TECHNICAL INFORMATION

BARLO PC
ENGLISH

Contents

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1. Product identification

BARLO PC is the brand name for extruded Polycarbonate sheet from Quinn Plastics in accordance with: ISO 11963/DIN 16801.
The BARLO PC programme offers solutions to both indoor and outdoor applications and for outdoor use we recommend BARLO PC UVP, a material with 10 years warranty.
As a result of the extrusion process, Quinn Plastics can offer, in addition to the clear, opal white and brown versions, a variety of colours and patterns on request. See the Quinn Product selector for range availability.

2. Characteristics

BARLO PC sheets have excellent optical properties and a brilliant surface.
The BARLO PC range contains sheets that are easy to fabricate and show exceptional performance at both low and high temperatures (range from -40 °C to +135 °C).
Important benefits of BARLO PC sheets are their excellent mechanical, thermal and electrical properties.
They are virtually unbreakable in normal use.

BARLO PC sheets also combine the following excellent properties:
- Easy to vacuum form, (pre-drying required)
- Exceptional low and high temperature performance
- Easy to recycle
- Very high impact properties, virtually unbreakable
- Normally inflammable - building regulations l Class B2 to DIN 4102, Part 1.

For gauges from 1.00 up to 4.00 mm Class B1 applies BARLO PC UVP sheets are manufactured by coextrusion, which means that the two UV-protection layers are integral with the base sheet. BARLO PC UVP sheets are strongly recommended for external use. Even after long years of weathering exposure, BARLO PC UVP sheets will maintain their clarity.

3. Applications

■ BARLO PC
- Moulded containers, bowls, tubs
- Machine safety guards, vending machine fascias
- Vehicle and boat construction, aircraft (only for internal use)
- Safety glazing (sport establishments, kindergartens, penal establishments and other buildings)
- Street and traffic signs
- Office machinery (covers, sight panels)
- Industrial construction
- Partition walls
- Advertising panels
- Replacement glazing

■ BARLO PC UVP
- Lighting covers
- Balcony glazing
- Sound barrier walls
- Greenhouses
- Conservatories
- Glazed walkways
- Doors and windows
- Canopy roofs
- Barrel vaults

3.1. Safety glazing

Quinn Plastics has the following "General Approvals for Construction" (issued by German KRAFTFAHRTBUNDESAMT) for safety glazing:

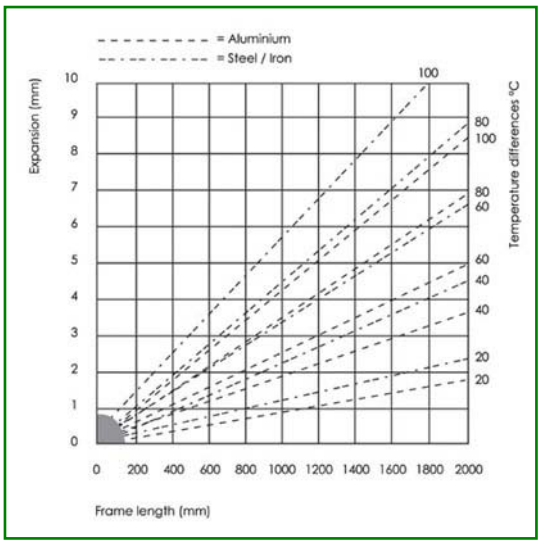
- BARLO PC brown 851 D 2271 Thicknesses 3 - 6 mm
- BARLO PC clear D 469 Thicknesses 2 - 6 mm

3.2. Balcony glazing

BARLO PC and BARLO PC UVP sheets, when used for balcony glazing, meet the requirements of DIN 52290 Part 4, Loading Class A3, as well as of DIN 52337; details on request.

3.3. Thermal properties

When processing BARLO PC sheets with other materials, different rates of expansion on heating should be taken into consideration. BARLO PC is frequently used in conjunction with metal profiles, and care should be given to allow sufficient room for expansion and contraction. BARLO PC expansion rate is 0.065mm/m (degree) C.



4. Fabrication and finishing techniques

BARLO PC and BARLO PC UVP sheets are easy to handle.
Milling, drilling, tapping, sawing, shearing and punching, die cutting, routing, forming, cold and hot bending and welding do not offer any problems to the BARLO PC and the BARLO PC UVP range.
More detailed information on these items can be found in the "USER GUIDE", further in this brochure.

5. Statements

5.1. Statement on guarantee for BARLO PC UVP

As stated before, BARLO PC UVP sheets are suitable for outdoor use.
The careful selection of raw materials and extensive quality control during production permit Quinn Plastics to warrant that BARLO PC UVP sheets will remain:

- Weather resistant for 10 years
- Unbreakable for 5 years

WARRANTY

1. Quinn Plastics warrants that clear and opal BARLO PC UVP sheets are protected on both surfaces from the adverse effects of UV-radiation and, when exposed to moderate European climates, will not show a significant change in light transmission for a period of 10 years and mechanical properties for a period of 5 years, as described below, from the date of sales by Quinn Plastics.

2. This warranty applies exclusively to clear and opal BARLO PC UVP sheets used correctly as flat sheets which are installed, handled and maintained according to Quinn Plastics recommendations and instructions. The purchaser is presumed to be informed of said recommendations and instructions. If this is not the case he can obtain said documents through the sales representative or authorised distributor.

