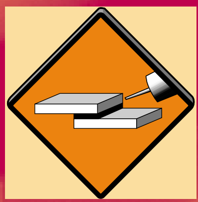
Quadrant Engineering Plastic Products

global leader in engineering plastics for machining

ADHESIVE BONDING INSTRUCTIONS

QUADRANT
ENGINEERING PLASTIC PRODUCTS

Adhesive Bonding Instructions

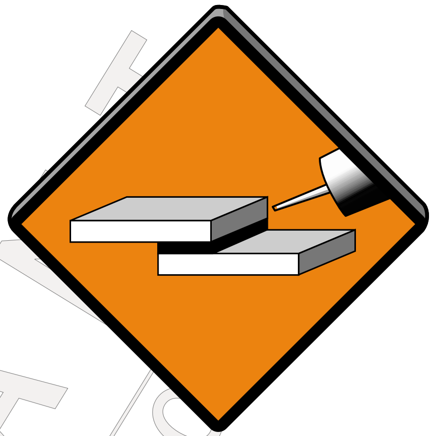


TABLE OF CONTENTS

Page

Introduction

This brochure aims to assist in the correct use of adhesives in combination with **Quadrant Engineering Plastic Products**' materials. This includes not only the selection and application of the right adhesive type, but also a correct design of the joint and an appropriate surface preparation.

Within the portfolio of Quadrant Engineering Plastic Products, we distinguish:

General Engineering Plastics

ERTALON® / NYLATRON®	**Polyamide**	**PA 6, PA 66, PA 4.6**
ERTACETAL®	**Polyacetal**	**POM-C, POM-H**
ERTALYTE®	**Polyethylene terephtalate**	**PET**
PC 1000	**Polycarbonate**	**PC**
CESTILENE / CESTICOLOR		
CESTIDUR® / CESTILITE	**Polyethylene**	**PE-(U)HMW**
CESTITECH		

Advanced Engineering Plastics

CELAZOLE® PBI	**Polybenzimidazole**	**PBI**
TORLON® PAI (4203, 4503, 4301, 4501, 5530)	**Polyamide-imide**	**PAI**
KETRON® PEEK (PEEK-1000, PEEK-HPV, PEEK-GF30, PEEK-CA30)	**Polyetheretherketone**	**PEEK**
TECHTRON® HPV PPS	**Polyphenylene sulphide**	**PPS**
PPS 1000	**Polyphenylsulphone**	**PPSU**
PEI 1000	**Polyetherimide**	**PEI**
PSU 1000	**Polysulphone**	**PSU**
SYMALIT® PVDF 1000	**Polyvinylidene fluoride**	**PVDF**

How to make the best use of this brochure?

1. Read chapter 1 about advantages and disadvantages of adhesives and weigh these against those of other joining methods.

2. If it turns out that adhesive bonding is the most suitable joining technique for your application, use the design tips from chapter 2 to arrive at the best geometry for the bonded joint.

3. Refer to chapter 3 for the correct preparation of the surfaces to be bonded and ensure that this operation is carried out before attempting to perform bonding itself.

4. In chapter 5, select a suitable adhesive for your application. In order to make a good choice, it is necessary to read thoroughly the description and properties of the adhesive types being considered (chapter 4).

5. When an adhesive has been selected, make a few prototype bonds and test the bonded component for performance, preferably in the intended application. If this test is satisfactory, production can be undertaken. If the bond fails, repeat the test with other adhesives or with variants of the first adhesive until a satisfactory product is found.

6. Attention must be paid to the safety precautions summarised in chapter 6. Always follow the directions for use and safety instructions given by the manufacturer.

7. If you have difficulty in selecting the right adhesive for your application, Quadrant Engineering Plastic Products will be pleased to render assistance.

IMPORTANT

Never hesitate to ask adhesive suppliers or manufacturers for advice about your application. Never start bonding on a large scale before doing a practical test.

1. Advantages and disadvantages of adhesive bonding

As with every joining method, adhesive bonding has a number of advantages and disadvantages.

The enumeration below contains the most important ones.

ADVANTAGES	DISADVANTAGES
the bond is continuous which results in a more uniform distribution of stresses over the bonded area (local concentrations of stresses are avoided).	the strength of the joint is often low in comparison with other joining techniques.
most adhesives have good mechanical damping properties (sound and vibration damping).	adhesives perform badly under peel and cleavage stresses.
in most cases the assembly can take place at relatively low temperatures.	full strength is attained only after a curing period.
the joint is gas and waterproof and as such forms a reliable seal.	certain chemicals may affect the adhesives.
materials of completely different nature can be joined.	this method of joining is not suitable for joints subject to alternate loading.
adhesive bonding reduces the weight of the whole construction.	it is often difficult to separate the bonded components in a non-destructive way.
in comparison with other joining techniques, adhesive bonding is a rather simple method.	precautions must be taken to avoid health hazards by solvents and other chemicals.

2. The correct design of bonded joints

Bonded joints can be subject to tensile, compressive, shear, peel or cleavage forces, often in combination.

Adhesives are strongest in shear and compression, but perform relatively poorly under peel and cleavage loading (see fig. 1 to 5). Consequently, bonded joints need to be designed so as to minimise or avoid cleavage or peel forces.

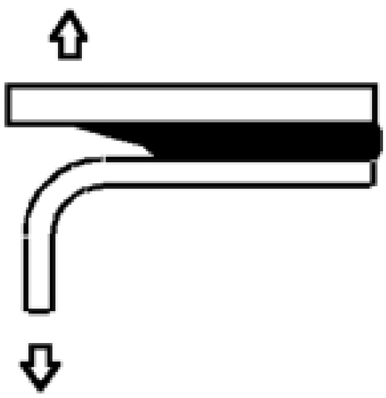


Fig. 1 : peel

(at least 1 component is flexible)

AVOID

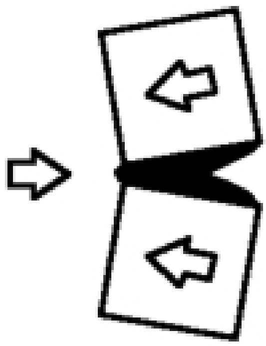


Fig. 2 : cleavage

(2 rigid components)

