

Technical manual, January 2005

Makrolon[®] Solid Polycarbonate Sheets

Bonding, fastening, finishing and cleaning

1. Bonding with solvent-based adhesives

Warning! Solvents may be toxic or contain carcinogens. Always ensure good ventilation when working with solvents and follow the information contained in the safety data sheets provided by the manufacturer.

When bonding Makrolon[®] sheets the load should be evenly distributed across the entire adhesive coating. Please note that the joint should not be subject to peel stress but only to shear or tension stress.

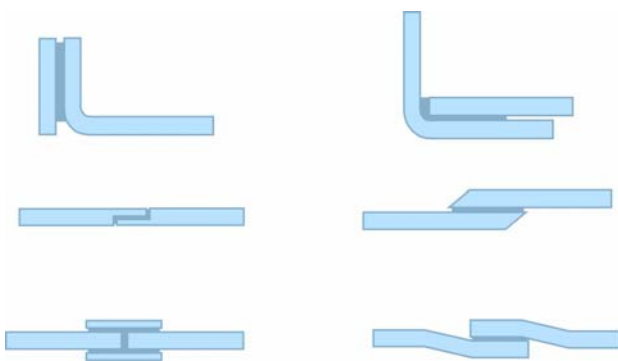


Fig. 1: Different bonded joints

Solvent-based adhesives are the easiest and most economical way of bonding Makrolon[®] parts.

The addition of 8 % Makrolon[®] shavings gives an adhesive coating with lower evaporation speed and higher viscosity, which makes it easier to apply and handle the adhesive.

A further advantage of this adhesive coating is that the surfaces being bonded no longer have to fit together as well (gap filling) as when using pure solvent-based adhesive.

Important:

- The surfaces to be bonded should be thoroughly cleaned with a soft cloth soaked in isopropyl alcohol to remove grease, dirt and other foreign bodies.
- The solvent-based adhesive should be applied as a thin layer to one of the surfaces to be bonded (any excess of adhesive will result in a weak joint).
- The surfaces should be laid on top of each other immediately and briefly pressed together to ensure a good joint.
- The adhered parts may be moved after just a few minutes, although – at normal room temperature – maximum bonding strength is only achieved after a few days (slow release of adhesive from the adherent).

Do not use any solvent-based adhesives for flat joints with either side of **Makrolon[®] AR**. The scratchresistant surface prevents the adhesive from bonding properly.

Solvent-based adhesives can also be used to bond Makrolon[®] to other thermoplastic materials with dissolvable surfaces. These joints generally have a lower level of strength depending on the combined materials. Adhesion bonding agents are preferable if this is the case.

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2. Bonding with adhesive bonding agents

Please adhere to the general safety measures recommended by the manufacturer. Makrolon[®] parts may be adhered to each other or to other materials using industrial adhesive bonding agents that are compatible with Makrolon[®]. In selecting a bonding agent it is important to consider the following parameters: heat resistance, elasticity, appearance of adhesive coating, ease of processing etc.

Important:

- The surfaces to be bonded must be roughened and thoroughly cleaned to improve the adhesive result.
- Adhesives that contain solvents or catalysts that are not compatible with Makrolon[®] should not be used.
- The instructions for use provided by the manufacturer must be observed.

If using an adhesive bonding agent with Makrolon[®] AR, conduct tests as the material is not easily bonded.

3. Bonding with adhesive tape

Transparent, double-sided adhesive tape (acrylic based) may be used for rapid bonding. These tapes are elastic and adhere well to Makrolon[®]. They are particularly suitable for bonding thin Makrolon[®] sheets to other plastics, glass or metal.

Tips for good bonding:

- Fold the sheet so that it is slightly wider than the adhesive tape.
- Clean this area with isopropyl alcohol.
- Carefully apply the adhesive tape.
- Use a roller to apply even pressure to remove any air bubbles and improve adhesion.