3. No warranty will be available for sheets that have been scratched, abraded, cracked or exposed to corrosive materials or environments, nor for sheet that has notches (resulting for instance from sawing) or if the protective layer of the sheet has been damaged in any manner whatsoever.
   Furthermore, this warranty does not apply to product that has been exposed to extremes of temperature for prolonged periods of time.

4. In the event of a claim against this warranty, the sheet and the original sales receipt must be returned to Quinn Plastics via the sales representative or original authorised distributor.

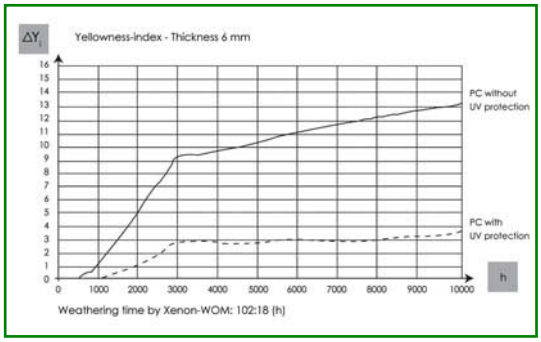
5. Weather resistance in the sense of this guarantee is defined as the degree of light transmission, in accordance with DIN 5036 for clean, unscratched sheets. Light transmission is warranted not to decrease within 10 years by more than 6% in comparison to the delivered condition.
   A BARLO PC UVP sheet showing a change in light transmission of an average less than 6% compared to its original value, as defined by Quinn Plastics on the date of manufacturing, will not be subject to any claim.

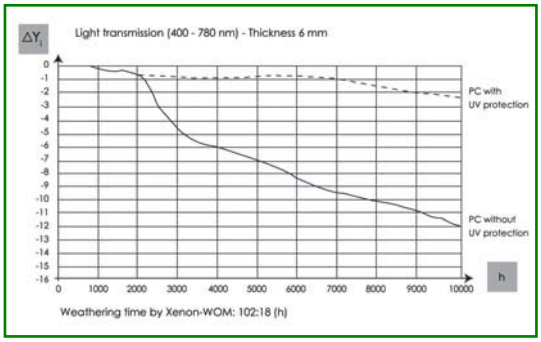
6. Unbreakability in the sense of this warranty means that, after 5 years:
   The tensile modulus of elasticity (to ISO 527) is E(t) > 2100 MPa and
   The tensile strength (to ISO 527) is sigma(m) > 55 MPa
   Tensile modulus of elasticity is tested to ISO 527-2/1B/1 and to ISO 11963. Testing speed must be 1mm/min. Tensile strength is tested to ISO 527-2/1B/50 and to ISO 11963. Testing speed must be 50mm/min.
   Tests of tensile modulus and tensile strength are carried out at 23°C/50% Relative Humidity (±5%) to ISO 291 with unscratched test specimens. Before testing the test specimens must have been conditioned for at least 48 hours in the same atmosphere. Test pieces should be dumbbell-shaped type 1B to ISO 527-2.

7. In the event of a claim against this warranty proving justified, Quinn Plastics will provide a replacement for the material at issue without any other liability for any other additional indemnification whatsoever:
   Up to 5 years time from the purchase date, Quinn Plastics will replace 100% material.
   Within 6 years time from the purchase date, Quinn Plastics will refund 75% material costs.
   Within 7 years time from the purchase date, Quinn Plastics will refund 60% material costs.
   Within 8 years time from the purchase date, Quinn Plastics will refund 45% material costs.
   Within 9 years time from the purchase date, Quinn Plastics will refund 30% material costs.
   Within 10 years time from the purchase date, Quinn Plastics will refund 15% material costs.
   If replacement material cannot be provided within a reasonable period of time, Quinn Plastics may choose to refund the original cost of the material without any other liability for any additional indemnification whatsoever. This warranty does not, for instance, cover re-installation expenses or any other incidental costs, which may result from a breakage.

8. There are no express or implied, written or oral warranties and or representations by Quinn Plastics including warranties and representations of merchantability or fitness of purpose, except as set forth herein.

Changes in the Yellowness-Index and Light Transmission under artificial weathering (Xenon-lamp).





5.2. Safety data statement

Safety data sheet is available on request.

5.3. Statement on thermal insulation

BARLO PC and BARLO PC UVP sheets used in glazing applications result in considerable energy cost savings by preventing excessive heat loss in winter and by blocking heat entry in the summer.
The heat loss factor, normally referred to as the K (u)-value, of BARLO PC and BARLO PC UVP is significantly lower than for glass at the same thickness. Some examples of the heat insulation performance of BARLO PC and BARLO PC UVP in single and double-glazing systems are given below and compared with glass.

Advantages of BARLO PC and BARLO PC UVP to glass

■ **At the same thickness:**
- ➢ Improvement of the K-value
- ➢ Unbreakable
- ➢ Weight saving

Single glazing
- Improvement K-value:
  Glass 5 mm: K-value = 5.74 W/m²°C
  BARLO PC 5 mm: K-value = 5.16 W/m²°C
  ΔK-value = 0.58 W/m²°C = 10.1%
- Weight saving
  Glass 5 mm: 12.5 kg/m²
  BARLO PC 5 mm: 6.00 kg/m²
  Δ = 6.50 kg/m² = 52.0%