AVOID

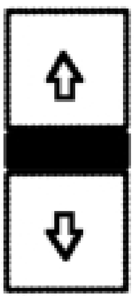


Fig. 3 : tension

FAIR

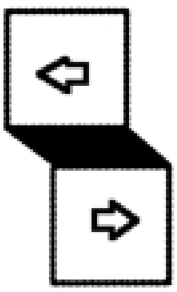


Fig. 4 : shear

GOOD

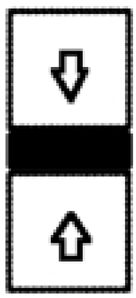
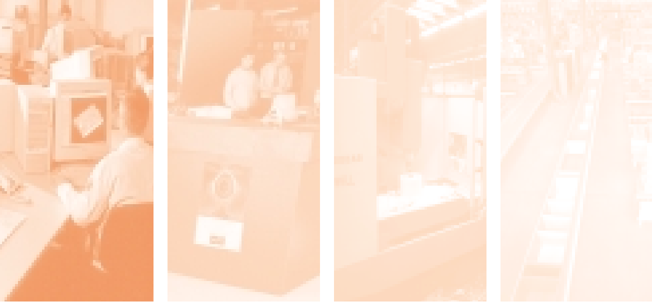
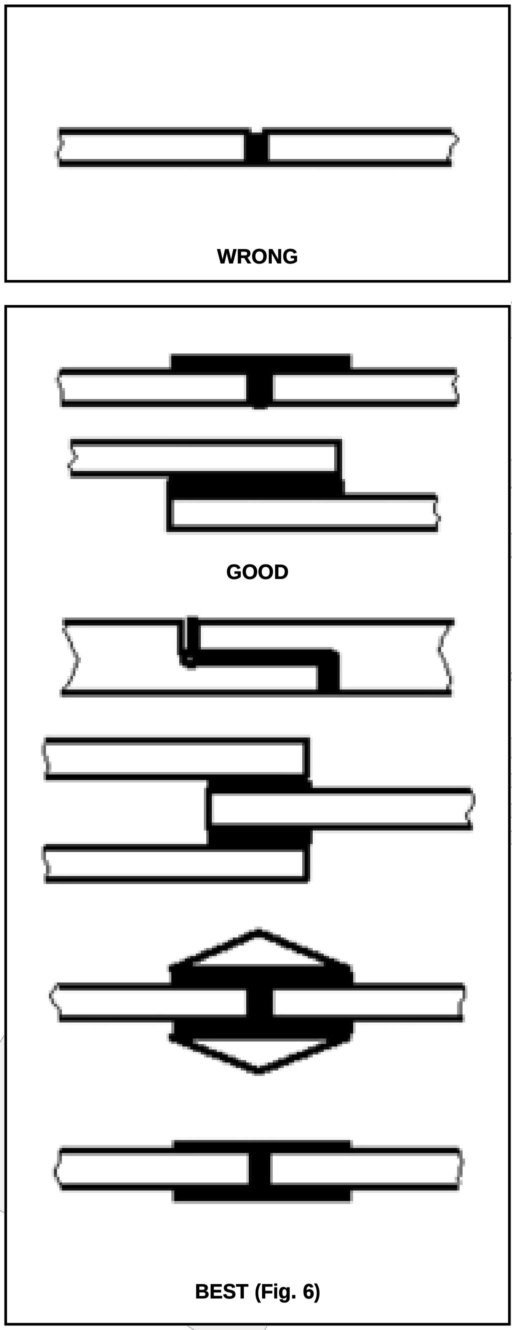


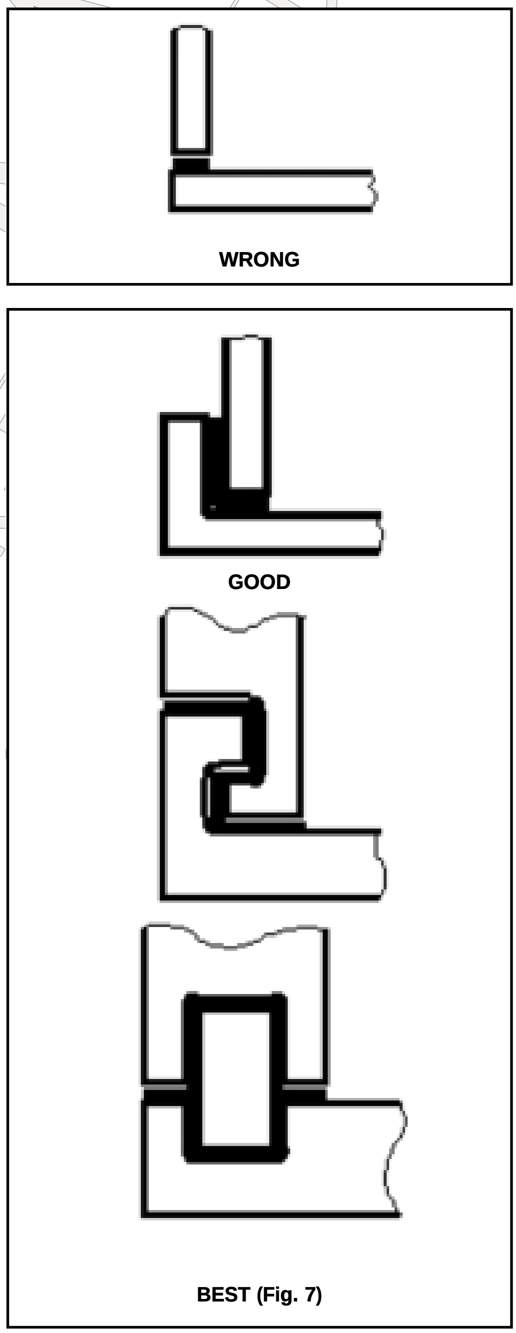
Fig. 5 : compression

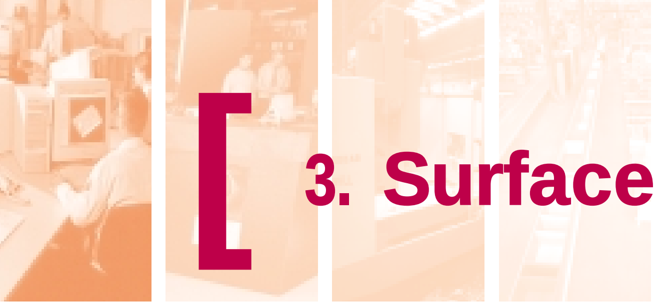
BEST



Figures 6 and 7 show how two common types of joints can be designed in the "wrong" way (subject to destructive cleavage forces), and how they can be re-designed, with dramatic improvements in performance







3. Surface preparation

The strength of a bonded joint is determined by:

- the cohesion of the cured adhesive
- the adhesion between adhesive and surfaces to be bonded

The cohesive forces depend on the type of adhesive used. The adhesive forces are influenced by electrostatic and chemical effects and depend as such largely upon the surface preparation.

