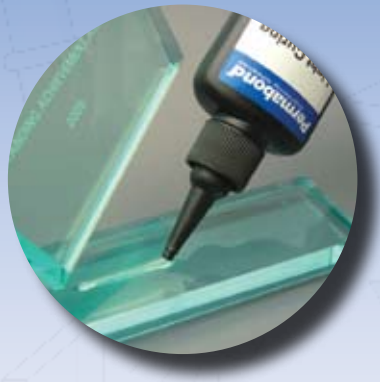
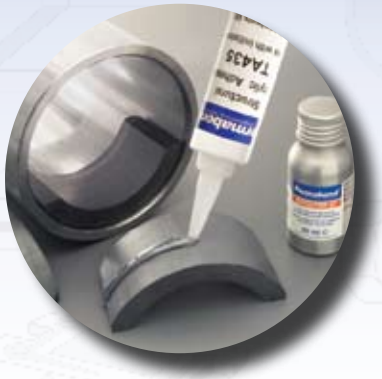
Engineers' Guide to Adhesives





Permabond®
Engineering Adhesives

The information given and the recommendations made in this booklet are based on our experience and are believed to be accurate. No guarantee as to, or responsibility for, their accuracy can be given or accepted, however, and no statement herein is to be treated as a representation or warranty. In every case we urge and recommend that purchasers, before using any product, make their own tests to determine, to their own satisfaction, its suitability for their particular purposes under their own operating conditions.

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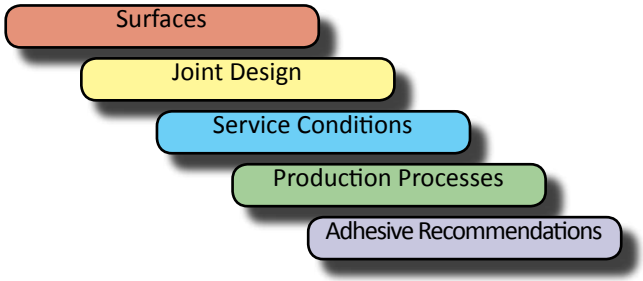
Adhesive Selection

Selecting the most appropriate adhesive for an engineering application requires consideration of a number of factors:



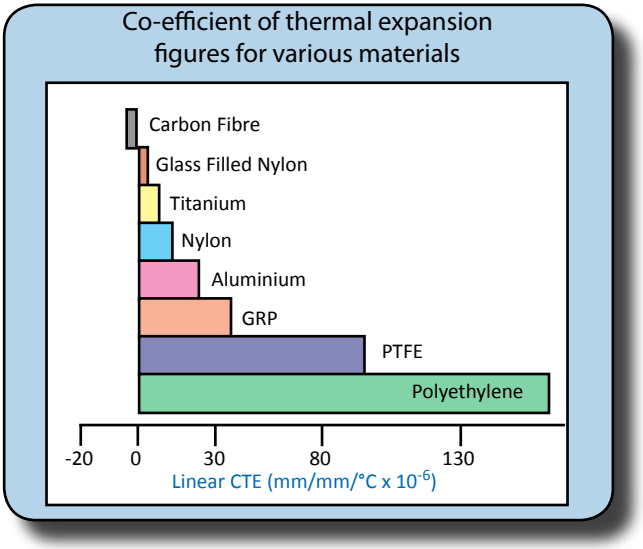
Surfaces:

- Can the substrate(s) be bonded?
- Which adhesive works best on the substrate?
- What are the surface preparation requirements?
- Reactivity of the substrate affects adhesive cure-speed.

Table below shows how **anaerobic adhesive** cure is affected by surface reactivity:

Super Active (Very fast cure)	**Active (Fast cure)**	**Inactive (Slow cure)**	**Passive (Activator required)**
Brass Copper Magnesium	Steel Nickel Iron Aluminium Zinc	Anodized aluminium Cadmium finishes Chrome finishes Passivated metals Stainless steel Titanium	Ceramics Glass Plastics Painted finishes Lacquered finishes

Bonding dissimilar materials together requires special consideration, particularly in an environment subject to temperature change. This is because differential thermal expansion and contraction between materials can induce stress into the substrates and into the joint. For this reason slightly flexible, toughened adhesives can be better than rigid methods of fixture - such as mechanical fastenings.



Joint Design (see also next section):

There are three basic joint types; co-axial, lap and butt joints. Anaerobic adhesives are usually most suitable for co-axial type joints (where one part slots into another). Whether or not the joint needs to be dissembled will determine the strength of adhesive to use. Lap joints can be bonded easily with cyanoacrylate.