Double glazing
- Improvement K-value
  2 x glass 4 mm with air gap 5 mm: K-value = 3.57 W/m²°C
  2 x BARLO PC 4 mm with air gap 5 mm: K-value = 3.25 W/m²°C
  ΔK-value = 0.32 W/m²°C = 9.0%
- Weight saving
  2 x glass 4 mm: 20.0 kg/m²
  2 x BARLO PC 4 mm: 9.6 kg/m²
  Δ = 10.4 kg/m² = 52.0%

■ **At the same K-value:**
- ➢ Weight saving
- ➢ Unbreakable
- ➢ Volume saving

Single glazing
Glass 10 mm: K-value = 5.60 W/m2°C
BARLO PC 2 mm: K-value = 5.57 W/m2°C
- Weight saving
  Glass 10 mm: 25.0 kg/m²
  BARLO PC 2 mm: 2.40 kg/m²
  Δ = 22.6 kg/m² = 90.4%
- Volume saving
  Δ = 8 mm

Double glazing
2 x glass 5 mm with 15 mm air: K-value = 3.05 W/m2°C
2 x BARLO PC 3 mm with 10 mm air: K-value = 3.05 W/m2°C
- Weight saving
  Glass 2 x 5 mm 25.0 kg/m²
  BARLO PC 2 x 3 mm: 7.2 kg/m²
  Δ = 17.8 kg/m² = 71.2%
- Volume saving
  Glass 2 x 5 + 15: 25 mm
  BARLO PC 2 x 3 + 10: 16 mm
  Δ = 9 mm

K (u)-values for customer specific glazing systems can be provided upon request. For more information contact your local Quinn Plastics sales office.

6. Technical information

6.1. Technical data sheet

■ GENERAL			
Property	**Method**	**Units**	**BARLO PC + BARLO PC UVP**
Density	ISO 1183	g/cm³	1.2
Rockwell Hardness	D-78	M-scale	-

■ OPTICAL			
Property	**Method**	**Units**	**BARLO PC + BARLO PC UVP**
Light Transmission	DIN 5036	%	86
Refractive Index	T3	n^{D}_{20}	1. 585

■ MECHANICAL			
Property	**Method**	**Units**	**BARLO PC + BARLO PC UVP**
Flexural Modulus	ISO 489	MPa	-
Flexural Strength	ISO 178	MPa	>95
Tensile Modulus	ISO 527	MPa	2200
Tensile Strength	ISO 527	MPa	60
Elongation	ISO 527	%	80

■ THERMAL			
Property	**Method**	**Units**	**BARLO PC + BARLO PC UVP**
Vicat Temp. (VST/A 50)	ISO 306	°C	145
Heat Deflection Temp. (A)	ISO R75	°C	135
Specific Heat Capacity	-	J/gK	1.17
Coefficient of linear thermal expansion	DIN 53328	$K^{-1}x10^{-5}$	6.5
Thermal conductivity	DIN 52612	W/mK	0.2
Degradation temperature		°C	>280
Max. service temperature continuous use		°C	115
Max service temperature short term use		°C	130
Sheet forming temp. range		°C	180-210

■ IMPACT STRENGTHS			
Property	**Method**	**Units**	**BARLO PC + BARLO PC UVP**
Izod (notched)	ISO 180	kJ/m²	-
Charpy (notched)	ISO 179	kJ/m²	>40
Charpy (unnotched)	ISO 179	kJ/m²	NB

■ ELECTRICAL			
Property	**Method**	**Units**	**BARLO PC + BARLO PC UVP**
Dielectric constant 50 HZ	DIN 53483		3.0
Volume Resistivity	DIN 53482	Ω.cm	10^{15}
Surface Resistivity	DIN 53482	Ω	10^{15}
Dielectric strength	DIN 53481	kV/mm	>30
Dissipation Factor (50 HZ)	DIN 53483		8×10^{-4}

Resistance to chemicals

BARLO PC and BARLO PC UVP sheets are resistant to mineral acids up to higher concentrations, many organic acids (e.g. carbonic, lactic, oleic and citric acids), oxidation and reduction substances, neutral and acidic saline solutions, a range of fats and oils, saturated aliphatic and cyclo-aliphatic hydrocarbons and alcohols, except for methyl alcohol. BARLO PC and BARLO PC UVP sheets can be destroyed with alkalis, ammonia and their solutions, and amines. BARLO PC and BARLO PC UVP sheets can be dissolved by a large number of solvents. Organic compounds such as benzene, acetone and carbon tetrachloride make them swell. If you have any queries, please contact your Quinn Plastics distributor or local sales office.

Chemical resistance at 20°C

Acetone	-	Glycols	+
Acids (weak solution)	+	Glycerine	+
Alcohols		Hexane	+
Ethyl	+	Methylenechloride	-
Isopropyl	0	Methylethylketone	-
Methyl	-	Mineral Oil	+
Ammonia (weak solution)	-	Paraffin	+
Benzene	-	Toluene	-
Carbon tetrachloride	-	Sodium Chloride (aq)	+
Chloroform	-	Sodium Hydroxide (aq)	-
Ethyl Acetate	-		

\- Attacked
0 Restricted
\+ Not attacked

6.2. Product range BARLO PC and BARLO PC UVP

BARLO PC and BARLO PC UVP sheets are protected on both sides with a PE-film, except patterned sheets, which are only protected on the smooth underside.