A good adhesion can only be achieved by an appropriate preparation of the surfaces to be bonded. Bad or no preparation results in a weaker bonded joint and may even lead to failure. It is good practice to start bonding as soon as possible after completion of the surface preparation.

Surfaces are prepared by one of the following pre-treatment procedures (listed in order of increasing effectiveness as to the strength of the bonded joint):

1. **Clean and degrease**; dirt, grease and paint obstruct a good adhesion.
2. **Clean, degrease and abrade mechanically**; mechanical abrasion increases and activates the contact surfaces of the parts to be bonded.
3. **Clean, degrease and pre-treat chemically**; chemical etching considerably improves the affinity of the surfaces to be bonded for the adhesive. Apart from chemical etching, surface activation by a flame-, an electrical (corona discharge) or a plasma pre-treatment is also possible.

Depending on the nature of the materials to be bonded and the requirements of the bonded joint, a pre-treatment consisting of cleaning and degreasing, followed by abrasion with emery paper, may often be sufficient (see 3.1.1).

For maximum bond performance, a chemical-, thermal, electrical or plasma pre-treatment has to be applied.

If solvent cementing is possible (see p. 4.1), chemical etching is redundant. Then, cleaning, degreasing and abrasion with medium-grit emery paper are sufficient.

Recommended procedures for surface preparation of Quadrant Engineering Plastic Products' materials and of a few other common materials are described in detail below.

Note : When using chemicals, one must proceed with caution. Safety measures are given in chapter 6.

3.1. General Engineering Plastics

3.1.1. ERTALON / NYLATRON AND ERTALYTE

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Abrade with medium-grit (80-150) emery paper.
- Degrease again carefully and remove loose particles with a clean soft brush.

3.1.2. ERTACETAL

Method I:

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Abrade with medium-grit (80-150) emery paper.
- Degrease again carefully and remove loose particles with a clean soft brush.

Method II

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Immerse for 5 minutes at room temperature in the following solution:

- water	330 pbw
- concentrated sulphuric acid* (density 1,84 g/cm^3)	184 pbw
- potassium or sodium dichromate*	2 pbw

(pbw = parts by weight)

or etch for 5 to 20 seconds in phosphoric acid* (85%) at 50°C.

- Wash with clean cold running water followed by clean hot running water.
- Dry with hot air.

Method III

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Immerse for 10 to 20 seconds in the following solution at 90-100°C :

- perchloroethylene*	96 pbw
- dioxane*	3,7 pbw
- p-toluene-sulfonic acid*	0,3 pbw

(pbw = parts by weight)

- Place for 30-60 seconds in a 100-120°C hot oven.
- Immediately after removing from the oven, rinse with clean, hot (about 60°C) running water.
- Dry with hot air.

3.1.3. PC 1000

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner* (pay attention for stress-cracking).
- Abrade with medium-grit (80-150) emery paper.
- Degrease again carefully and remove loose particles with a clean soft brush.

3.1.4. CESTILENE / CESTICOLOR / CESTIDUR / CESTILITE

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Etch the surface for 15 minutes at room temperature in a chromo-sulphuric acid bath with the following composition:

- water	20 pbw
- concentrated sulphuric acid* (density 1,84 g/cm^3)	184 pbw
- potassium or sodium dichromate*	3 pbw

(pbw = parts by weight)

- Wash with clean cold running water followed by clean hot running water.
- Dry with hot air.

* see chapter 6.

[3.2. Advanced Engineering Plastics

3.2.1. CELAZOLE PBI, TORLON PAI, KETRON PEEK AND TECHTRON HPV PPS

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Abrade with medium-grit (80-150) emery paper.
- Degrease again carefully and remove loose particles with a clean soft brush.

3.2.2. PPSU 1000, PEI 1000 AND PSU 1000

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner* (pay attention for stress-cracking).
- Abrade with medium-grit (80-150) emery paper.
- Degrease again carefully and remove loose particles with a clean soft brush.

3.2.3. SYMALIT PVDF 1000

Being a fluoropolymer with a very good chemical resistance, SYMALIT PVDF 1000 is very hard to bond (weak joints) to any other materials than itself. Whereas only pre-treating the bonding surface mechanically (Method I) will give poor bond strength, better results will be obtained by chemical etching of the PVDF bonding surface (Method II).

Method I

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Abrade with medium-grit (80-150) emery paper.
- Degrease again carefully and remove loose particles with a clean soft brush.

* see chapter 6.

Method II

- Clean and degrease the bonding surface with isopropyl alcohol*
- Pre-treat the PVDF bonding surface with Acton FluoroEtch or Gore Tetra-Etch. For information on the use of these products:

Acton Technologies, Inc.
100 Thompson Street
P.O. Box 726
Pittston, Pennsylvania 18640
1-717-654-0612

W.L. Gore & Associates, Inc.
1505 North Fourth Street
P.O. Box 3000
Flagstaff, Arizona 86003-3000
1-800-344-3644

3.3. Other commonly used materials

3.3.1. METALS [ALUMINIUM (ALLOYS), COPPER (ALLOYS), STEEL, CAST IRON...]

- Clean and degrease the bonding surface with isopropyl alcohol* or any other suitable and effective 'ozone-depleting-chemical-free' cleaner*.
- Grit-blast or abrade the surface with medium-grit (80-150) emery paper or a steel wire brush.
- Degrease again carefully and remove loose particles with a clean soft brush.
- Bond the surfaces as soon as possible now as to prevent surface corrosion.

The adhesion to the plastics surface being the weakest link of the plastics-metal joint, the preparation procedure indicated above for the metal surface is the most satisfactory. However, if a better bond performance of the adhesive to the metal surface is required, this can be obtained by chemical etching of the latter.

3.3.2. WOOD

- Wood with a moisture content of over 20% should be oven-dried before bonding.
- Remove contaminated material mechanically.
- Remove loose particles and dust from the surface with a clean brush.

3.3.3. CONCRETE, STONE AND CERAMICS

- Remove all dust and dirt from the surface. If contaminated with oil or grease, scrub the surface with a detergent solution, followed by rinsing with clean running water.
- Grit-blast or abrade the surface with emery paper or a steel wire brush.
- Remove all loose particles and dust from the surface with a clean brush. Ensure the surface is completely dry before applying the adhesive.

