.
• Allow at least 1/2" between the clamp frames and the vacuum box to assure proper heating and to promote a good vacuum seal.
• Make draft angles as generous as possible for easy part removal: 1) Male molds should have a minimum draft angle of 5° to 7°. 2) Female molds require less - 2° to 3° is usually sufficient.
• Avoid sharp edges on molds. A minimum radius of 1x thickness is required for proper part performance.
• Control drape of sheet sag by shading the center of the sheet with metal window screen.
• Trim the flange immediately after forming to reduce part warpage.
• Provide sufficient vacuum holes for fast removal of air between the sheet and mold. In female molds, provide evacuation holes at all deep areas - especially the mold perimeter. Keep hole diameters small - .030" - .050". Long slots can be used instead of holes.
# Thermoforming Troubleshooter

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
<th>Suggested Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voids or Bubbles in Formed Parts</td>
<td>• Excessive moisture in sheet</td>
<td>• Dry as recommended - 250°F for specified time with minimum separation of one inch</td>
</tr>
<tr>
<td>Crazed or Brittle Parts</td>
<td>• Mold design. • Part left on mold too long. • The use of incompatible mold</td>
<td>• Mold radii should be at least the thickness of material. • Remove part from mold as soon as it becomes form stable. • Use compatible powdered mold release.</td>
</tr>
<tr>
<td>Part Warpage</td>
<td>• Mold too cold. • Clamp frames too cold.</td>
<td>• Preheat mold 200°-260°F. • Preheat clamp frames.</td>
</tr>
<tr>
<td>Non-Uniform Drape</td>
<td>• Uneven heating of sheet.</td>
<td>• Check heater section and adjust. Use selective screening if necessary.</td>
</tr>
<tr>
<td>Difficult Part Removal</td>
<td>• Insufficient draft angle mold undercuts. • Mold finish perpendicular to direction of part removal</td>
<td>• Increase draft angle. Use strip rings or cam action mold. • Resurface mold. Sand mold sides vertically.</td>
</tr>
<tr>
<td>Poor Surface Finish</td>
<td>• Mold surface too rough. • Mold mark-off.</td>
<td>• Draw-polish mold or use different mold material. • Use silicone or powdered mold lubricant sparingly.</td>
</tr>
<tr>
<td>Insufficient Draw Down Poor</td>
<td>• Improper sheet heating. • Insufficient vacuum. • Poor Mold design.</td>
<td>• Increase heating time and temperature. • Check vacuum system for leakage. • Add more vacuum holes. Check for good seal between clamp frames and vacuum box.</td>
</tr>
<tr>
<td>Definition Webbing or Bridging</td>
<td>• Improper mold layout. • Blank too large for mold. • Material overheated. • Improper mold design.</td>
<td>• Increase spacing between molds. Use grid or ring assist. • Leave minimum of material around mold. 2” is a good rule of thumb. • Shorten heat cycles. • Increase radii and draft angle.</td>
</tr>
<tr>
<td>Chill Marks</td>
<td>• Mold too cold.</td>
<td>• Mold should be heated (250°-260°F).</td>
</tr>
<tr>
<td>Loss of Vacuum Seal</td>
<td>• Cold clamp frames. • Improper spacing between clamp</td>
<td>• Preheat clamp frames (250°-260°F) • Minimum space between clamps and vacuum box 1/2” to 3/4”.</td>
</tr>
<tr>
<td>Material Pulling Out of Frame</td>
<td>• Insufficient clamp area. • Inadequate clamp pressure.</td>
<td>• Adjust clamp points uniformly at sheet perimeter. • Increase clamp pressure to maximum.</td>
</tr>
<tr>
<td>Excess Thinning Severe Necking</td>
<td>• Drape speed too fast. • Improper forming temperature. • Mold design.</td>
<td>• Drape speed should be set between 4-9 inches per second. • Ideal forming temperature 375°F. • Increase upper radii.</td>
</tr>
<tr>
<td>Poor Surface Finish</td>
<td>• Excess thickness variation. • Uneven heating. • Non-uniform clamp pressure.</td>
<td>• Check gauge tolerances. • Check uniformity of heater output. Screen if necessary. • Maintain uniform clamp pressure to avoid pull-out.</td>
</tr>
<tr>
<td>Uneven Material Distribution</td>
<td>• Uneven cooling due to slow drape speed. • Material too hot (too much sag or</td>
<td>• Drape at higher speed 6-8 in/sec. • Screen center of sheet allowing edges to heat first. Use taller vacuum box to provide</td>
</tr>
<tr>
<td>Wrinkles on Flat Horizontal Surfaces</td>
<td>• Forming temperature too high. • Improper heating technique.</td>
<td>• Reduce heater inputs and cycle time. • Heat sheet from smooth side. Keep texture cool.</td>
</tr>
<tr>
<td>Texture Washout and Excess Gloss</td>
<td>• Vacuum holes too large. • Dust on mold or sheet. • Mold too cold/too smooth surface finish.</td>
<td>• Use 50-mil holes or smaller. • Clean mold and sheet with deionizing airgun. • Keep mold temperature at 250°F. Sand mold surface with medium grit paper.</td>
</tr>
</tbody>
</table>
Bonding and Fastening
Polycarbonate sheet can be joined or bonded to itself and other substrates with the use of adhesives and mechanical fasteners. Selecting the correct adhesive and avoiding stress (such as sharp notches), brittle components and regions of potential stress crazing, will maximize the benefits of the polycarbonate and the success of the application.