Thickness range for:

- BARLO PC standard version
  From 1.00 mm up to 15 mm
  Standard thicknesses 1-1.5-2-3-4-5-6-8-10-12 and 15 mm
- BARLO PC UVP version
  From 2.00 mm up to 12 mm
  Standard thicknesses 2-3-4-5-6-8-10-12 mm

Widths cut on line

Max 1250 mm	for 1 and 1.5 mm
Max 2050 mm	from 2 mm up to 15 mm

Standard lengths cut on line

Min 1000 mm	
2050 mm	for thicknesses < 2 mm
3050 mm	for thicknesses > 2 mm (over lengths on special request)

Thickness tolerances

2.0 mm - 3.0 mm	± 10%
4.0 mm up to 15 mm	± 5%

Cut on line tolerances for standard sizes

> 1000 mm	- 0 + 3‰ (3 mm per 1000 mm)
< 1000 mm	on application

- **Cut to size tolerances**
  ± 1.00 mm
- **Minimum production runs for**

Special thicknesses in clear	7.500 kg
Special colours	15.000 kg

- **Shrinkage**

Thickness 1.5 - 2.5 mm	max. 6%
Thickness 3.0 - 15.0 mm	max. 3%

Other thicknesses, sizes and tolerances on request.
For the standard stock programme see our product selector brochure.

7. User guide

7.1. Introduction

The manufacture of plastic articles from BARLO PC and BARLO PC UVP sheet normally involves secondary fabrication operations, including sawing, drilling, bending, decorating, and assembling. This guide covers the properties and characteristics of BARLO PC and BARLO PC UVP that need to be taken into account if secondary operations are to be performed successfully.

7.2. Fabricating

7.2.1. Machining guidelines

BARLO PC and BARLO PC UVP sheet can be worked with most tools used for machining wood or metal. Tool speeds should be such that the sheet does not melt from frictional heat. In general, the highest speed at which overheating of the tool or plastic does not occur will give the best results.
It is important to keep cutting tools sharp at all times. Hard, wear-resistant tools with greater cutting clearances than those used for cutting metal are suggested. High-speed or carbon-tipped tools are efficient for long runs and provide accuracy and uniformity of finish.
Since plastics are poor heat conductors, the heat generated by machining operations will be absorbed by the tool. A jet of air directed on the cutting edge aids in cooling the tool and in removing chips.
The protective film on Quinn Plastics sheets should not be taken off during handling and machining in order to prevent scratches or damaging the surface of the sheet. Machining of plastic materials will result in stress build-up in the material. For applications where the treated surface is in contact with active solvents e.g. decorating and cementing, it is recommended to anneal the parts prior to this secondary step.

7.2.2. Milling

Sheet manufactured from BARLO PC and BARLO PC UVP can be machined with standard high-speed milling cutters for metal, provided they have sharp edges and adequate clearance at the heel.

7.2.3. Drilling

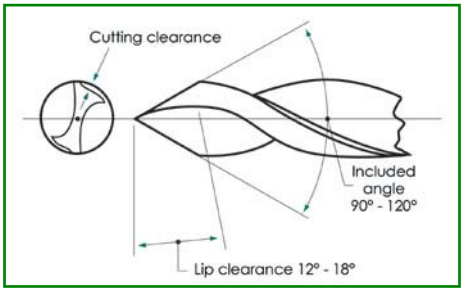


Figure 1
Suggested Drill-point Design for Drilling Plastic sheet

Drills designed especially for plastics are available, and their use is suggested. Standard twist drills for wood or metal can be used; however they require slower speeds and feed rates to produce a clean hole. Twist drills for plastics should have 2 flutes, a point with an included angle of 90° to 120°, and a lip clearance of ~30°; as shown in Figure 1.
Wide, highly polished flutes are desirable since they expel the chips with low friction and thus tend to avoid overheating and consequent gumming. Drills should be backed out often to free chips, especially when drilling deep holes. Peripheral speeds of twist drills for BARLO PC ordinarily range from 10 to 60 m per minute. The rate of drill feed into the plastic sheet generally varies from 0.10 to 0.50 mm per revolution.

NOTE:
When drilling, be sure to hold or clamp the part securely to prevent it from cracking or slipping and presenting a safety hazard to the operator.

7.2.4. Tapping

Conventional 4-flute taps can be used for cutting internal threads in plastic sheet when a close fit is required. Such taps, however, have a tendency to generate considerable heat during the tapping operation. A high-speed, 2-flute tap should offer longer life and greater tapping speed than a conventional tap, as well as provide clearance for chip discharge. Flutes should be ground so that both edges cut simultaneously; otherwise the thread will not be uniform. Cutting edges should be 85° from the centre line, giving a negative rake of 5° on the front face of the lands so that the tap will not bind in the hole when it is backed out. It is desirable to have some relief on the sides of threads. The pilot hole must be 0.1 mm bigger than for steel. When tapping BARLO PC it is recommended that molybdenum sulphide should be used for lubrication.