* see chapter 6.

4. The different adhesive types

We distinguish solvent cementing and adhesive bonding:

4.1. Solvent cementing

Solvent cementing can only be used for bonding identical or similar thermoplastics. The solvent is applied to the bonding surfaces, after which the parts are assembled and firmly clamped together. After diffusion of the solvent out of the bond, one gets a very strong bond (usually stronger than with adhesive bonding).

The quantity of solvent applied greatly influences the strength of the bond: the use of too little solvent leads to a weak bond; if the solvent layer is too thick, however, it can take days before the solvent is diffused out of the bond and local material degradation can occur.

4.2. Adhesive bonding

Plenty of one or two part adhesives are commercially available. The choice of the right adhesive depends on the materials to be bonded and the operating conditions.
Below follows a summary of the most important adhesives for plastics and their principal properties.

4.2.1. EPOXY ADHESIVES

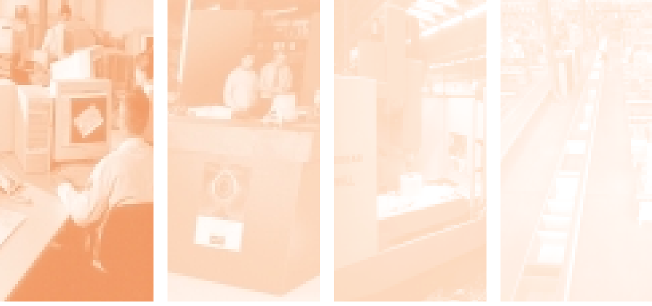
Description and properties
Epoxy adhesives are thermosetting resins.
Two-part resin/hardener systems cure after mixing (curing can mostly be accelerated by heating). In single-part epoxies these two components are already mixed and simply require heating to cure.
Bonding amorphous thermoplastics (PC, PPSU, PEI, PSU) with two-component epoxy adhesives containing amines can cause stress-cracking ; conduct a compatibility test and/or get advice from the adhesive supplier.

Compared with other adhesives, epoxies yield joints with high shear strength and excellent creep properties. Peel and impact strength, however, are relatively low, which can be improved by use of the so-called "toughened" adhesives. These contain a finely dispersed rubber phase, which prevents crack propagation.

Epoxy adhesives are well known for their versatility of application.
Operating temperature range:
- two-component adhesives: -50 to +80°C
- one-component adhesives: -50 to +120°C
(there are now also types available, which can be used up to 200°C)

Method of use
The manufacturer's directions for use should be observed. Weighing and mixing of the two components needs to be done very carefully.
The mix is applied to one of the bonding surfaces. The parts are then assembled immediately and clamped together until sufficient handling strength is achieved. The curing time is generally long, but can usually be shortened by applying heat. The temperature resistance of the plastics to be bonded must obviously be born in mind.

Precautions *(see also chapter 6.)*
Epoxy-resins are relatively hazard free, unless swallowed. It's recommended to avoid contact with the skin and to provide proper ventilation of the workshop.



4.2.2. POLYURETHANE ADHESIVES

Description and properties

These are usually two-component adhesives, one of which is isocyanate-based.

Polyurethane adhesives with low viscosity are available but health hazards are associated with their low-molecular-weight reactants. Consequently, one preferably works with the higher viscous grades.

After mixing at room temperature both components react rapidly and a polymer is formed. These adhesives give strong, resilient bonds and can be used for the bonding of a wide range of materials. They have a high impact strength and an excellent resistance to peel forces. They have general utility but their high viscosity and rate of cure can be limiting.

They can not be used in hot, wet environments.

Operating temperature range: -50 to +80°C

Method of use

The manufacturer's specific directions for each adhesive should be followed.

The working environment should be as dry as possible since atmospheric moisture reacts readily with the isocyanate resin, in this way disturbing the curing process.

Precautions *(see also chapter 6.)*

Very high standards of hygiene are required because the isocyanate is physiologically active. This should be backed up by detailed attention to ventilation of the workshop and the alertness of the staff.

4.2.3. SOLVENT-BORNE RUBBER ADHESIVES (CONTACT ADHESIVES)

Description and properties

These are based on natural and synthetic rubber solutions ranging from relatively low viscous solutions to high viscous pastes and semi-solids. They cure at room temperature by evaporation and/or absorption of the solvent.

These adhesives are very simple to use and can be applied to nearly all materials which are not attacked by the solvent.

Bonding amorphous thermoplastics (PC, PPSU, PEI, PSU) with solvent-borne rubber adhesives can cause stress-cracking ; conduct a compatibility test and/or get advice from the adhesive supplier.

Solvent-borne rubber adhesives are eminently suitable in those cases where flexibility is required, the load is light and the operating environment is not too demanding.

The high viscosity and stringy nature make some variants difficult to use in fine work.

Heat-curing variants (vulcanised versions) usually result in high load-bearing joints. Their suitability for bonding thermoplastics depends on the curing temperature.

Operating temperature range: -30 to +80°C

Method of use

As with all adhesives the manufacturer's directions for use should be followed strictly.

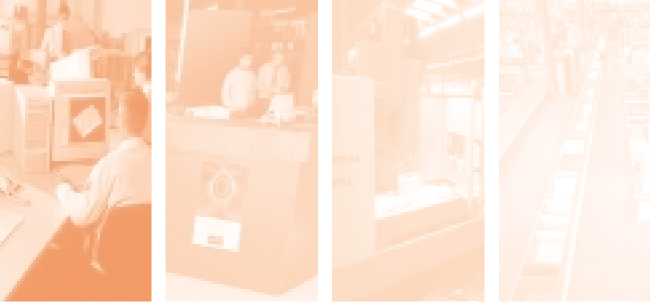
After application of the adhesive an "open time" is needed for the necessary solvent loss prior to joint closure. Components must be designed to allow precise placement because instantaneous "grab" is displayed by many formulations, not allowing post-repositioning of the components. Adequate means of pressing the parts together after initial contact must often be available. In the simple, evaporating variants, assembling either too soon or too late, is the major hazard, because too much or too little solvent does not allow adhesion to occur.

Precautions *(see also chapter 6.)*

The physiological activity of the solvents and the vapours and fumes released during evaporation/ vulcanisation must be recognised. Good ventilation of the workshop is essential.

Contact of the adhesive with skin or eyes must be avoided.

