CHEMISTRY THAT MATTERS™

LEXAN™ EXTRITE™ SHEET PROCESSING GUIDE

FABRICATING, FORMING, FINISHING AND DECORATING

Index

Introduction	3
Main characteristics of LEXAN EXTRITE sheet	4
Fabricating Techniques	5
Fabricating Techniques	5
Drilling	6
Milling	7
Mechanical Fastening Devices	7
Riveting Systems	9
Equipment	10
Molds/Tooling	10
Shrinkage	10
Surface Finish	10
Key points of attention	11
Troubleshooting tips	12
Forming	13
Thermoforming Techniques	13
Heating and Cooling	13
Drape Forming	14
Cold Curving	15
Cold Line Bending	15
Finishing, Decorating and Cleaning	16
Finishing, Decorating and Cleaning	16
Chemical Resistance	16
Painting	18
Screen Printing	18
Anti-static Treatment	19
Adhesives and Sealants	19
Cleaning Recommendations	21
Self-Healing	22
Repairing properties	22
LEXAN EXTRITE sheet availability	23
Contact us	24

INTRODUCTION

Introducing LEXAN™ EXTRITE™ sheet, a transparent polycarbonate solid sheet with proprietary UV protection on both sides and abrasion resistance on one side, offering excellent weathering properties. With its excellent impact and and one side abrasion resistance makes it a perfect candidate for a wide variety of building and construction applications.

To the new protective layer, the material is fulfilling a demand for areas where abrasion and scratch resistance and weathering is important. The intrinsic properties of LEXAN™ polycarbonate combined with a one side protective layer results in improved abrasion, chemical and UV resistance.

Transparent LEXAN EXTRITE sheet has an excellent light transmission, between 87-90% and can be used for buildings in demanding climates or in solutions with south facing aspects.

LEXAN EXTRITE sheet as an expected lifetime of at least 30 years with a one side protected surface, which is backed by a unique fifteen (15) year written limited warranty.

- HIGH ABRASION RESISTANCE
- CHEMICAL RESISTANCE
- TRANSPARENCY UP TO 87-90%
- UV-RESISTANCE
- HIGH IMPACT STRENGTH - UP TO 250 TIME STRONGER THAN GLASS
- UNIQUE 15 YEAR LIMITED WARRANTY
- THERMOFORMABLE
- EXCELLENT FIRE PERFORMANCE
- WEATHER RESISTANCE

MAIN CHARACTERISTICS OF LEXAN™ EXTRITE™ SHEET

- A patented polycarbonate LEXAN™ sheet product.
- 1 Side abrasion resistant
  (over full surface of the sheet, back side is UV-protected).
- 1 Side sand abrasion resistant (against sand storms).
- 1 Side resistant against small scratches like steel wool.
- Has excellent UV resistance (weather ability), the back side has a traditional UV protected side.
- Comes with a 15 year written limited warranty.
- Excellent chemical resistance against the common solvents.
- Thermoformable.
- The sheet can be cold bended and cold curved.
- Superior repair properties.
- Excellent transparency with large color availability.
- Available in long lengths.
- Traditional tooling, cutting and installation.
- Excellent fire performance, gauges 2 – 6mm, B-S1-d0 rating according to European EN 13501-1 standard.
- Reduced system costs.

FABRICATING TECHNIQUES

Fabrication can be defined as the construction, manufacture or assembly of a number of related component parts. For LEXAN EXTRITE sheet, that could involve the construction of window panels, the manufacture of a large motorway sign or the assembly of a safety shield around a piece of machinery. In one way or another each of these applications requires fabrication. The following section discusses the techniques and processes used to fabricate finished products from LEXAN EXTRITE sheet and provides recommendations and advice on how to achieve the best results.

NOTE: by the nature of the product the surface of the sheet might show small areas with a degree of melting caused by the heat coming from the fabrication tools e.g. saw, drill or milling tools, see page 22.

CUTTING AND SAWING

LEXAN EXTRITE sheet can be cut and sawn easily and accurately using standard workshop equipment. Circular saws, band saws, jig saws and common hacksaws can all be used successfully. However, certain important guide-lines should be followed. General guide-lines are listed below with specific recommendations outlined in each cutting section.

- The sheet must always be securely clamped to avoid undesirable vibration and rough cut edges.
- All tools should be set for cutting plastics with fine toothed panel blades.
- The protective masking should be left on the sheet to prevent scratching and other surface damage.
- All LEXAN sheet products should be clean and free of notches, before finishing the edges of the sheet.
- If possible swarf and dust build-up should be blown away with a compressed air supply.

CIRCULAR SAWS

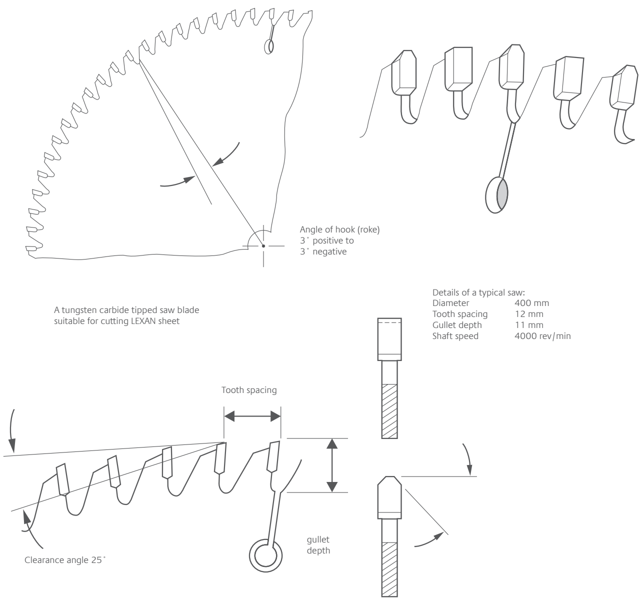
This type of cutting operation is the most common and, while cutting speeds and feeds are not so critical as with other thermoplastics, it is important to follow the recommended guide-lines.

- Tungsten carbide tipped saw blades are preferred with alternative teeth bevelled at 45° on both sides to improve cutting and reduce side pressure.
- Always use a low feed to get a clean cut.
- Always start cutting with the blade at full speed.
- For single sheets less than 3 mm (0.12") thick, bandsaws or jig saws are preferred to circular saws.

Table 1: Cutting and Sawing Recommendations

	Circular Saw	Bandsaw
Clearance Angle	20°-30°	20°-30°
Rake Angle	5-15°	0-5°
Rotation Speed	1800-2400 m/min	600-1000 m/min
Tooth Spacing	9-15 mm (0.35-0.47")	1.5-4 mm (0.06-0.16")

Figure 1: Tungsten carbide tipped saw blades used for circular saws



BANDSAWS

These can be of the conventional vertical type or the specially developed horizontal type suitable for plastic sheet materials. In both cases it is vital that the sheet is adequately supported and clamped during the cutting operation. The saw guides should be as close to the sheet as possible to reduce blade twist and off-line cutting.