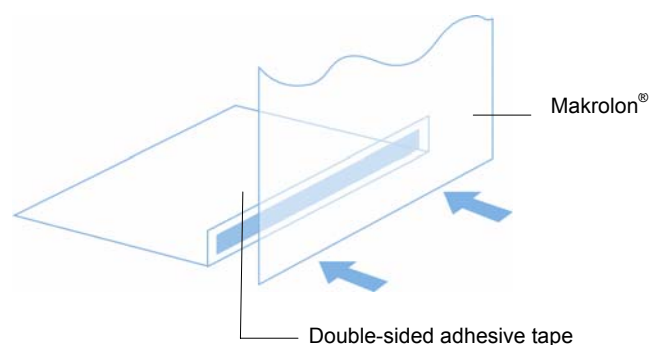


Fig. 2: Bonding with adhesive tape

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4. Welding

Welding is primarily used with opaque sheets. The optical quality achieved from welding is not ideal so that this technique should only be used after careful consideration.

If welding is selected, please note the following points:

- The Makrolon[®] work pieces and welding rod if applicable must be dried and cleaned before welding to avoid the formation of blisters and to stop dirt from becoming trapped in the weld.
- To eliminate the inner stresses caused by local heat expansion during welding the work pieces should be conditioned after the welding process.

Hot air welding

This type of welding is suitable for joining Makrolon[®] parts up to a maximum weld length of 300 mm, for which the internal stresses and resulting warpage is easily controlled using local heating.

An air quantity of 50 to 100 l/min and an air temperature of 350 to 400 °C, measured 5 mm from the nozzle, is recommended. Extruded round or profile rods or even narrow strips cut from a Makrolon[®] sheet may be used as a welding rod.

Ultrasonic welding

Makrolon[®] sheets may be joined to each other using ultrasonic welding. Detailed information on ultrasonic welding equipment and the welding conditions should be requested from the relevant equipment manufacturer.

5. Mechanical fastening

Holes drilled in Makrolon[®] sheets impair the strength of the sheets. Bearing in mind the relatively high linear thermal expansion coefficient of Makrolon[®] compared with metal or glass, structural measures should be taken to ensure that the Makrolon[®] part can move freely under temperature fluctuations.

Example:

The table below shows the expansion of a sheet measuring 1 m in length under a temperature increase of 20 °C.

	Linear thermal expansion coefficient (mm/mK)	Expansion at $\Delta 20\text{ °C}$ (mm)
Makrolon [®]	0.065	1.30
Aluminium	0.024	0.48
Steel	0.012	0.24
Glass	0.008	0.16

During fastening work make sure that the Makrolon[®] sheet is not excessively stressed by local pressure forces. Washers or profiled rubber/foam strips should be used to distribute the pressure.

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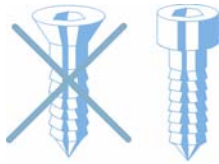
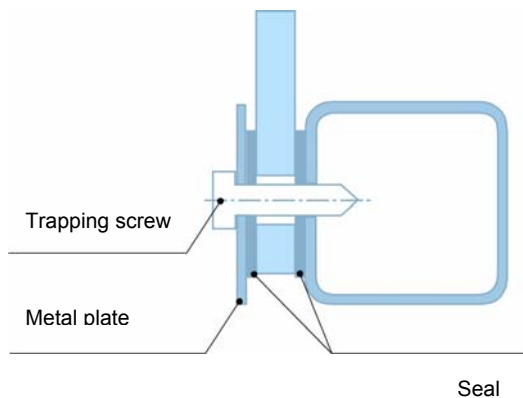


Fig. 3: Avoid screws with beveled heads, which can cause cracking.

Fastening holes should always be drilled with allowance for expansion and shrinkage. The allowance should be based on the sheet dimensions and the expected temperature fluctuations. With very large sheets it may even be necessary to drill oblong holes. The distance between the mid-point of the holes and the outer edge of the sheet must be at least twice the diameter of the hole and a minimum of 6 mm. The screws should only be tightened to a position that enables the Makrolon[®] sheet to expand or shrink freely when exposed to temperature stress. Distance: $2 \times \varnothing$ drilled hole, but > 6 mm (see Fig. 5).