These adhesives cause few problems, however, when used sensibly.



4.2.4. CYANOACRYLATE ADHESIVES

Description and properties

Cyanoacrylates are relatively low viscous fluids based on acrylic monomers. They cure very rapidly upon contact with minute traces of surface moisture. When placed between closely fitting surfaces, some will cure to give a strong joint in two to three seconds. Full strength is attained after 5 to 20 hours.

Because of the rapid cure rate, cyanoacrylates can only be used to bond relatively small surfaces. They produce bonds with high shear strength, but mostly these can't sustain peeling forces and shock loads.

These adhesives will bond almost all materials except polyolefin plastics (e.g. PE), fluoropolymers (e.g. PTFE and PVDF) and silicone-based rubbers. However, recently developed primers, to be used in conjunction with cyanoacrylates, have shown that even these "difficult" plastics can be bonded successfully.

Bonding amorphous thermoplastics (PC, PPSU, PEI, PSU) with cyanoacrylate adhesives can cause stress-cracking: conduct a compatibility test and/or get advice from the adhesive supplier.

Operating temperature range: -50 to +100°C
(with allyl-based cyanoacrylates, operating temperatures up to 250°C are possible)

Method of use

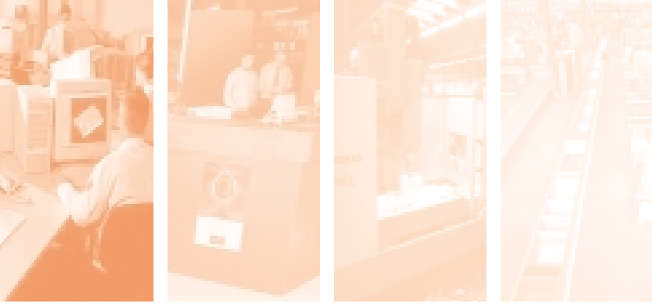
The manufacturer's directions for use should be followed. Normally the adhesive is applied directly from the bottle in a thin layer on one of the bonding surfaces. The two parts are then immediately assembled (precise placement!) and held together by contact pressure. Handling strength is achieved in seconds, but it is recommended to wait another 24 hours before loading the joint.

Too high or too low a percentage of moisture in the environment, or too thick an adhesive layer, may cause weak bonds or can prevent curing altogether. The same occurs when acid residues are left on the surface, e.g. after degreasing with chlorinated solvents such as 1,1,1-trichloroethane, trichlorotrifluoroethane (not recommended anymore because of their high ozone depleting potential). If bonding with cyanoacrylate adhesives, prior degreasing should be done with isopropyl alcohol.

Precautions *(see also chapter 6.)*

Cyanoacrylate adhesives bond skin very readily and rapidly, presenting a real hazard, which must be anticipated. Several cyanoacrylates have irritant vapours (nose and eyes) which must be extracted under constant use.

The family of cyanoacrylate adhesives as a whole is not considered as toxic.



4.2.5. TOUGHENED ACRYLIC ADHESIVES

Description and properties

This group of adhesives, based on a variety of acrylic monomers, incorporate low molecular weight rubbers that build in a very good resistance to impact and peel forces. They are two-component adhesives (resin + hardener) with viscosities ranging from very low to very high.

The toughened acrylic adhesives are suitable for bonding nearly all materials with the exception of the polyolefine plastics, the fluoropolymers and several rubber-based materials.

The bonded joint is very robust and will cope with demanding environments. Some versions of these adhesives induce stress-cracking in amorphous thermoplastics (PC, PPSU, PEI, PSU) ; conduct a compatibility test and/or consult the adhesive supplier.

Operating temperature range: -50 to +120°C

Method of use

Directions for use can differ greatly depending on the type of adhesive. In most types a thin layer of hardener (initiator) is applied to one surface and a layer of resin to the other, after which they are assembled. For some types, the components should be pre-mixed.

Although all these adhesives are intended to cure at room temperature, some of them may be heated in order to speed up the process. Depending on the type of adhesive used, it takes minutes to hours before the bond may be handled.

Precautions *(see also chapter 6.)*

Although not hazardous, all products in the group should be considered to be physiologically active to some degree and appropriate precautions taken. Vapour extraction should be used where the more volatile versions are in continuous use.

4.2.6. HOT MELT ADHESIVES

Description and properties

Hot melts are a refinement of the first known adhesive: molten wax. They are available in a variety of forms: tapes, films, rods, powders, pellets and also liquids. Many synthetic thermoplastic polymers can be used as hot melt adhesive.

These adhesives melt on heating and solidify on cooling. They harden quickly but cannot sustain high loads and usually have a poor temperature resistance.

Hot melts will even bond the difficult polyolefins. However, they are unsuitable for most rubbers. The generally high melt-viscosities make close work on small objects difficult.

Operating temperature range: -20 to +60°C (there are now also types available, which can be used up to 180°C).

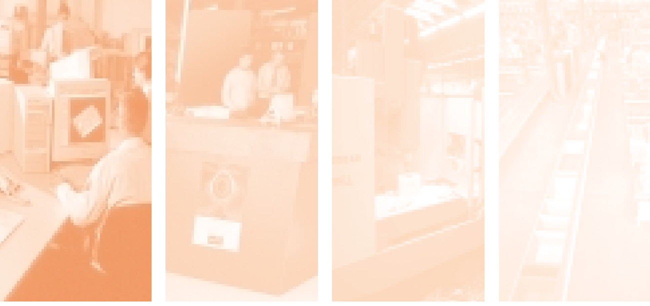
Method of use

Mostly the adhesive is supplied in form of cartridges and applied by means of an electrically heated gun. This is an easy, fast and economical way for applying hot melts.

Precautions *(see also chapter 6.)*

Because of the high temperature of the molten adhesive, the major problem is the possibility of severe burns.

According to the application and the type of adhesive used, precautions vary considerably; ranging from gloves, glasses and good ventilation to complex metering and dispensing equipment coupled to fume and vapour extracting facilities.



4.2.7. ANAEROBIC ADHESIVES

Description and properties

As distinct from the adhesives mentioned above, most anaerobic adhesives are not really structural adhesives but are better known as "sealants" or "locking compounds".

These one-component adhesives, based on the acrylic polyester resins, cure in absence of air and in the presence of metal. It is sufficient for only one of the bonding parts to be metal.

They are especially suited to bond closely fitting parts (small clearances) and are mainly used for:

- retention of co-axial components, e.g. bushings, bearings...
- thread-locking (bolts, nuts...),
- pipe-sealing and gasketing.