**NOTE:** In general, structural-type bonding requires a combination adhesive bond and mechanical fastener backup.

ADHESIVE BONDING
Suitable adhesives are elastomeric, touch, impact absorbing, vibrational and thermal stresses without fracturing. Adhesives inherently brittle or with chemically incompatible properties should be avoided.

<table>
<thead>
<tr>
<th>Adhesive</th>
<th>Bonds LEXAN® Sheet To</th>
<th>Comments</th>
<th>Color</th>
<th>One or Two Part System</th>
<th>Application Method</th>
<th>Set-up Time</th>
<th>Cure Time</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urethane</td>
<td>Virtually anything (specific grades bond to butyrate)</td>
<td>A clear, flexible high-impact bond. Excellent peel &amp; shear strength.</td>
<td>Clear</td>
<td>Two</td>
<td>Flow</td>
<td>30 mins. to 8 hrs. @ 75°F</td>
<td>5 hrs. @ 150°F or 7 days @ 75°F</td>
<td>Hartel Enterprises Inc. Ciba-Geigy Hartrenn Corp. IPS Weld-On</td>
</tr>
<tr>
<td>RTV Silicone</td>
<td>Metal Plastic Wood</td>
<td>Excellent heat resistance. Good thermal expansion.</td>
<td>• Clear • Red • Black • White</td>
<td>One</td>
<td>Flow Brush</td>
<td>60 mins.</td>
<td>24 hrs. @ 75°F</td>
<td>General Electric</td>
</tr>
<tr>
<td>Signbond</td>
<td>LEXAN sheet Acrylic</td>
<td>A clear, fast-setting bond. Moderate impact resistance.</td>
<td>Clear</td>
<td>One</td>
<td>Flow</td>
<td>20 secs.</td>
<td>24 hrs. @ 75°F</td>
<td>General Electric</td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>LEXAN sheet Acrylic</td>
<td>A clear solvent that produces high tensile strength bonds. Low impact resistance.</td>
<td>Clear</td>
<td>One</td>
<td>Flow</td>
<td>20 secs.</td>
<td>48 hrs. @ 75°F</td>
<td>Any chemical company</td>
</tr>
<tr>
<td>Weld-On #35</td>
<td>Butyrate</td>
<td>Thin syrup offering quick bonds. Medium syrup.</td>
<td>Clear</td>
<td>One</td>
<td>Flow</td>
<td>1 min.</td>
<td>24 hrs.</td>
<td>IPS</td>
</tr>
<tr>
<td>Weld-On #55</td>
<td>Butyrate</td>
<td>Clear Solvent</td>
<td>Clear</td>
<td>One</td>
<td>Flow</td>
<td>15 min.</td>
<td>24 hrs.</td>
<td>ASE</td>
</tr>
</tbody>
</table>

Urethane is an outstanding adhesive for polycarbonate to polycarbonate use with its flexible impact-resisting bonds and characteristic optical clarity, high peel and lap shear strength. Required with Urethane is critical accuracy in the mixing of the two components.