7.2.5. Sawing

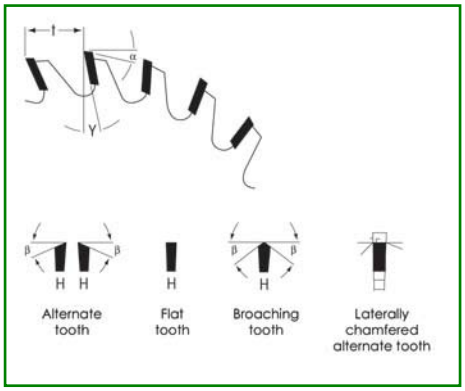


Figure 2
Example of Sawblades

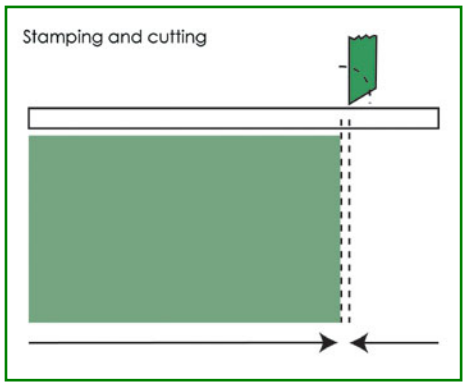
Many types of sawing operations can be used to cut polycarbonate sheet: band saw, circular saw and jigsaw as well as hand operated saws. It is recommended that new or well-sharpened tools are used. At very high cutting speeds, the saw blade should be cooled with a jet of air.

Table 1
Sawing Recommendations

Type of sawing	Band saw	Circular saw
Tooth distance	sheet thickness below 3 mm, 1 to 2 mm sheet thickness 3 to 12 mm, 2 to 3 mm	8 to 12 mm 8 to 12 mm
Clearance angle a	30 to 40°	15°
Rake angle Ψ	15°	10°
Tooth angle β	-	15°
Cutting speed	1200 - 1700 m/min	2500 - 4000 m/min
Feed speed	-	20 m/min

7.2.6. Stamping and cutting

It is possible to stamp out BARLO PC sheets up to about 2 mm thick, using normal, but very sharp metalworking tools.
For thicker materials (up to 5 mm maximum), it is recommended to contact the Quinn Plastics technical service department for further advice.



7.2.7. Laser cutting

BARLO PC and BARLO PC UVP sheet can be cut by laser beam. A laser may be used to make intricate holes and complex patterns, or it can be controlled to merely etch the plastic. Tolerances can be controlled more closely with a laser than with conventional machining operations. Laser power and travel speed must be optimised to minimise 'whitening' of the BARLO PC sheet while cutting. By laser cutting BARLO PC the edge always will have a slightly brown colour, therefore, if clear edges are preferred, laser cutting is not recommended for BARLO PC.

7.2.8. Routing

BARLO PC and BARLO PC UVP can be routed using the following guidelines:

Diameter of the router	4 - 6 mm
Feed speed	ca.1.5 m/min
Rpm	18 - 24.000

Table 2: Routing Recommendations

7.2.9. Welding

The hot air welding of BARLO PC and BARLO PC UVP sheets using filler rod is possible. Welding techniques where the entire weld is treated simultaneously are preferred, e.g. hot plate welding or friction welding.
In the case of hot air welding, it is essential that the work piece and the filler rod are pre-dried for 12 hours at 120° to 130°C. BARLO PC and BARLO PC UVP sheets are particularly suitable for ultrasonic welding in series production, this technique being limited to spot and rivet welding or the insertion of metal parts, such as rivets or thread inserts.

7.3. Forming

7.3.1. Hot bending

BARLO PC and BARLO PC UVP sheet can be bent to a small radius by preheating an area on both sides with an electric strip heater and then quickly bending the sheet along the heated line. When the optimum sheet temperature is reached (slightly over 160°C) and a slight resistance to bending is noticeable, the part can be readily formed. Pre-drying is only necessary if bubbles appear in the sheet bending zone. If bending is performed too cold, stresses will be created that will result in a brittle part.
The protective film must be removed on both sides, at least from that part which is to be heated.

7.3.2. Cold bending

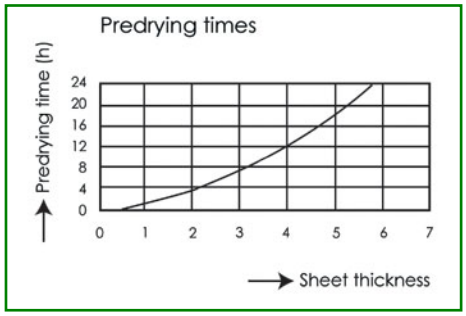
Cold bending is possible in exceptional circumstances and should be carried out with regard to the following guidelines, using the normal bending machines available from trade suppliers. The bending should take place in several steps, e.g. in 30° intervals such as 40°, 70°, 100° and 120°. Hot bending gives much better results.

Sheet thickness in mm	Bending radius in mm	Max. bending angle
1; 2; 2.5	2	90°
3; 4	3	90°
5; 6	5	90°

Cold bending is not recommended for BARLO PC KRISTAL decor.

7.3.3. Thermoforming

There are a number of different thermoforming techniques that can be used to form BARLO PC and BARLO PC UVP sheet, once heated, into the shape of a mould by mechanical, air pressure, or vacuum forces. Both male (plug) and female (cavity) moulds are used. The required temperature for thermoplastic forming of BARLO PC and BARLO PC UVP sheets lies between 180° and 210°C. Because of the high heat drop, surface temperature to room temperature, it is recommended that the sheets are heated on both sides, for which a total IR radiation power of 30KW/m² will achieve good results. For the continuous production of mouldings made from BARLO PC sheets, in most cases aluminium or steel are chosen as material for the moulds. Bringing the moulds up to the optimum working temperature is therefore necessary. Optimum surfaces in the freezing zone of BARLO PC sheets are achieved with a mould temperature of about 130°C.