Normally, the joints may be handled between ten and thirty minutes after assembly, with full strength after 6 to 24 hours. The curing process can be accelerated considerably by the use of a supplementary catalyst (surface primer) or heat.

Anaerobic adhesives are available in a wide range of viscosities (function of application and gap to be filled) and strengths (permanent or dismantable joints).

Operating temperature range: -50 to +150°C

Precautions *(see also chapter 6.)*

No major toxicity problems have been associated with this family of materials. Their general physiological activity can be considered to be very low. However, by extra long or repeated contact with skin some people can suffer from dermatitis.

5. Suitable adhesives for Quadrant Engineering Plastic Products' Materials

This chapter indicates which adhesive types are considered suitable for bonding Quadrant Engineering Plastic Products' materials. The best choice does not depend only on the nature of the materials to be bonded. A number of other factors also come into consideration, such as:

- desired flexibility of the joint ; e.g. if two materials with considerably different coefficient of expansion are bonded and afterwards subject to a strongly varying operating temperature
- environmental conditions: temperature, humidity, contact with chemicals
- size and kind of load:
  - co-axial parts : anaerobic adhesives
  - joints subject to compression or shear:
    - solvent-borne rubber adhesives or hot melts for lightly loaded parts
    - cyanoacrylate, toughened acrylic, polyurethane or epoxy adhesives for heavier loaded parts
  - joints subject to tension, peel or cleavage: toughened acrylic adhesives or toughened epoxy adhesives
- size of the gap between the mating parts: large gaps require high viscous liquids, small gaps low viscous ones
- adhesive colour
- user friendliness: one-component adhesives are easier in use than two-component ones. The presence of hazardous elements, if any, requires special measures of precaution.
- curing time: adhesives, which cure rapidly, require an instantaneous precise assembly of the bonding.

5.1. General Engineering Plastics

5.1.1. ERTALON / NYLATRON

• ERTALON / NYLATRON to ERTALON / NYLATRON

Here solvent cementing is possible. As solvent for the extruded products (ERTALON 6SA, ERTALON 66SA, NYLATRON GS and ERTALON 4.6) formmic acid is used; for cast nylon (ERTALON 6PLA, ERTALON 6XAU+, NYLATRON MC 901 and NYLATRON GSM) an aqueous phenol solution (12% water) or a resorcinol/ethanol-solution (1:1 ratio) should be used.

Formic acid*

Apply a solvent layer to both surfaces. After 15 to 20 minutes, a second layer is applied, after which the bonding parts are immediately clamped together under a pressure of about 0.2 N/mm^2, pressure to be maintained for 10 hours. Full strength is attained after 2 to 3 days.

Aqueous phenol solution* (12% water)

Immediately after application of the solvent to both surfaces, while the surfaces are still wet, clamp the mating parts together under a pressure of at least 0.2 N/mm^2. Higher pressures may be used but the improvement is negligible.
After clamping the surfaces together, submerge the joint in boiling water. The curing time varies depending on the wall thickness: about 2 minutes per mm thickness. If done properly, no phenol odour will be detected when the joint is removed from the water.
Air curing at room temperature is possible, but this requires considerably more time. Full strength is then only attained after about 4 days.

Resorcinol/ethanol-solution* (1:1 ratio)

Apply a solvent layer to both surfaces. After 15 to 20 minutes a second layer is applied followed by immediate clamping of the bonding parts under a pressure of about 0.2 N/mm^2. This pressure should be maintained for 10 hours. Full strength is attained after 2 to 3 days.
Contact of the solvents with skin or eyes and inhalation of the vapours must be avoided. Rubber gloves, safety glasses and a well-ventilated workshop are necessary safety precautions.

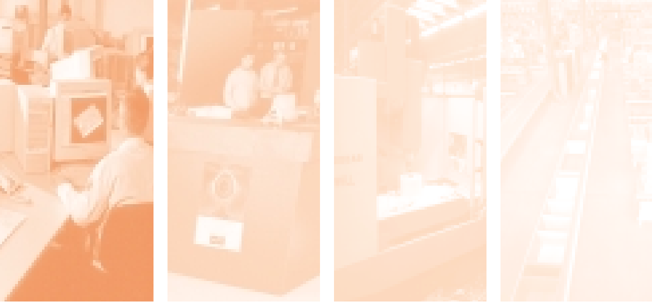
Remark: addition of 5 parts by weight of ERTALON / NYLATRON (e.g. chips) to the solvents mentioned above increases the viscosity and facilitates application.

• ERTALON / NYLATRON to OTHER MATERIALS

The following adhesives are to be considered:
- two-component epoxy adhesives
- two-component polyurethane adhesives
- solvent-borne rubber adhesives
- cyanoacrylate adhesives
- toughened acrylic adhesives
- hot melts

These adhesives may also be used to bond ERTALON / NYLATRON to ERTALON / NYLATRON, yielding, weaker bonds than achievable using solvent cements.

* see chapter 6.



5.1.2. ERTACETAL

• ERTACETAL to ERTACETAL

With the solvent “hexafluoroacetonesesquihydrate"*, solvent cementing ERTACETAL is possible. The bonded joint is stronger than when bonded with the usual adhesives and does not weaken with time.

This low viscous fluid requires closely fitting and very flat mating surfaces. Apply the solvent to both surfaces and clamp them together while still wet. Maximum bond strength is attained after a few hours.
Hexafluoroacetonesesquihydrate is toxic and consequently the necessary precautions should be taken (see directions for use from the supplier). It is a very expensive product, so use it economically.

• ERTACETAL to OTHER MATERIALS

The following adhesives, preferably after a thorough chemical surface pre-treatment (see 3.1.2.), are to be considered:
- two-component epoxy adhesives
- two-component polyurethane adhesives
- solvent-borne rubber adhesives
- cyanoacrylate adhesives
- toughened acrylic adhesives
- hot melts

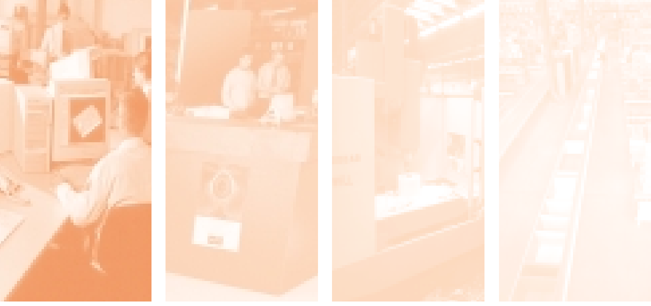
Bonding ERTACETAL to ERTACETAL with these adhesives is also possible.