JIG SAWS AND HACKSAWS

The most important consideration with this type of cutting is support and clamping, particularly with the use of a jig saw. Blades having a tooth spacing of 2-2.5 mm (0.08-0.1") are ideal with the emphasis upon low cutting feeds.

DRILLING

Standard high speed steel twist drills or drills with an angular wedged bit can be used for drilling LEXAN EXTRITE sheet products. Carbide-tipped drills can also be used since they retain their sharp cutting edge. The most important factor to consider when drilling LEXAN EXTRITE sheet products is the heat generated during the actual process. In order to produce a clean, well-finished hole that is stress-free, the heat generated must be kept to an absolute minimum. By following a few basic guidelines, clean, stress-free holes can easily be produced.

- The drill hole must be cleared frequently to prevent swarf build-up and excessive frictional heat.
- The drill must be raised from the hole frequently and cooled with compressed air.
- The sheet or product must be adequately clamped and supported to reduce vibration and ensure a correctly sized hole.
- Holes should not be drilled closer to the edge of the sheet than 1-1.5 times the diameter of the hole.
- All holes must be larger than the bolt, screw or fixing to allow for thermal expansion and contraction.
- For long production runs the use of carbide-tipped twist drills is recommended.

Drilling feeds and speeds are outlined in Table 2 with the various drill configurations in Figures 2 to 5.

Table 2: Drilling Recommendations

Hole Diameter	Speed (rev/min)	Feed (mm/min)
3	1750	125
6	1500	100
9	1000	75
12	650	50
18	350	25

Figure 2: Typical Drill Configuration

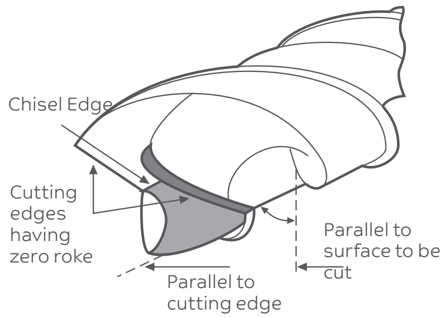


Figure 3: Drill suitable for large holes

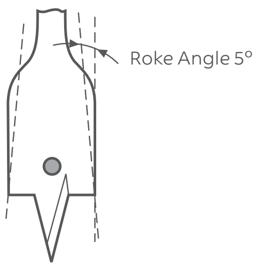


Figure 4: Drill suitable for thin sheet

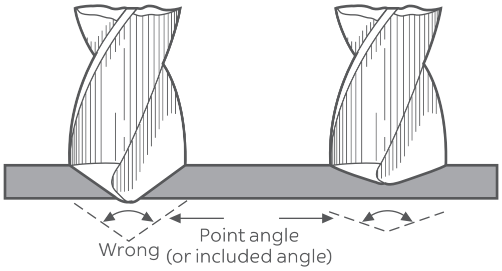
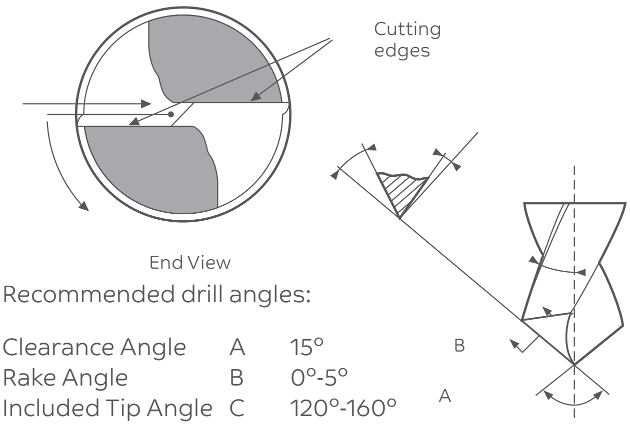


Figure 5: Recommended drill angles



Recommended drill angles:

Clearance Angle	A	15°
Rake Angle	B	0°-5°
Included Tip Angle	C	120°-160°
Helix Angle	D	30°

MILING

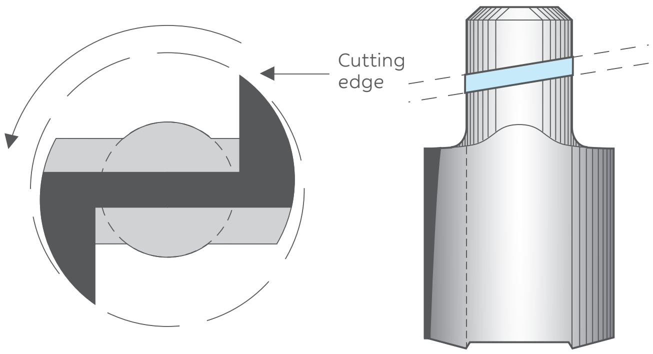
LEXAN EXTRITE sheet products can be machined using conventional milling machines fitted with standard high speed knife cutting tools. Once again the importance of suitable clamping cannot be over-emphasised. Mechanical jigs and fixtures, or vacuum chucks provide a suitable clamping medium. Table 3 outlines appropriate cutting speeds and feeds with a typical cutting tool illustrated in Figure 6. Forced-air cooling enables higher cutting rates. However, care should be taken not to over-heat the material. The use of cutting fluids to lubricate or cool the sheet is not recommended.

Computerised trimming is a fully automatic milling process. It is extremely accurate and operates horizontally as well as vertically. The use of a vacuum-operated jig avoids vibration of the part ensuring a smooth cut. Standard high speed, two-sided cutting routers with tungsten carbide tips are recommended, with a cutting speed of approximately 250 m/min at 25.000/30.000 RPM at a sheet thickness of 4 mm (0.16”).

Table 3: Milling Recommendations

Clearance Angle	5º-10º
Rake Angle	0º-10º
Cutting Speed	100-500 m/min
Cutting Feed	0.1-0.5 mm/rev.

Figure 6: Typical Milling Cutter



MECHANICAL FASTENING DEVICES

With a few exceptions, all mechanical assembly techniques involve some form of additional fastening device. The choice of device is often dependent upon the nature of the fastening required. While rivets tend to be permanent, screws and nuts can be made detachable and some of the spring clips types can be either permanent or separable.

There are many different types of mechanical fastening system which can be used successfully to assemble plastic sheet components. Within the limitations of this publication only a small number can be discussed.

For simplicity they are divided into three groups:

- Screws, nuts and bolts
- Rivets
- Spring clips and other fastening devices

Two important factors need to be considered with all these fastening systems. Firstly, allowance needs to be made for thermal expansion and contraction. All holes, slots and cut-outs must be machined oversize to allow for the dimensional changes as a result of temperature changes. Secondly, the distribution of tightening torque should be equal. With the aid of compatible rubber washers and large screw and rivet heads, the tightening torque should be spread over as wide an area as possible and should not be excessive.