**NOTE:** Urethane has limited UV stability.

Silicone should not be considered a structural adhesive. It should only be used in conjunction with mechanical fasteners or when bonding large surface areas.

MECHANICAL FASTENERS
Non-rusting, aluminum pop rivets with back-up washers, plastic and metal bolts, and type 23 or 25 pan head screws are recommended fasteners for LEXAN sheet. For all types of fasteners the sheet should be pre-drilled with 1/16” oversized holes to allow for expansion. An approved RTV silicone sealant is used in the hole with the fastener to prevent possible stress or fatigue cracking at the hole around the fastener.

**NOTE:** The mechanical fasteners should be spaced so the expected load is carried without localized overstressing.

FINISHING
SANDING
Polycarbonate can be sanded using both wet and dry techniques. While dry sanding can cause gumming, wet sanding produces a smooth surface. Utilizing either method should not be considered an end finishing. Buffing can be done using a 2-wheel system, first wheel with a buffing compound to remove shallow scratches, the second to polish.
PAINTING
A clean surface is all the preparation necessary for polycarbonate sheet. Paint systems compatible with polycarbonate are available as standard items from various manufacturers.

CUT AND SPRAY PAINTING
When using this technique, avoid deep cuts in the sheet surface when cutting through the masking layer. Cuts should not be deeper than 3 mils. It should also be noted that notches may cause sheet failure. Best results are obtainable by using the following guidelines:
- Clean sheet and remove static with damp chamois.
- Avoid too wet a “mist coat” when spraying.
- Be careful to avoid too high a delivery rate and too heavy a wet coat thickness, especially at corners and bends.
- Allow enough pre-dry time before applying spray mask over painted areas.
Excessive residual paint solvents can absorb water from the spray mask system and affect adhesion and paint film toughness.
- Do Not expose painted faces to chill or high humidity while drying.
- Use dry air in all compressed air lines. Drain water taps regularly.
- Try to evaporate paint solvents from the painted face as rapidly as possible by providing maximum air flow.
- Follow recommended machining and trimming practices for finishing of post-decorated faces.

SCREEN PROCESS PRINTING
LEXAN® sheet screen paints when properly applied to flat uniformed sheet. For best results see the following guidelines:
- Use only approved screen paints and thinners developed for screen printing on Lexan® sheet.
- Do Not blend paints from different manufacturers.
- Do Not blend screen paints into spray paints.
- Do Not substitute spray thinners for screen thinners.
- Do Not add solvents such as toluene or xylene, methyl ethyl ketones or other ketones, cellosolve acetate or other related homologues to any paints used on LEXAN sheets.
- Use water-moistened chamois or soft cloths to avoid abrasion and scratching when cleaning and destaticizing sheet prior to painting.
- Thin paints to desired viscosity with recommended polycarbonate screen thinner. Use super retarders only where needed and in minimal amount needed. Excessive super retarder can slow drying unnecessarily.
- Use proper paint for color and degree of opacity needed.
- Do Not use an excessively thick paint film to gain opacity.
- Use the correct screen for intended job. The screen functions as a metering device and should be selected to apply the wet paint thickness needed.
- Provide good air circulation and ventilation during drying. Drying conditions which favor rapid evaporation from the wet paint film are important to trouble-free screening. Large surface areas release large quantities of solvent during drying. Maintain adequate ventilation to insure removal. Provide at least 1 to 2 inches of air space where sheets are stacked for drying. Forced air ventilation is desirable. These procedures speed drying and increase production rates.

CLEANING
Wet the sheet thoroughly with warm water then using a soft cloth or sponge wash with mild soap or detergent then rinse with clean water. Do Not use abrasive cleaners.
When used according to the manufacturer’s recommendations, the following cleaning agents have been shown to be compatible with polycarbonate sheet:
- Formula 409*
- Top Job**
- Joy**
- Palmolive Liquid***
- Windex with Ammonia D****

* Registered Trademark of Clorox Company
** Registered Trademark of Proctor & Gamble
*** Registered Trademark of Colgate Palmolive
**** Registered Trademark of Drackett Products Company
Polycarbonate mirror is more expensive than acrylic or PETG, but while rivaling acrylic optically, it is 30 times tougher than the latter, fire resistant with a rating of UP 94 V2 and CC1, and self extinguishing. Therefore, applications include areas where vandalism is a threat, such as schools, prisons, jails, and public restrooms. It may be die cut and is FAA approved at .118” for 9600 type commercial aircraft.