5.1.3. ERTALYTE

Solvent cementing is not possible because of the excellent resistance of ERTALYTE to solvents.
The following adhesives are to be considered:

- two-component epoxy adhesives
- two-component polyurethane adhesives
- solvent-borne rubber adhesives
- cyanoacrylate adhesives
- toughened acrylic adhesives
- hot melts

* see chapter 6.



5.1.4. PC 1000

• PC 1000 to PC 1000

This can be done by solvent cementing. The most common solvent is methylene chloride*, which is not, however, suitable for bonding large areas due to its fast rate of evaporation. By adding up to 8 per cent polycarbonate (e.g. chips), one obtains a solvent solution with a reduced evaporation rate giving the supplementary advantage that the mating surfaces must not fit as closely as they have to using the pure solvent.

Apply a thin layer of solvent (excess solvent will result in poor bonds) to one of the surfaces and quickly assemble the two parts. As soon as they are assembled, the parts should be clamped together for a couple of minutes under an even pressure of about 1 N/mm^2 to ensure good interface contact.

Bonded parts may be handled safely after the initial holding time, although maximum bond strength is only attained after about 2 days at room temperature.

• PC 1000 to OTHER MATERIALS

The following adhesives are to be considered:
- two-component epoxy adhesives (preferably without amines)
- two-component polyurethane adhesives
- solvent-borne rubber adhesives (not all versions are suitable)
- cyanoacrylate adhesives (not all versions are suitable)
- toughened acrylic adhesives (not all versions are suitable)
- hot melts
- silicone adhesive sealants without amines

PC 1000 can also be bonded to itself with these adhesives but they produce a weaker bond in comparison with solvent cementing.

5.1.5. CESTILENE / CESTICOLOR / CESTIDUR / CESTILITE / CESTITECH

Solvent cementing of these materials is not possible.
Polyolefin plastics, such as PE-HD and PP, are extremely difficult to bond (weak joints) and if possible other joining methods should be applied.

If adhesive bonding remains the only joining method possible, one of the following adhesives can be used after a thorough surface pre-treatment (see chapter 3.1.4.):
- two-component epoxy adhesives
- two-component polyurethane adhesives
- solvent-borne rubber adhesives
- cyanoacrylate adhesives in conjunction with special primers
- hot melts

* see chapter 6.

5.2. Advanced Engineering Plastics

These engineering plastics find their application especially at high temperatures (150-300°C). When designing bonded joints for these materials one should first look for an adhesive which is compatible with the operating temperature of the particular application. At temperatures above 220°C, most adhesives decompose with exception of a few polyimide-based ones. Silicone adhesive sealants, although not to be regarded upon as structural adhesives, are suitable as well because of their high temperature resistance (up to 200°C). They result in bonds with low shear strength but with high flexibility.

5.2.1. CELAZOLE PBI, TORLON PAI, KETRON PEEK AND TECHTRON HPV PPS

The following adhesives are to be considered:
- epoxy adhesives
- solvent-borne rubber adhesives
- toughened acrylic adhesives
- silicone adhesive sealants
- two-component polyurethane adhesives
- cyanoacrylate adhesives
- hot melts

5.2.2. PPSU 1000, PEI 1000 AND PSU 1000

• PPSU to PPSU – PEI to PEI – PSU to PSU – PPSU to PEI – PPSU to PSU – PEI to PSU

Bonding can be done by solvent cementing using methylene chloride* to which 1 to 5% PPSU, PEI or PSU is added, as solvent.

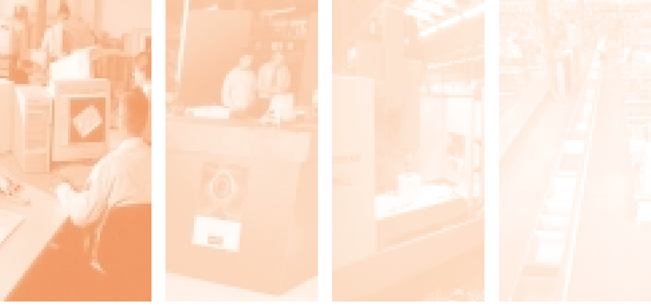
Apply a thin layer of solvent (excess solvent will result in poor bonds) to one of the surfaces and quickly assemble the two parts. As soon as they are assembled, the parts should be clamped together for a couple of minutes under an even pressure of about 1 N/mm^2 to ensure good interface contact.
Bonded parts may be handled safely after the initial holding time, although maximum bond strength is only attained after about 2 days at room temperature.

• PPSU 1000, PEI 1000 or PSU 1000 to other materials

The following adhesives are to be considered:
- epoxy adhesives (preferably without amines)
- two-component polyurethane adhesives
- solvent-borne rubber adhesives (not all versions are suitable)
- cyanoacrylate adhesives (not all versions are suitable)
- toughened acrylic adhesives (not all versions are suitable)
- hot melts
- silicone adhesive sealants without amines

These adhesives can also be used to bond PPSU 1000, PEI 1000 and PSU 1000 to each other.

* see chapter 6.



5.2.3. SYMALIT PVDF 1000

• SYMALIT PVDF 1000 to SYMALIT PVDF 1000

Bonding can be done by solvent cementing. Suitable solvents are dimethylformamide* and dimethylacetamide* to which up to 15% of PVDF-chips are added.

Apply a thin layer of solvent (excess solvent will result in poor bonds) to one of the surfaces and quickly assemble the two parts. As soon as they are assembled, the parts should be clamped together for a couple of minutes under an even pressure of about 1 N/mm² to ensure good interface contact.

Bonded parts may be handled safely after the initial holding time, although maximum bond strength is only attained after about 2 days at room temperature. However, the strength of the bond will never reach the level of a welded bond.

• SYMALIT PVDF 1000 to other materials

As mentioned on page 9, SYMALIT PVDF 1000 is very hard to bond to other materials. If required, the following adhesives are to be considered:

- two-component epoxy adhesives
- two-component polyurethane adhesives
- solvent-borne rubber adhesives
- cyanoacrylate adhesives in conjunction with special primers
- hot melts.

* see chapter 6.