Depending on forming technique, a good surface quality can be attempted at a mould temperature in the range of 80° to 120°C. Though the water absorption of BARLO PC sheets is low, the sheets must be pre-dried before forming. The drying is best carried out in an air circulation oven at about 110° to 120°C, with individual sheets and with the protective film removed.
When thermoforming BARLO PC UVP sheets, care is to be taken to ensure that the depth of draw ratio should not be more than 1:1.5 to guarantee sufficient UV protection under the terms of the warranty.

7.3.4. Straight vacuum forming

Vacuum forming is the most versatile and widely used forming process. The equipment costs less and is simpler to operate than most pressure or mechanical techniques. In straight vacuum forming, BARLO PC and BARLO PC UVP is clamped in a frame and heated. When the hot sheet is in an elastic state, it is placed over the female mould cavity. The air is then removed from the cavity by vacuum and atmospheric pressure then forces the hot sheet against the contours of the mould. When the BARLO PC or BARLO PC UVP sheet has cooled sufficiently, the formed part can be removed. Thinning at the upper edges of the part usually occurs with relatively deep moulds and is caused by the hot sheet being drawn to the centre of the mould first. Sheeting at the edges of the mould must stretch the most and thus becomes the thinnest portion of the formed item. Straight vacuum forming is normally limited to simple, shallow designs.
See figure 3

7.3.5. Drape forming

Drape forming is similar to straight vacuum forming except that after the BARLO PC or BARLO PC UVP sheet is framed and heated, it is mechanically stretched and a pressure differential is then applied to form the sheet over a male mould. In this case, however, the sheet touching the mould is close to its original thickness. It is possible to drape-form items with a depth-to-diameter ratio of approx. 4 to 1; however, the technique is more complex than straight vacuum forming. Male moulds are easier to build and generally cost less than female moulds; however, male moulds are more easily damaged. Drape forming can also be used with gravitational force alone. For multicavity forming, female moulds are preferred because they do not require as much spacing as male moulds.
See figure 4

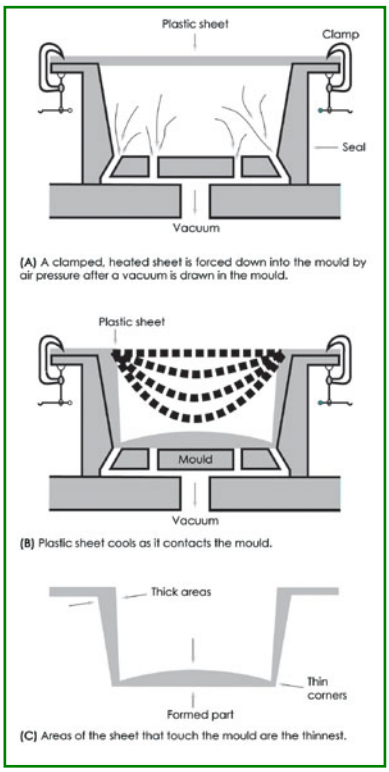


Figure 3
Straight Vacuum Forming

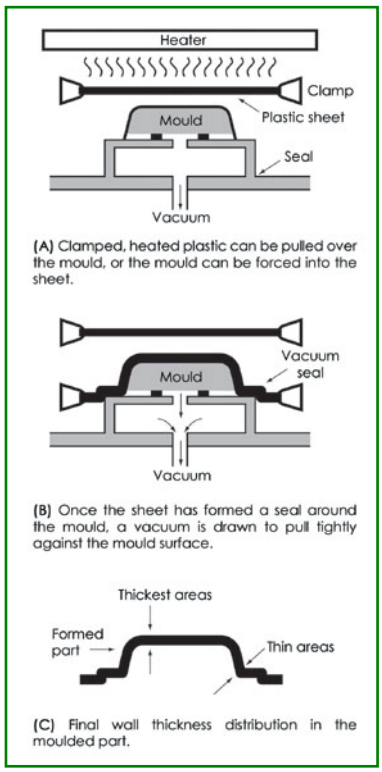


Figure 4
Drape Forming

7.3.6. Matched-mould forming

Matched-mould forming is similar to compression moulding in that heated BARLO PC or BARLO PC UVP sheet is trapped between male and female dies made of wood, plaster, epoxy or some other material.
Although they cost more, water-cooled matched moulds produce more accurate parts with close tolerances.

7.3.7. Pressure-bubble plug-assist vacuum forming

The pressure-bubble plug-assist vacuum forming technique can be used when BARLO PC or BARLO PC UVP sheet is to be formed into deep articles that must have good thickness uniformity. The sheet is placed in a frame and heated and controlled air pressure is used to create a bubble. When the bubble has been stretched to a predetermined height, the male plug-assist (normally heated) is lowered to force the stretched sheet into the cavity. Plug speed and shape can be varied for improved material distribution; however, the plug is made as large as possible so that the plastic material is stretched close to the shape of the finished product. The plug should penetrate 75 to 85% of the mould cavity depth. Air pressure is then applied from the plug side while a vacuum assist is being drawn on the cavity. The female mould must be vented to allow the escape of trapped air.

7.3.8. Plug-assist pressure forming

Plug-assist pressure forming is similar to plug-assist vacuum forming in that a plug forces the hot BARLO PC and BARLO PC UVP sheet into a female cavity. Air pressure applied from the plug then forces the plastic sheet against the walls of the mould. Plug design and plug speed can be varied to optimise material distribution.