Table 4: Thermal expansion

Material	m/m °C x 10^{-5}
LEXAN EXTRITE sheet	6.7
Glass	0.7 - 0.9

MACHINE SCREWS

The majority of these screws are made from steel, but other metals and alloys are used for specialised applications. Several examples of this type of fastening system are shown on this page. Figures 7 and 8 illustrate sheet fastening devices known as 'blind screw' and 'blind nut' anchors.

SELF-TAPPING SCREWS

Self-tapping screws are widely used within the plastics industry. Basically they produce their own thread as they are driven into a hole and may be considered whenever an assembly is likely to be dismantled and re-assembled. While the majority of these screws are designed for plastic moldings, with the aid of spring clips and washers they can be adapted for sheet applications.

Figure 9 shows some typical fastening systems.

CAUTION

If the application calls for a screwed assembly, it is vitally important that the following recommendations are considered.

- Do not use countersunk head screws as the 'wedging' action of the countersunk head causes excessive hoop stress on the sheet. This can lead to part failure.
- Be sure that all oil, grease and other coatings are removed from the screws before assembly. Certain oils and greases can cause environmental stress cracking.

Figure 7: Blind Nut and Blind Screw Anchor

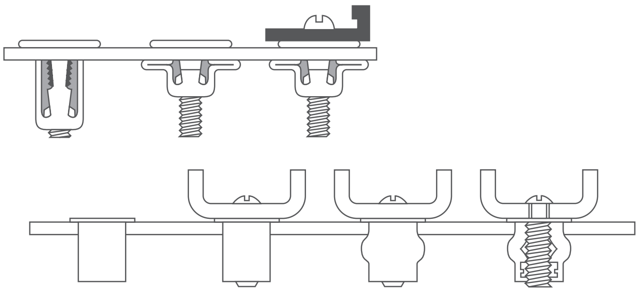


Figure 8: Other Typical Fastening Systems

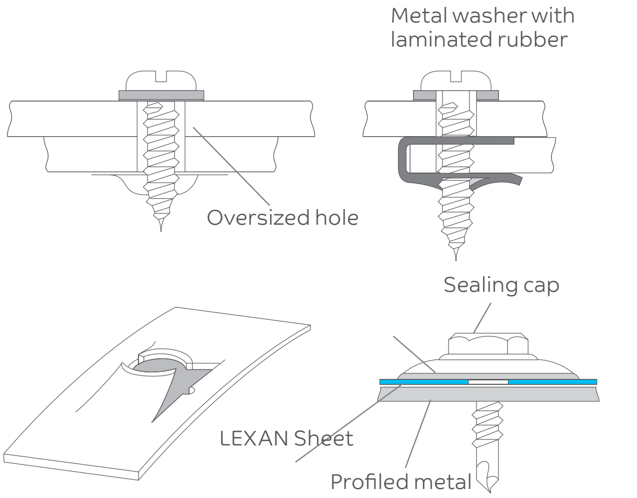
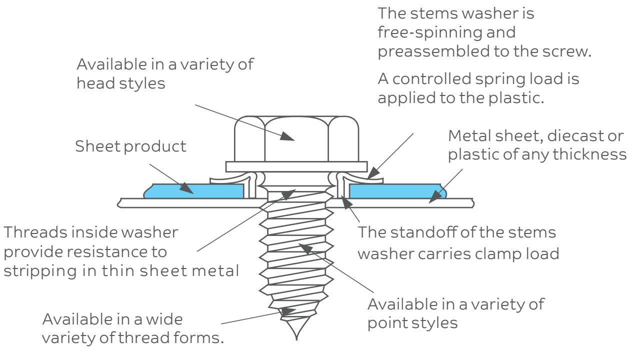


Figure 9: Typical self-tapping screw fastening system



RIVETING SYSTEMS

While riveting is a popular and effective assembly technique, certain guide-lines should always be followed when considering this type of assembly method. Riveting can induce both radial and compressive stresses in the plastic sheet and precautions should be taken to distribute these forces over as wide an area as possible. In a plastic-to-plastic assembly a metal back-up washer with laminated rubber is recommended to reduce the compressive stresses. If the diameter of the rivet with a rubber washer is slightly bigger than the hole diameter, then the hoop stresses will be transmitted to the washer rather than the plastic sheet.

For plastic-to-metal joints, the head of the rivet with a rubber washer should be against the plastic, and the hole in the sheet should be large enough to allow for thermal movement. Holesize is 1.5 x expanded rivet diameter. Rivet diameters should be as large as possible and spacing should be between 5-10 times their diameter. SABIC recommends the use of aluminium, brass and copper rivets. There are several different types of riveting system, however, the most popular is the 'pop-rivet'. This type of rivet provides the means to assemble two components together with access restricted to one side only. Figures 10 and 11 illustrate typical rivet assemblies.

Figure 10: Rivet Assembly

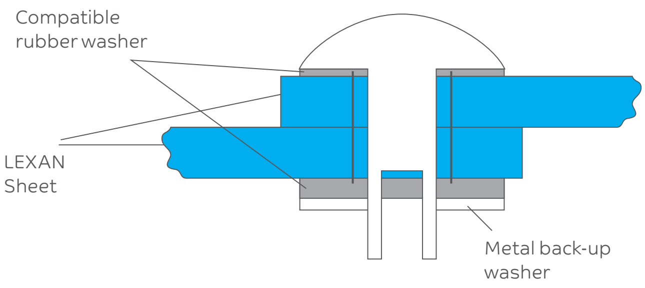
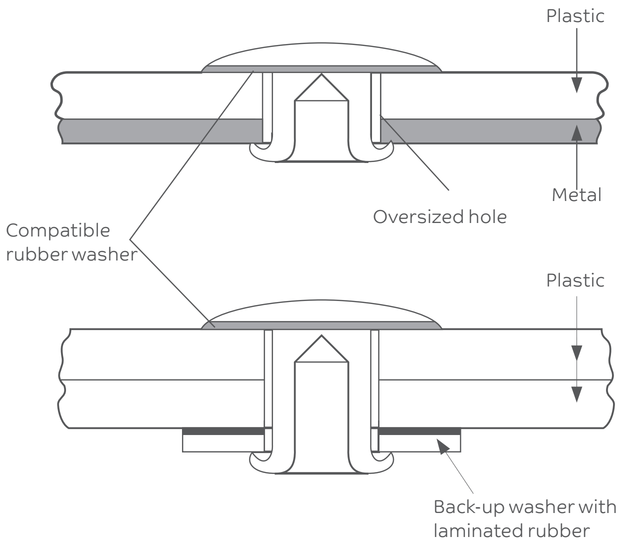


Figure 11: Typical Pop-rivet assembly



EQUIPMENT & TOOLING MATERIALS

EQUIPMENT

A Geiss U8 Thermoformer with Geiss Quartz "Fast" top and bottom heaters was used to develop these guidelines. Results may vary depending on the specific thermoforming equipment used for production.

MOLDS/TOOLING

Internally heated cast or machined aluminum molds were successfully used to thermoform LEXAN EXTRITE sheet parts for production.
Prototype parts can be produced using tools made of wood, epoxy, silicone, etc. This allows for inexpensive tooling modifications if part changes are necessary.