**Polycarbonate See-Thru Mirror**

This mirror, designed for interior surveillance purposes, is semi-transparent providing 5/6% light transmission allowing observation from one side while appearing to be a plain mirror on the other.

**First Surface Mirror**

Made of extruded polycarbonate, the sheet is hardcoated to protect the mirror and provide a clear finish. Applications include light reflectors, two-sided mirrors, display and cut parts.

**CARE AND CLEANING**

Mirror products should be cleaned with a soft damp cloth or chamois, wiping gently. Cleaning compounds, gritty cloths, leaded or ethyl gasolines or strong solvents such as alcohol, acetone, carbon tetrachloride, etc. should never be used. To remove tar, grease, paint, etc., use a good grade of naphtha or kerosene.

A periodic waxing with a good grade of automotive paste wax (not a cleaner-wax combination) will protect the surface of the mirror product and help maintain the luster.

**PRODUCT AVAILABILITY**

This product is available in gauges from .060” to .236” and standard sheet size of 48” x 96”. Contact your nearest Regal Plastic Supply Distributor for current availability.

With high molecular weight, excellent impact strength, and good electrical and insulating characteristics, polycarbonate rod and tube lend themselves well to a wide variety of engineering applications. Inherently tough, transparent, heat and flame resistant, and normally not affected by greases, oils or acids, there are numerous formulations available which supply improved chemical resistance, flame-retardance, radiation resistance, colors, tints, and meet with FDA approval.

**Key Properties**

- High impact strength
- Superior dimensional stability
- Good transparency (not optical grade)
- Thermal properties from below -40F to 270F
- Stain resistant and non-toxic

Polycarbonate parts can be easily machined using standard metal working tools. Annealing is always recommended when substantial machining is involved.

**Typical Applications**

- Electrical/electronic components
- Cable guides
- Parts where impact strength is critical
- Aircraft & missile components
- Gauges, instrumentation and precision components
- Medical - special grades meet U. S. Pharmacopeia regulations
- FDA - wet and dry applications
- Electric insulators

**SHAPES**

As with Acrylic, there are a wide variety of profiles and shapes available such as cubes, balls, triangles, domes and other geometric designs. Consult with your nearest Regal Plastic Supply Distributor for current availabilities.

**PRODUCT AVAILABILITY**

**Rod:**

1/8” to 12” diameters, 2’, 4’, and 8’ standard lengths.

**Tube:**

1/8” - 3 3/4” I.D. - wall thicknesses of 1/16” & 1/8”
3/16” - wall thicknesses of 5/32”
Standard Length - 8’
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Click on trademark name to locate within document

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### Acknowledgements

The following companies have assisted in the development of this plastics reference guide by providing product specific and general technical information.

<table>
<thead>
<tr>
<th>Company Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>A. L. Hyde Company</td>
<td>International Paper Company</td>
</tr>
<tr>
<td>Alusuisse Composites, Inc.</td>
<td>Kleerdex Company</td>
</tr>
<tr>
<td>Coroplast Division, Great Pacific Enterprises</td>
<td>Kömmerling USA, Inc.</td>
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<td>Cyberbond L.L.C.</td>
<td>ORACAL®</td>
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<td>CYRO Industries</td>
<td>Polycast High Performance Plastics, Inc.</td>
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<td>DSM Engineering Plastic Products</td>
<td>Poly Hi Solidur, Inc.</td>
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<td>Sheffield Plastics, Inc.</td>
<td>R Tape Corporation</td>
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<td>Elf Atochem North America, Inc., atoglas™ division</td>
<td>Seeyle, Inc.</td>
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<td>Ensinger Engineering Products</td>
<td>Shin-Etsu Silicones of America, Inc.</td>
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<td>General Electric Company GE Structured Products</td>
<td>SPAR-CAL®</td>
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<td>GE Silicones</td>
<td>Thermoplastic Processes, Inc.</td>
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<td>Hunt Corporation</td>
<td>Tremco®, Inc.</td>
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<td>I.A.P.D. (International Association of Plastic Distributors)</td>
<td>W. F. Lake Corporation</td>
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<td>Ineos Acrylics</td>
<td>Wegner North America, Inc.</td>
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<td>Zeus Industrial Products</td>
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