7.3.9. Plus-assist vacuum forming

Corner or periphery thinning of cup- or box-shaped articles can be prevented by use of a plug-assist to mechanically stretch and pull additional plastic material into the female cavity. The plug should be 10 to 20% smaller than the mould and should be heated to just under the forming temperature of the sheet. Once the plug has forced the hot sheet into the mould cavity, air is drawn from the mould to form the part.
Plug-assist vacuum forming and plug-assist pressure forming (see previous section) allow deep drawing and permit shorter cooling cycles and good wall thickness control. Both processes require close temperature control and are more complex than straight vacuum forming.

7.4. Assembly

BARLO PC and BARLO PC UVP sheet can be fabricated into a variety of shapes and articles with solvent, cement (a polymer dissolved in a solvent), or adhesive bonds. In general, when the surfaces to be joined are irregular, cement is preferred over a solvent.

7.4.1. Assembly guidelines

The following guidelines should be observed when bonding BARLO PC and BARLO PC UVP sheeting:

- The sheet edges must be clean and free from contamination.
- The surfaces must be smooth and accurately aligned.
- A solvent or cement must be sufficiently active to soften the mating surfaces for some flow to occur when pressure is applied.
- When using solvents in BARLO PC and BARLO PC UVP sheet assembly, it is advisable that the work area be climate controlled with low humidity to minimise joint 'whitening' or use of a slower curing cement-type bond is suggested.
- Fixture pressure must be maintained to prevent movement of the joint until it is solid.
- Good ventilation is required when working with solvents. Exposure levels must be controlled according to OSHA guidelines.

7.4.2. Bonding techniques: solvents, cements and adhesives

BARLO PC sheets can be bonded to other plastic surfaces, following normal care to ensure the contact surfaces are clean. Particularly suitable for this on small contact surfaces are adhesive solvents, such as methylene chloride (Boiling Point 41.6°C) or ethylene chloride (1.2 dichloro-ethylene, Boiling Point 83.7°C). To avoid over use of the solvent, its application should be limited to only 5 to 10 seconds.
Thereafter, the glued surfaces should be joined immediately and pressed together for a short time with a pressure of 30 to 100 N/cm². Adhesive lacquers, e.g. an 8% solution of polycarbonate in methylene or ethylene chlorides, can be applied whilst pure solvents cannot be used because of their rapid evaporation effect.

Important: The adhesive lacquer should only be applied thinly! Otherwise, use same technique as for solvents.

Reaction adhesives are particularly suitable for bonding BARLO PC sheets to other materials.
Recommended reaction adhesives are those based on epoxy resin. Whatever bonding technique is adopted, it should first be determined with trials on scrap material.

Recommended suppliers are shown below:

Colacril	Quinn Plastics
Agovit 1074	Agomer
UHU endfest 300	UHU-Vertrieb
Helmitin A+B	Forbo-Helmitin
Perenator V23-11	Dow Corning
Perenator V23-6	
Perenator XW018122	
Perenator V43-4	
Perenator V43-5	
Silglaze N	GE Bayer Silicones
Silpruf	
Bostik 7431	Bostik Ltd
Technicoll 8201	Fuller GmbH

7.4.3. Mechanical fastening

BARLO PC and BARLO PC UVP sheet can be fabricated with mechanical fasteners into attractive joints. When frequent disassembly is required, threaded metal inserts are preferred. Screws and rivets provide permanent assembly. Standard nuts, bolts, and machine screws are used in many instances: in addition, special screws and rivets specifically designed for use with plastics are available. Springs, clips, and nuts are low cost, rapid, mechanical fasteners. Hinges, knobs, catches, and dowels are some other devices used in mechanical assemblies.

7.5. Finishing

7.5.1. Sanding

BARLO PC and BARLO PC UVP sheet is best sanded wet to avoid the frictional heat build-up that is characteristic of dry sanding techniques. If water coolants are used, the abrasive lasts longer and the cutting action increased. Progressively finer abrasives should be used: for example, rough sanding with 80-grit silicon carbide would be followed by finer sanding with 280-grit silicon carbide, wet or dry. The final sanding may be with 400 or 600 grit sandpaper. After the sanding is finished and the abrasives removed, additional finishing operations may be required.

7.5.2. Filing

When many thermoplastics, including BARLO PC and BARLO PC UVP, are filed, a light powder that tends to clog some files is produced. Therefore, aluminium Type A, shear-tooth, or other files that have coarse, single-cut teeth with an angle of 45° are preferred.

7.5.3. Printing

BARLO PC and BARLO PC UVP sheeting can be printed with conventional equipment; however, the ink does not penetrate a plastic as it does with paper and cloth and is therefore subject to damage by abrasion. This can be minimised by applying a light coat of clear lacquer over the printing.
There are a number of different methods used when printing on plastics including letterpress, letterflex, dry offset, offset lithography, rotogravure, stencilling, and silk screen process. In silk screening, the ink is poured on to a fine metallic or fabric screen, and a squeegee is used to force the ink through the screen. Since each application may require a different type of ink, it is suggested that an ink manufacturer be consulted for recommendations.

7.6. Glazing

7.6.1. Vertical glazing

In order to determinate the required dimensions for glazing panels made from BARLO PC sheets fixed on all sides, the following factors are to be taken into consideration:

- Coefficient of thermal expansion, which is:
  $65x10^{-6}\ K^{-1}$, corresponding to 0.065 mm per m length and 1°C change of temperature.

- Inside width of the frame
  Frames can be made of plastic, wood or metal. It is recommended to equip the frame rebate with a relatively dense material. For a defined edge length of the sheet, the frame must be larger by the following amounts.