Fig. 4: Mechanical fastening



Industrial screw taps may be used for thread-cutting in Makrolon[®]. There is a risk of cracking due to the notching effect. We advise only opting for this type of fastening if no other form – e.g. bonding, clamping or screwing through a clearance hole – is possible. Cutting oil may not under any circumstances be used on Makrolon[®].

Distance a: $2 \times \varnothing$ drilled hole, but > 6 mm

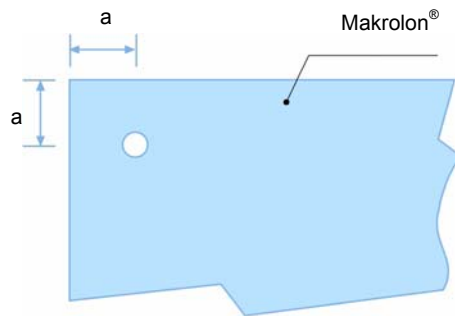


Fig. 5: Mechanical fastening

Metal threaded inserts can be sunk into Makrolon[®] and fastened using ultrasonic welding. Protective plates for machinery may also be clamped into rubber profiles made from EPDM. Thin sheets may also be nailed, tacked or riveted, though these forms of fastening should only be used in exceptional cases.

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6. Finishing

Grinding

Makrolon[®] sheets can be ground either dry or wet using industrial abrasives to prepare for polishing. The contact pressure between the grinding tool and the work piece should be kept low to avoid melting.

When grinding it is recommended that you use different grits in succession (e.g. in the sequence 150, 240 and 400).

Polishing

Medium-density riding polishing wheels with a peripheral velocity of 20 to 30 m/s can be used to polish Makrolon[®] sheets with alkali free polishing pastes.

A clean polishing wheel without polishing paste is then used to complete the polishing process.

Large-surface polishing should be avoided.

Decorating

Before treating Makrolon[®] sheets – e.g. by coating, screen printing or thermoforming – we recommend removing any loose particles of dirt or dust adhering to the surface using ionized air (see Section 7 on Cleaning).

The **low surface adhesion of Makrolon[®] AR** sheets makes decorating very difficult. The **matt side of Makrolon[®] NR is not suitable** for printing.

Coating and printing

Once cleaned, Makrolon[®] may be coated and printed without any other pre-treatment.

Care should be taken to ensure that the coatings and printing inks are chemically compatible with Makrolon[®]. Otherwise, the properties of Makrolon[®] may be impaired. Various manufacturers can provide suitable ink systems. The manufacturer's instructions should be followed at all times.

Hot embossing

Makrolon[®] sheets may be heat embossed with embossing film.

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7. Cleaning

Makrolon® has a pore-free surface to which it is difficult for dirt to adhere. Dusty parts can be wiped with water, a soft cloth or a sponge but should **never be rubbed when dry!**

For thorough cleaning, we recommend a non-abrasive detergent. Razor blades or other sharp tools, abrasive or strongly alkaline detergents, solvents, leaded benzene and carbon tetrachloride should not be used.

The only way to achieve effective cleaning without streaks is to use a microfiber cloth that is simply dampened with water. In the case of a greater build-up of dirt or greasy stains in particular, benzene-free pure petroleum spirit (cleaner's naphtha or light gasoline) may be applied.

Splashes of dye, grease or residual sealing putting etc. may be removed using a soft cloth soaked in ethyl alcohol, isopropyl alcohol or petroleum ether (boiling point 65 °C) and gentle rubbing prior to curing. Rust marks can be removed with a 10 % solution of oxalic acid.

Mechanical systems involving e.g. rotating bristles, strippers etc. are not suitable for use with Makrolon® – even if generous quantities of water are added to the brushes, the sheet surface may become scratched, with the exception of Makrolon® AR.

It may be possible to remove or disguise smallish scratches that are not too deep using hot air polishing. This does not apply, however, to Makrolon® AR.

Makrolon® has good electrical insulation properties resulting in electrostatic charging and the attraction of dust particles.

Before treating Makrolon® sheets we recommend removing any loose particles of dirt or dust on the surface by blowing with ionized air. The particles cannot be removed using a normal compressed air gun or a cloth but will generally just be moved around

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