SHRINKAGE

Formed parts will contract in size as they cool to room temperature. This mold shrinkage is predictable and must be considered in the mold design. In general, LEXAN EXTRITE sheet parts will shrink approximately .009 - .011" per inch.

SURFACE FINISH

Since the best details appear on the material contacting the mold surface, female molds are used when exterior details are required, and male molds should be used when interior details are required. Male molds may also be preferred when the exterior details are minimal and the exterior polish or matte finish of the sheet needs to be preserved.

The functional side of the LEXAN EXTRITE sheet should not touch the mold. After heating the functional side is soft and sticky. Vacuum or air evacuation holes can be located in non-appearance areas (i.e., corners). Vacuum holes with diameters less than .030" will minimize dimple formulation. Back drilling with larger drills will produce more rapid air evacuation.

MOLD SHRINKAGE CALCULATION

$$\text{Shrinkage} = \frac{\text{Mold dimension @ temperature} - \text{Part dimension (after 24 hs)}}{\text{Mold dimension @ mold temperature}}$$

KEY POINT OF ATTENTION WITH FORMING LEXAN EXTRITE SHEET

- Suggested heat sources are calrod, halogen, quartz, nichrome wire, gas, infrared, and ceramic.
- Preheat the clamp frames. Cold clamp frames will act as a heat- sink and draw the heat away from the edges of the LEXAN EXTRITE sheet. Ideal clamp frame temperature is 230 - 250°F.
- 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 2° to 3°.
- Avoid sharp edges on molds. A minimum radius of 1x thickness of the sheet is required for proper part performance.
- Allow at least 1/16” per foot of sheet dimension for mold shrinkage.
- 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.
- Male tools form best with minimal center heat on the sheet and a modest 2-3 second pre-vacuum to stretch the material down as the tool moves up into it. If the center heat is too high you may experience burn thru and/or high gloss.
- Parts with a draw of up to 4.5” have been successfully made using a heated male tool. The maximum draw is dependent on the specific tool and gauge of material.
- Female tools form best with full heating and no pre-stretching.
- Parts with a draw of up to 3” have been successfully made using a heated female tool. The maximum draw is dependent on the specific tool and gauge of material. Plug assist forming can be used to help increase the draw.
- A reduction in thickness and density of the material can be expected and should be considered/planned for when forming parts. This reduction is a result of stretching the sheet material to form the part and is dependent on the expanded surface area of the part vs. the area of the original sheet.
- Work in a dust free environment. When the LEXAN EXTRITE is heated the functional side is soft and sticky.

TROUBLESHOOTING TIPS

Problem	Possible Causes	Suggested Solutions
Surface Bubbles in Formed Parts	- Excessive moisture in sheet	- Dry as recommended (250°F for specified time)
Crazed or Brittle Parts	- Mold design - Part left on mold too long - The use of incompatible mold lubricants	- 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
Non-Uniform Drape	- Uneven heating of sheet	- Check heater section and adjust - Use selective screening if necessary - Check for cold air drafts
Difficult Part Removal	- Insufficient draft angle - Mold undercuts - Mold finish perpendicular to direction of part removal - Ejection pressure too low	- Increase draft angle - Use strip rings or cam action mold - Resurface mold - Sand mold sides vertically - Add air holes, increase ejection pressure, use powdered mold release
Insufficient Draw Down or Poor Definition	- Improper sheet heating - Insufficient vacuum - Poor mold design	- Increase heating time & temperature - Check vacuum system for leakage - Add more vacuum holes - Check for good seal between clamp frames and vacuum box
Material Pulling Out of Frames	- Insufficient clamp area - Inadequate clamp pressure - Uneven heating	- Adjust clamp points uniformly at sheet perimeter - Increase clamp pressure to maximum - Control sheet temperature - Use center screening to allow more heat at sheet perimeter
Chill Marks	- Mold too cold - Insufficient draft angle and radii	- Heat mold to 230 - 250°F - Increase mold radii and draft angles
Loss of Vacuum Seal	- Cold clamp frames - Improper spacing between clamp frames and vacuum box	- Preheat clamp frames (230 - 250°F) - Minimum space between clamps and vacuum box is 1/2" to 3/4"
Texture Washout & Excess Gloss	- Forming temperature too high - Improper heating technique	- Reduce heater inputs & cycle time - Heat sheet from smooth side - Keep texture cool - Precoat texture with strippable mask
Pinholing or Pimples	- Vacuum holes too large - Dust on mold or sheet - Mold too cold / surface finish too smooth - Vacuum rate too high	- Use 50-mil holes or smaller - Clean mold and sheet with deionizing air gun - Keep mold temperature at 250°F - Lightly sand mold surface with medium grit paper - Place small orifice over main vacuum holes
Webbing or Bridging	- Improper mold layout - Blank too large for mold - Material overheated - Improper mold design - Vacuum rate too fast	- 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 - Slow down vacuum rate (use smaller vacuum holes) - Restrict main vacuum lines

FORMING

THERMOFORMING

LEXAN EXTRITE sheet can be thermoformed with sharp detail on conventional forming equipment that is capable of quickly transferring the sheet from the heating station to the mold and then applying sufficient vacuum.

DRYING

- Use a vented, air circulating oven at 210°F (100°C) with 1" (25 mm) air gap between sheets.
- Remove protective masking before pre- drying.
- Prevent that the functional layer is touching anything during drying. This will cause damages, prevent dust particals etc. on the forming tool.

CLAMPING FRAMES

- Preheat the clamp frame to 230 - 250°F (110 - 120 °C).
- Allow ½ - 1 ¼" (12 - 32 mm) gap between the clamp frame and the mold vacuum box.
- The mold needs to break the plane of the clamp to create a vacuum seal.

MOLD HEATING

- Recommended forming tool temperature: 230 - 250°F (110 - 120 °C).
- Thermocouple should be within ¼" (6 mm) of the surface.
- Always check the temperature with a surface probe.

Table 5: Recommended Drying Times

Sheet Thickness Inch(mm)	Drying Time (hrs)
0.030 (0.75)	1.50
0.040 (1.00)	2.00
0.060 (1.50)	2.50
0.080 (2.00)	4.00
0.118 (3.00)	5.00
0.160 (4.00)	10.00
0.197 (5.00)	16.00
0.236 (6.00)	24.00
0.315 (8.00)	36.00
0.374 (9.50)	40.00
0.472 (12.0)	48.00
0.591 (15.0)	56.00

HEATING / COOLING CYCLE

- Recommended forming temperature: 338 - 428°F (170 - 225 °C), depending on thickness of sheet and male / female tool arrangement.
- Measure temperature with an IR gun with emissivity set at 0.95.
- Trigger the cycle with an IR sensor that monitors top of sheet temperature rather than time.
- When LEXAN sheet reaches forming temperature, bring the tool up into the sheet and apply vacuum. LEXAN sheet sets up very quickly, permitting a much shorter cycle than is possible with most other materials.
- The functional side should not be overheated, this will cause degradation of the functional layer.