6. Safety regulations

Plenty of chemicals, to be used for surface pre-treatment or solvent cementing, are mentioned in this guide for adhesive bonding of Quadrant Engineering Plastic Products' materials: dimethylacetamide, dimethylformamide, dioxane, ethanol (ethyl alcohol), formic acid, hexafluoroacetonesesquihydrate, isopropyl alcohol (isopropanol), methylene chloride, perchloroethylene (tetrachloroethylene), phenol, phosphoric acid, potassium dichromate, p-toluene-sulfonic acid, resorcinol, sodium dichromate, sulphuric acid, 1,1,1-trichloroethane, trichlorotrifluoroethane.

Always be cautious when using chemicals. All chemicals are more or less toxic: inhalation, swallowing and contact with skin or eyes must thus be avoided. Therefore, provide good ventilation and/or an exhaust system in the work area and wear protective clothing, gloves and safety glasses or face shield. When using do not eat, drink or smoke.
Open fire or smoking is prohibited when using flammable products since their vapours combined with air may form potentially explosive mixtures.
When working with acids, add acid to water and never vice versa!

Prior to working with chemicals, carefully read their "chemical cards" and "material safety data sheets" and observe the given directions.

Where adhesives are used, the usual safety regulations must be taken in consideration, together with the specific directions for safe use given by the adhesive manufacturer (ask for the material safety data sheet).

7. Adhesive manufacturers

Based on the information given above, we recommend you to consult adhesive suppliers and/or manufacturers in your country or area for assistance in selecting the most appropriate adhesive for your specific application, the method of use to apply and any safety regulations to be observed.

Important adhesive manufacturers such as BOSTIK, CIBA, DEGUSSA, GENERAL ELECTRIC Sealants and Adhesives, HENKEL, PERMABOND and 3M are present and/or have agents practically all over the world and will be pleased to help you selecting a suitable adhesive from their extensive portfolio's (search the World Wide Web for their websites and gain plenty of up to date information on their adhesives, sites and agents, etc.). It goes without saying that this enumeration of manufacturer names is not restrictive and that adhesives of other, non-listed, producers may suit perfectly as well.

Please note that a practical test under real operating conditions is always the best way to assess the ultimate suitability of a selected adhesive for your application.

Global quality standard • Global production and logistics • Global technical support

Quadrant Engineering Plastic Products

www.quadrantepp.com

Regional Headquarters

ASIA-PACIFIC

108 Tai To Tsuen, Ping Shan
YUEN LONG - N.T. Hong Kong
Tel +852 (0) 24702683
Fax +852 (0) 24789966
epp.asia@qplas.com

EUROPE

I.P. Noord - R. Tavernierlaan 2
8700 TIELT - Belgium
Tel +32 (0) 51 42 35 11
Fax +32 (0) 51 42 33 00
epp.europe@qplas.com

NORTH AMERICA

2120 Fairmont Avenue
PO Box 14235 - READING, PA 19612-4235
Tel (800) 366 0300 / +1 610 320 6600
Fax (800) 366 0301 / +1 610 320 6868
epp.americas@qplas.com

Quadrant Engineering Plastic Products Companies Worldwide

BELGIUM
I.P. Noord - R. Tavernierlaan 2
8700 TIELT
Tel +32 (0) 51 42 35 11
Fax +32 (0) 51 42 33 00

I.P. Noord - Szamotulystraat 14
8700 TIELT
Tel. +32 (0) 51 42 32 24
Fax +32 (0) 51 42 33 40

CANADA
495 Laird Road
GUELPH, Ontario - N1G 3M1
Tel (800) 567 7659 / +1 519 837 1500
Fax (800) 265 7329 / +1 519 837 3770

FRANCE
ZAC de Satolas Green
69330 PUSIGNAN
Tel +33 (0) 4 72 93 18 00
Fax +33 (0) 4 72 93 18 96

Z.I. Front de Bandière
BP 26
01360 BALAN
Tel. +33 (0) 4 72 25 17 87
Fax +33 (0) 4 72 25 91 35

GERMANY
Koblenzerstraße 38
56112 LAHNSTEIN
Tel +49 (0) 2621 6990
Fax +49 (0) 2621 69933

Am Leitzelbach 11
74889 SINSHEIM
Tel + 49 (0) 7261 15 50
Fax + 49 (0) 7261 15 51 55

HONG KONG
108 Tai To Tsuen, Ping Shan
YUEN LONG,
N.T. Hong Kong
Tel +852 (0) 2 470 26 83
Fax +852 (0) 2 478 99 66

HUNGARY
Sikert str 2-4
1108 BUDAPEST
Tel +36 (0) 1 264 4206
Fax +36 (0) 1 262 0145

INDIA
B 166 Yojnavihar,
DELHI 92
Tel +91 (0) 11 214 49 17
Fax +91 (0) 11 216 45 41

ITALY
Via Trento 39,
20017 Passirana di Rho,
MILANO
Tel +39 02 93 26 131
Fax +39 02 93 50 8451

JAPAN
5-2, Marunouchi 2-chome
Chiyoda-K,
TOKYO 100
Tel +81 (0) 33 2834 267
Fax +81 (0) 33 2834 087

KOREA
97 Samjung-Dong
Ohjung-Ku, BUCHEON-CITY
Tel +82 (0) 32 673 9901
Fax +82 (0) 32 673 6322

MEXICO
Apartado Postal 13
52000 Lerma,
EDO DE MÉXICO
Tel +52 (728) 753 10
Fax +52 (728) 753 17

POLAND
Ul. Dziegielowa 7
61-680 POZNAN
Tel +48 (0) 61 822 70 49 / 825 70 45
Fax +48 (0) 61 820 57 51

SOUTH AFRICA
25 Nickel Street, Technicon
P.O. Box 63
ROODEPOORT 1725
Tel +27 (0) 11 760-3100
Fax +27 (0) 11 763-2811

THE NETHERLANDS
Anthony Fokkerweg 2
7602 PK ALMELO
Tel +31 (0) 546 877 777
Fax +31 (0) 546 860 796

UNITED KINGDOM
83 Bridge Road East
WELWYN GARDEN CITY
Hertfordshire AL7 1LA
Tel +44 (0) 1707 361 833
Fax +44 (0) 1707 361 838

U.S.A.
2120 Fairmont Avenue - PO Box 14235
READING, PA 19612-4235
Tel (800) 366 0300 / +1 610 320 6600
Fax (800) 366 0301 / +1 610 320 6868

QUADRANT
ENGINEERING PLASTIC PRODUCTS