Edge length	Addition
500 mm	3.0 mm
1000 mm	5.0 mm
1500 mm	7.0 mm
2000 mm	10.0 mm
3000 mm	15.0 mm

- Depth of rebate
  The rebate should be approx. 25 mm deep.

- Wind loading
  The wind loading is to be taken into account. A permissible deflection of the sheet of 20 mm per edge length is acceptable, when the wind loading is of hurricane strength (1000 N/m²). For a sheet with a determined format, the short side of the sheet is used for the definition of material thickness:

Shortest edge length	Thickness
up to 400 mm	3.0 mm
up to 600 mm	4.0 mm
up to 800 mm	5.0 mm
up to 1000 mm	8.0 mm
up to 1200 mm	10.0 mm
up to 1400 mm	12.0 mm
up to 1600 mm	15.0 mm
up to 2000 mm	15.0 mm

  For internal glazing, not subject to loading, the following dimensions apply:

Shortest edge length	Thickness
up to 400 mm	3.0 mm
up to 600 mm	3.0 mm
up to 800 mm	4.0 mm
up to 1000 mm	5.0 mm
up to 1200 mm	6.0 mm
up to 1400 mm	8.0 mm
up to 1600 mm	10.0 mm
up to 1800 mm	12.0 mm
up to 2000 mm	15.0 mm

- Length/width ratio
  In the figures, a length/width ratio of 1:1.5 up to 1:3 has been taken into account.

Important when glazing with BARLO PC sheets:

- Care should be taken on installation to allow for heat expansion
- The edging tape must not be stuck to the BARLO PC sheets. Suitable edging tapes are, for instance, plasticizer free rubber and plastic profiles.
- The sealing compound must have permanent elasticity. Suitable mediums are polysulfides and silicon rubber in neutral standardisation.

Arc-shaped, symmetrical barrel vaults

Cold bending
With cold bending, the sheet is installed under stress. Care is to be taken that the minimum bending radius of 150 x D (= 150 x the material thickness) is not exceeded.
For this type of application, we recommend taking note of the values in the following diagrams A-D.
Supporting bow spacing: max. 2000 mm; Average expansion level: 4 mm/m.

Example
With a supporting bow spacing of 1000 mm, diagram B would be used. For a loading of 700 N/m² and a bending radius of 2500 mm, a sheet thickness of 5 mm is obtained.

Diagram A

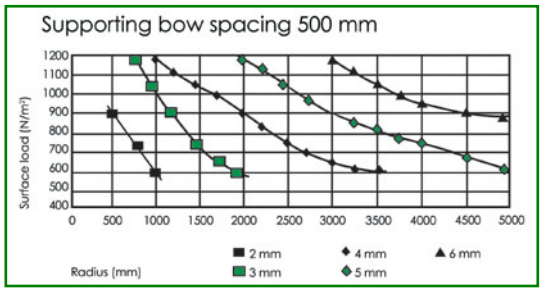


Diagram B

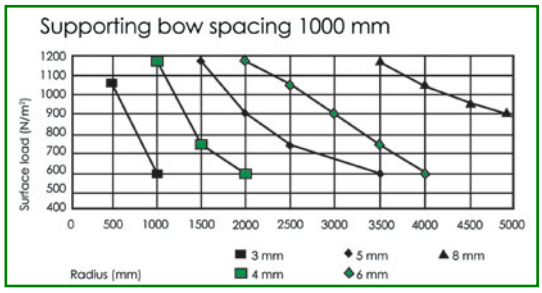


Diagram C

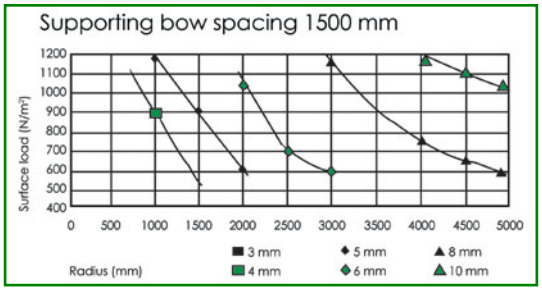


Diagram D

7.6.2. Horizontal glazing

The thickness of BARLO PC sheet to be fabricated, depends on the geometric factor and the surface load acting on the sheet. From diagram E, the geometric factor can be taken using the sheet width and length. With this geometric factor and the loading, you will reach the sheet thickness, according to Diagram F.

Example
A width of 1000 mm and a length of 3000 mm give a geometric factor of 12. With a geometric factor of 12 and an assumed surface load of 2 kN/m², a 12 mm thick BARLO PC sheet must be used.

Diagram E

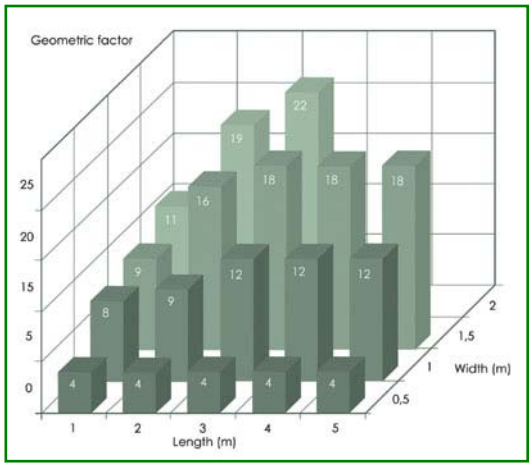


Diagram F