DRAPE FORMING

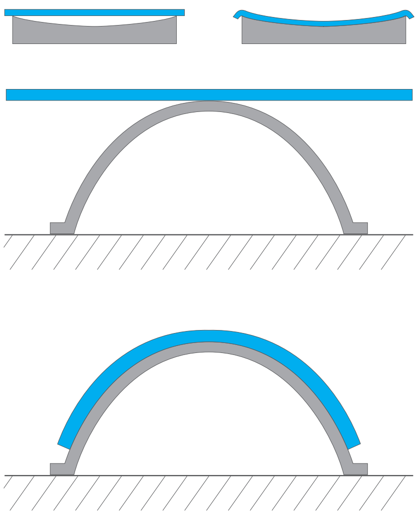
Drape forming is the simplest of all the thermoforming techniques. Using either a male or a female mold, the sheet is heated and allowed to conform to the shape of the mold under its own weight or with slight mechanical pressure. The functional side of LEXAN EXTRITE sheet should not touch the mold.

The process involves placing the sheet (without the masking) and mold in a hot-air circulating oven. The temperature is raised to the point where the sheet sags (between 140°C-155°C) and conforms to the shape of the mold. Both items can then be removed from the oven and allowed to cool. Figure 4 illustrates the basic steps. Exceeding the glass transition point of LEXAN EXTRITE sheet materials will result in a decreased optical quality. Pre-drying is not necessary due to the low processing temperatures.

The drape forming process can be a combination of different methods. These include:

- Shaping under its own weight at a temperature of ±155°C.
- Shaping under its own weight with a slight mechanical pressure. (Temp. 155°C)
- Cold curving into a jig and placing in an oven at temperatures between 150°C-165°C.
- Cold curving the sheet over a mold, exposure to a temperature of ±150°C and application of vacuum to obtain a 3D shape.

Figure 12: Typical Drape Forming Set-Up



Cold curving guide-lines must be strictly followed, to avoid surface cracking of coated products. Always allow for slow and unforced cooling. When shaping is carried out under the sheet's own weight, use oversized sheets in order to avoid material shrinkage problems. Alternatively, the sheets can be placed in the oven with the mold directly outside. Once the sheet has reached the required temperature, it should be quickly removed and allowed to drape itself over the mold. The transition between the oven and the mold should be handled very fast since the LEXAN EXTRITE sheet sets-up rapidly once it has been removed from the oven. Typical applications include visors and automotive safety glazing where the LEXAN EXTRITE sheet products easily meet the demanding quality requirements. In these types of application the mold needs to be made from a high gloss material such as steel, aluminium, or even glass in order to achieve the necessary optical quality.

COLD CURVING

This technique simply involves installing a curved sheet, thereby placing a slight bending stress across the sheet. The stress levels in the curve are a function of sheet thickness and radii, and, provided they do not exceed a recommended maximum, the stress will have no influence upon the property performance.
The basic criteria for the minimum radii is 175 times sheet thickness for LEXAN EXTRITE sheet. Table 7 outlines the recommended radii for a range of sheet thicknesses.

Figure 13: Cold Curving Radii Example

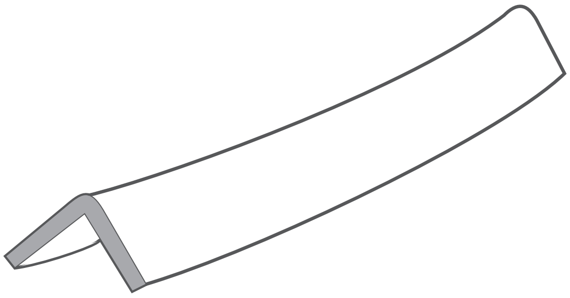


Table 7: Minimum Cold Curving Radii

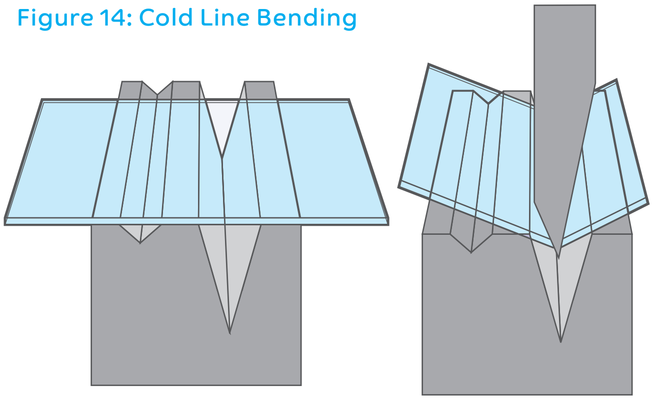
Sheet Thickness (mm)	LEXAN EXTRITE Sheet Min. Radius (mm)
1.0	-
1.5	-
2.0	350
3.0	525
4.0	700
5.0	875
6.0	1050
8.0	1400
9.5	-
12	-
15	-

COLD LINE BENDING

Cold line bending is possible, since LEXAN EXTRITE sheet products are very ductile, even at low temperatures. However, the process does involve some degree of permanent plastic deformation and the results are dependent upon sheet thickness, tooling and the angle of strain bending.

A typical cold line bending operation is illustrated in Figure 14.

Figure 14: Cold Line Bending



RECOMMENDATIONS FOR COLD LINE BENDING

- Use sharp tool edges.
- Allow sufficient time for sheet relaxation after bending (1 to 2 days).
- Do not reduce bending angle during installation or force the sheet into the desired position.
- Bending operation should be performed quickly for optimum results.
- Textured sheets should only be bent so that the textured surface is in compression.
- Due to stress relaxation immediately following bending, overbending is usually required to achieve the desired angle.
- Coloured sheets can show tint variations along the bend following bending.

Smooth and notch-free edges (rounded and/or 45° tapered edges) of the LEXAN EXTRITE sheet are necessary to avoid-side cracking during bending. In order to limit the critical elastic strain, cold line bending is usually restricted to an angle of 90°. Following bending, residual stresses will remain in the sheet and will reduce the impact strength of the material in the area along the bend. This technique should therefore be limited to less demanding applications. For more information on any of the forming techniques please contact your local SABIC Functional Forms Technical Service Centre.

FINISHING, DECORATING AND CLEANING

FINISHING, DECORATING AND CLEANING

Fabrication can be defined as the construction, manufacture or assembly of a number of related component parts. For LEXAN EXTRITE sheet, that could involve the construction of window panels, the manufacture of a large motorway sign or the assembly of a safety shield around a piece of machinery. In one way or another each of these applications requires fabrication. The following section discusses the techniques and processes used to fabricate finished products from LEXAN EXTRITE sheet and provides recommendations and advice on how to achieve the best results.

CHEMICAL RESISTANCE

The protected side of EXTRITE sheet has improved chemical resistance against oil based solvents and alcohols such as Kerosine ,Gasoline, Xylene and IPA . The back side is still polycarbonate based so there the guidelines for LEXAN polycarbonate sheet as mentioned here should be followed.

The non-protected side is like standard polycarbonate. LEXAN polycarbonate resin has a good chemical resistance, at room temperature, to a variety of dilute organic and inorganic acids. Water, vegetable oils, solutions of neutral salts, aliphatic hydrocarbons and alcohols are also included in this category. When a thermoplastic is attacked by a chemical it usually takes one of three forms. In the first case the chemical is absorbed into the plastic, and plasticisation and/or crystallisation occurs.

The visible signs of this type of attack are swelling or surface whitening. LEXAN polycarbonate is affected in this way by partial solvents such as low molecular weight aldehydes and ethers, ketones, esters, aromatic hydrocarbons and perchlorinated hydrocarbons. In addition, chemical attack ranging from partial to complete destruction of LEXAN polycarbonate occurs in contact with alkalines, alkali salts, amines and high ozone concentrations. The third type of attack is often the most difficult to predict since environmental conditions dictate whether or not the plastic will be affected.

Combinations of certain environments, coupled with stress and/or strain upon the material, cause stress cracking or crazing of the polycarbonate. Crazing can be induced at moderate to high stress levels by low molecular weight hydrocarbons. Products such as acetone and xylene may cause stress cracking even at very low stress levels and should therefore be avoided. Taking into account the complexity of chemical compatibility, all chemicals which come into contact with polycarbonate should be tested. For sheet products the most common contact is with sealants, gaskets and the various cleaning media. Chemical compatibility testing, table 8, is an on-going process at SABIC Functional Forms and many standard products have already been tested.

A complete list of recommended cleaners, gaskets and sealants is available upon request. However, a shortened list of some of the more common compounds is outlined in the respective sections in Tables 9 and 10. In case of doubt about any aspect of chemical compatibility of LEXAN polycarbonate sheet always consult your nearest SABIC Technical Service Centre for further advice.

The tests were conducted on 3 mm (0.12") samples with an exposure time of 5 minutes, at room temperature and stress-free.

Table 8: LEXAN sheet chemical compatibility summary

Chemical class	Effects
Acids (Mineral)	No effect under most conditions of concentration and temperature.
Alcohols	Generally compatible.
Alkalis	Acceptable at low concentration andtemperature. Higher concentrations and temperatures result in etching and attack as evidenced by decomposition.
Aliphatic Hydrocarbons	Generally compatible.
Amines	Surface crystallisation and chemical attack.
Aromatic Hydrocarbons	Solvents and severe stress-cracking agents.
Detergents and Cleaners	Mild soap solutions are compatible. Strongly alkaline ammonia materials should be avoided
Esters	Cause severe crystallisation. Partial solvents.
Fruit Juices and Soft Drinks	Compatible at low stress levels. Some concentrates not recommended.
Gasoline	Not compatible at elevated temperatures and stress levels.
Greases and Oils	Pure petroleum types generally compatible. Many additives used with them are not, thus materials containing additives should be tested.
Halogenated Hydrocarbons	Solvents and severe stress-cracking agents.
Ketones	Cause severe crystallisation and stress-cracking. Solvents.
Silicone Oils and Greases	Generally compatible up to 80°C.

Table 9: LEXAN EXTRITE sheet chemical compatibility summary

Chemical class	Effects
Gasoline	Generally compatible
Xylene	Generally compatible
Kerosine	Generally compatible
Aliphatic Hydrocarbons	Generally compatible
Alcohols	Generally compatible
Acids	Not compatible
Alkalis	Not compatible
Chlorinated hydrocarbons	Not compatible
Aromatic Hydrocarbons	Not compatible

PAINTING

Be it simple or complex, decorative or functional, hand-controlled or automatic, painting LEXAN sheet products offers the designer the freedom to create a dramatic effect in a sign or a simple colour code for instructions. Provided certain basic recommendations are followed, most techniques used to apply paint to wood, metal, building materials and other plastics can be used for LEXAN sheet products. The important factor is once again one of compatibility. Only approved paint systems should be used. Some paint and thinner systems are not compatible with LEXAN sheet products and can cause stress cracking and a reduction in impact performance. Paint systems for LEXAN sheet should be flexible. Combinations of flexible primers and hard top coats could also work. Any paint system should be flexible at subzero temperatures.

PAINTING RECOMMENDATIONS

- Clean the sheet and remove static with a damp chamois cloth or ionised air treatment.
- Avoid too high a delivery rate and too heavy a wet coat thickness.
- Allow adequate drying before applying spray mask to painted areas.
- Do not expose painted faces to a low temperature and high humidity environment during drying.
- Use dry air in all compressed air lines. Drain water taps frequently.
- Paint solvents should be evaporated from the paint surface as quickly as possible by providing appropriate air circulation.
- Follow recommended machining and trimming practices for finishing post-decorated faces.

For painting systems please consult technical centre.

SCREEN PRINTING

Silk-screen printing is a well-established process that offers a wide variety of options for a decorative finish. However, in most cases the printing must be accomplished prior to installation, since the process is basically a horizontal one and is generally restricted to small-to-medium part sizes. The process involves forcing viscous inks through a very fine, thin screen that is treated in such a way as to allow the ink only through to the patterned area. Special inks are required that are formulated so that they will pass through the mesh, while being sufficiently viscous to prevent run-out. This type of finishing operation is often used in the sign industry and a wide variety of screen printing inks and thinners are available. Once again the importance of chemical compatibility cannot be over-emphasised and only paints and thinners recommended for use with LEXAN sheet products should be used.

SCREENING RECOMMENDATIONS

- Use only approved paints and thinners.
- Do not mix different paints and inks.
- Do not substitute spray thinners for screen thinners.
- Do not add solvents such as toluene, xylene, cellulose acetate, methylethylketones or other related chemicals to the inks.
- Use water-moistened chamois or soft cloths to avoid abrasion or scratching during cleaning prior to printing.
- Use the correct colour of paint to achieve opacity required.
- Provide good air circulation and ventilation during drying.
- If a digital printing process is used, only print on the sheet side which has the unprinted masking.

For screen printing inks please consult SABIC's Technical Center.

ANTI-STATIC TREATMENT

As common with all insulating materials, LEXAN polycarbonate sheet tends to build up a static charge. It is often necessary to clean and discharge the surface prior to painting or screen printing. Wiping the sheet with a damp chamois or applying de-ionised air to the surface is often all that is required. Another effective method in minimising static charge build-up is control of the relative humidity: the higher the relative humidity, the lower the static charge build-up will be. Relative humidity preferably should always be above 60%.

ADHESIVES AND SEALANTS

The use of adhesives to bond dissimilar materials is now universal. Over the past twenty years polymer technologists have developed adhesives with a wide range of properties and application profiles. Adhesion technology has become a branch of the plastics industry in its own right, offering a technique that is one of the most efficient, effective and economical methods of joining plastic components to themselves and to other materials.

However, it is a technology that often causes the most problems. While some adhesives/sealants form a flexible bond, others form a rigid bond. Some are capable of filling gaps, while others are for close contact. Some can withstand high temperatures, while others cannot. The choice of adhesive types is vast, as are the applications areas. It is vitally important, therefore, to select the adhesive carefully, ensuring its compatibility with the materials being used and the working environment. The importance of chemical compatibility was discussed in Section 3.1 and adhesive selection and testing is an ongoing process at SABIC Functional Forms. A comprehensive data-base of suitable adhesives is available and in all cases it is strongly recommended that all adhesives are checked for compatibility before use. Table 10 presents an overview of some of the initial criteria used to select an adhesive and Table 11 provides a list of compatible adhesives indicating generic types, trade names and application areas. Figure 15 outlines some typical joint configurations

Table 10: Adhesive Selection Chart for LEXAN polycarbonate sheet products

Adhesive Type	Joins LEXAN sheet to	Supplier
Epoxy	Metals, Plastics, rubbers	3M Company
Epoxy	Plastics	3M Company
Polyurethane	Plastics, Metals, wood	Henkel
Polyurethane	Plastics, Metals, wood	Henkel
Hot Melt	Plastics, Wood	3M Company
Hot Melt	Plastics, Wood Glass, Ceramics	Henkel
Silicone	LEXAN EXTRITE, LEXAN uncoated, LEXAN EXELL D, LEXAN MARGARD MR5E + FMR, Building Materials	Momentive Performance Materials
MS polymer	LEXAN EXTRITE, LEXAN uncoated, LEXAN EXELL D, LEXAN MARGARD MR5E + FMR, Building Materials	Bostik
Tapes	Plastics, Glass, Metals	3M Company
Tapes	Metals / Plastic	Fasson
Tapes	—	Velcro
Tapes	—	Multifoil
Tapes	—	Sellotape

The actual choice of adhesive will depend upon the design of the joint, the circumstances under which the joint will be used and the prevailing environmental conditions. In all cases the adhesive type should be fully tested under exact conditions to determine complete compatibility and performance.

Table 11: Adhesive Groups and Property Profile

	Impact Behaviour	Moisture Behaviour	Number of Components	Temperature Limits (°C)	Gap Filling
Epoxy	Bad	Very Good	1 or 2	200 +	+
Polyurethane	Very Good	Good	1 or 2	140	+
Hot Melt	Good	Good	1	60	+/-
Silicone	Excellent	Very good	1 or 2	250	+

Figure 15: Joint Design Configurations

LAP JOINTS

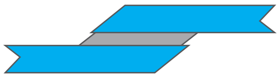
The double butt lap joint provides maximum uniform stress distribution in the load bearing area.

1. Double Butt Lap Joint

The joggle lap joint allows a more uniform stress distribution than a single tapered lap joint.

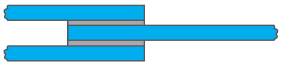
2. Joggle Lap Joint

A tapered single lap joint is more efficient than a single lap joint, allowing for bending of the joint edge under stress.



3. Tapered Single Lap Joint

A double lap joint allows for greater rigidity than a single lap joint.



4. Double Lap Joint

A simple lap joint could create cleavage and peel stress under loading, particularly in bonding thin sheets.

5. Simple Lap Joint

A round lap joint can be used to add rigidity and strength to an assembly and minimise the deflection of flat sheets.

6. Round Lap Joint

Double scarf lap joints have better resistance to bending forces than double butt joints.

7. Double Scarf Lap Joint

BUTT JOINTS

Rounded tongue and groove joints are self-aligning and can act as an overflow reservoir for adhesives.

1. Rounded Tongue and Groove Joint

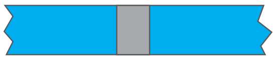
Landed scarf tongue and groove joints function as control stops for adhesive line thickness.

2. Landed Scarf Tongue and Groove

Recessed tongue and groove joints improve cleavage resistance of straight butt end joints.

3. Tongue and Groove Joint

Straight butt end joints are not usually recommended for most types of applications.



4. Butt Joint

CLEANING RECOMMENDATIONS

Periodic cleaning of all LEXAN polycarbonate sheet products can be accomplished easily and without the need for specialised cleaning agents. However, as is the case with all thermoplastic materials, certain chemicals can cause structural as well surface damage and precautions need to be taken to avoid any aggressive cleaning agents. The basic cleaning agent for all LEXAN polycarbonate products is a solution of lukewarm water with mild soap or household detergent, using a soft cloth or sponge to loosen any dirt and grime.

All surfaces are then rinsed with cold water and dried with a soft cloth to prevent water spotting. However, in some cases this may not be sufficient and certain solvent cleaners may be needed to remove stubborn stains, graffiti etc. In these cases the following list of cleaning agents are approved for use at room temperature:

- Methyl alcohol
- Ethyl alcohol
- Butyl alcohol
- Isopropyl alcohol
- White spirit
- Heptane
- Hexane
- Petroleum ether (BP 65°)

CLEANING PRIOR TO FORMING

Should it be necessary to Forming to clean LEXAN sheet, it is recommended that the dust is blown off with an ionising air gun or the sheet is wiped with a soft cloth dipped in water or a mixture of isopropanol and water.

Points to remember!

- Don't use abrasive or highly alkaline cleaners.
- Never scrape the sheet with squeegees, razor blades or other sharp instruments.
- Don't clean LEXAN sheet products in the hot sun or at elevated temperatures as this can lead to staining.

SELF-HEALING

REPAIRING PROPERTIES

LEXAN EXTRITE sheet, to an certain extend, does have self-healing and repair properties.

Small scratches and damages to the protected surface of LEXAN EXTRITE can be healed at increased temperatures due to the heat coming from sunlight or other sources when the surface temperature is elevated above 90 °C this also applies to small surface defects coming from sawing/cutting/drilling etc.

If scratches and/or small damages do not automatically disappear by the self-healing effect then it is worthwhile to try and repair them by means of a so-called temperature controlled hot-air gun.

The hot-air-gun needs to be set a temperature of 130 °C (and a max. temperature of 140°C) and is held at a distance of about 3 cm from protected surface of the LEXAN EXTRITE sheet. The hot-air-gun is aimed at the scratches or other damages and kept there until the damages disappear. repairable scratches/damages will (partly) disappear as of 15 seconds, if not then the scratches/damages are too deep into the surface of the sheet to be repaired with this method. Figure 17 shows the result after a repair action between LEXAN EXTRITE sheet and a standard Polycarbonate sheet material:

Figure 16: Repare using a hot-air gun

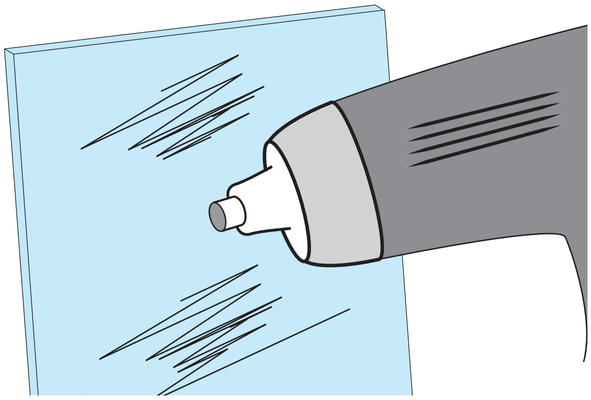
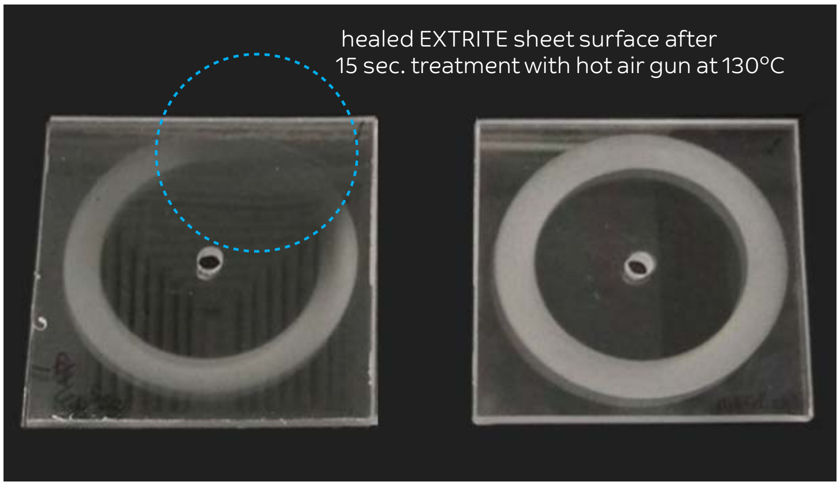


Figure 17: Result after repairing



LEXAN EXTRITE sheet after hot air treatment

Standard PC sheet not healed after hot air treatment

In the blue circle it is clearly visible how the scratches on LEXAN EXTRITE sheet have disappeared . This repair action can be repeated more often if needed.

NOTE 1:
SABIC advises to do some off line training on smaller size samples before doing repairs on larger actual installed LEXAN EXTRITE sheet to train the needed skills.

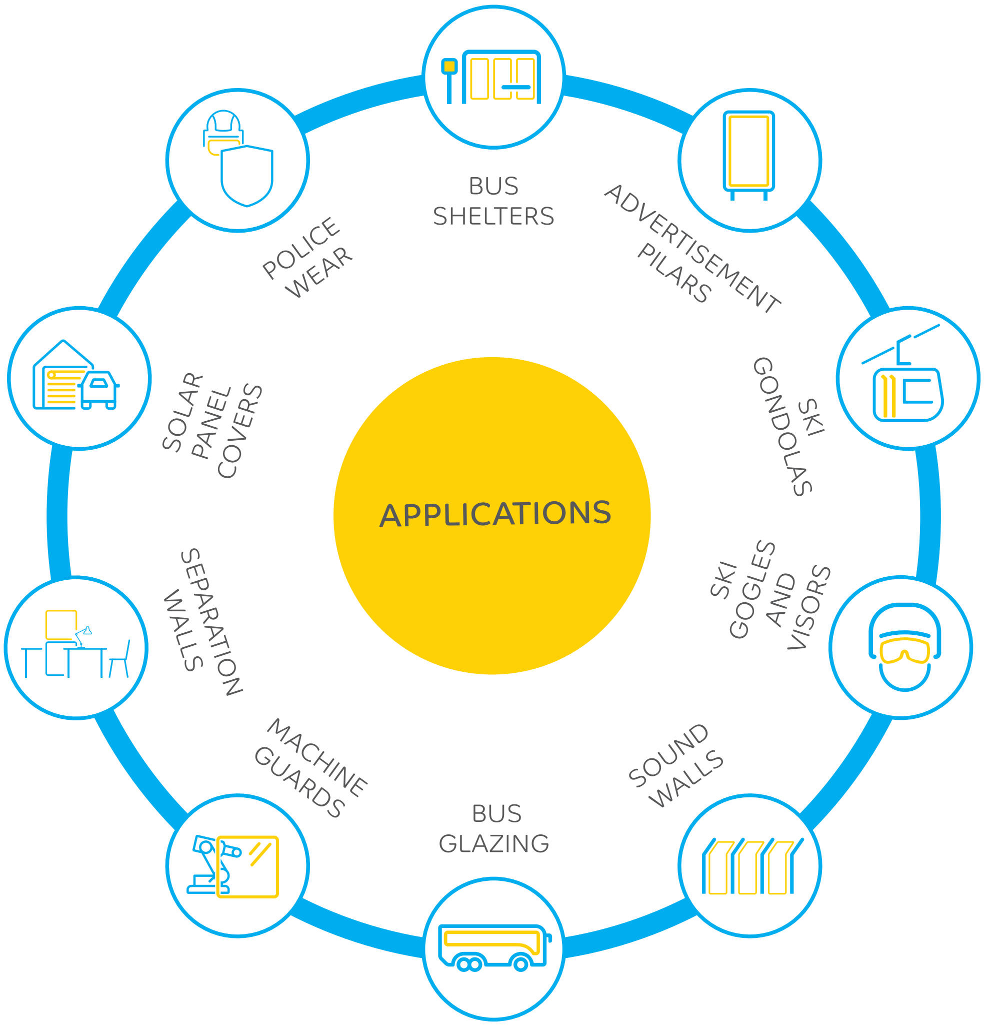
NOTE 2:
When scratches are too deep LEXAN EXTRITE sheet cannot be healed.

LEXAN™ EXTRITE™ SHEET AVAILABILITY

AVAILABILITY

Grade name:	EXTRITE1
Colors:	Clear (112) Opal (WH7D287O 50% LT) Opal (WH4D348O 25% LT) Bronze (5109) Grey (GY6E575T)
Gauges:	2 to 6 mm (0.08-0.24”)
Width:	1250mm (49.21")
Length:	1000-3000mm (39.37-118.1”) Longer lengths on request
Standard Price Volume: (SPV)	1000kgs or 1 pallet

POSSIBLE APPLICATIONS LEXAN EXTRITE SHEET



CONTACT US

SABIC Global Headquarters
PO Box 5101
Riyadh 11422
Saudi Arabia
T +966 (0) 1 225 8000
F +966 (0) 1 225 9000
E info@sabic.com

Americas
SABIC
Functional Forms
2500 CityWest Boulevard
Suite 100
Houston, Texas 77042
USA
T +1 800 323 3783
F +1 888 443 2033
E spinside.sales@sabic.com

Europe
SABIC
Functional Forms
Plasticslaan 1
4612 PX
Bergen op Zoom
The Netherlands
T +31 (0)164 293684
F +31 (0)164 293272
E ff.info@sabic.com

Pacific
SABIC
Functional Forms
2550 Xiupu Road
Pudong
201319 Shanghai
China
T +86 21 3222 4500
F +86 21 6289 8998
E ff.info@sabic.com

www.SABIC.com/sfs