Gap fill and adhesive viscosity:

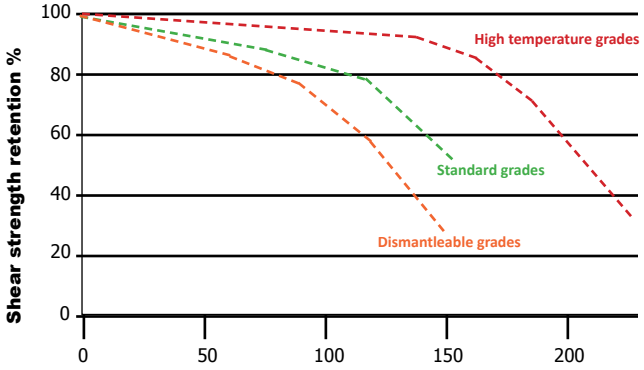
Viscosity of adhesive and gap fill capability are closely related - the higher the adhesive viscosity, the larger the gap filling capability.
To help "get a feel" for viscosity measurements, the list below shows everyday substances and their approximate viscosity:

Substance	Viscosity (mPa.s)
Water	1
Milk	3
SAE 10 Motor oil	85-140
SAE 20 Motor oil	140-420
SAE 30 Motor oil	420-650
SAE 40 Motor oil	650-900
Castor oil	1,000

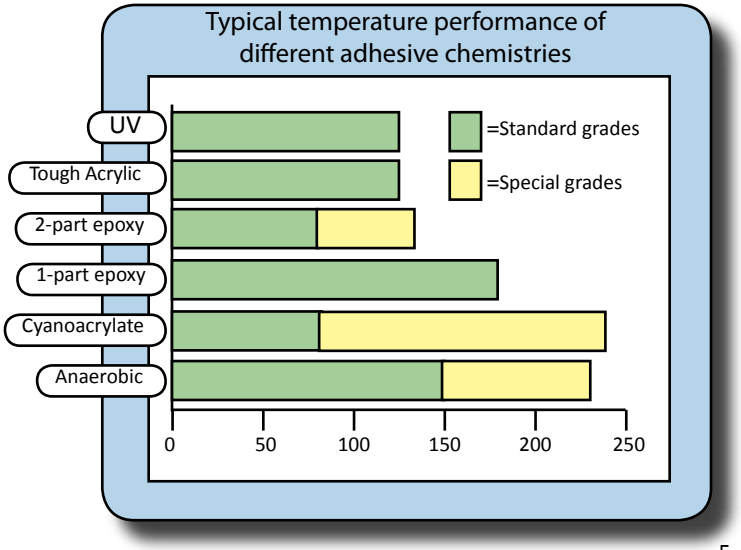
Substance	Viscosity (mPa.s)
Maple syrup	5,000
Honey	10,000
Choc. syrup	25,000
Ketchup	50,000
Mustard	70,000
Sour cream	100,000
Peanut butter	250,000

Service conditions:

Chemical exposure can affect adhesives (a detailed compatibility table is provided in this booklet, see page 10). It is important to consider not only the type of chemical the adhesive will be exposed to, but the concentration and the temperature of that chemical, the loading of the joint and whether the joint design leaves adhesive vulnerable to attack. The temperature range the joint will be exposed to is an important factor in deciding which adhesive to use. Adhesive strength reduces as temperature increases, as demonstrated in the graph to the right. Provided adhesives are kept within their recommended temperature range, full strength should be regained upon returning to room temperature.



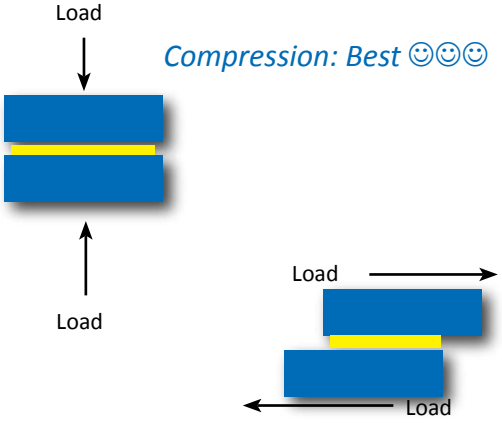
Above: Graph showing how temperature affects strength retention of Permabond anaerobic adhesives.



Joint Design

It is vital to consider joint configuration in the early stages of your product design to achieve maximum performance. Joints that have originally been designed to be welded may need to be redesigned to obtain optimum performance with adhesives. The engineer also needs to consider the loading of these joints and where the forces occur. The diagrams on these two pages explain which joints are good, which to avoid and some suggested alternative joint designs.

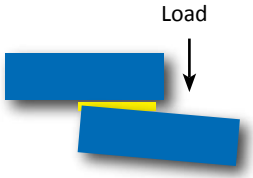
These are examples of good adhesive joint design.



Compression: Best ☺☺☺

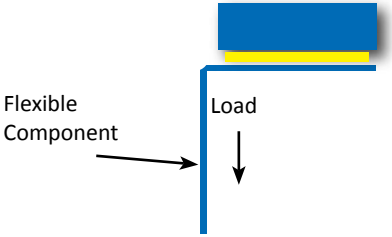
Shear: Good ☺☺

These are examples of bad adhesive joint design.



Cleavage: Bad ☹☹☹

Peel: Bad ☹☹☹

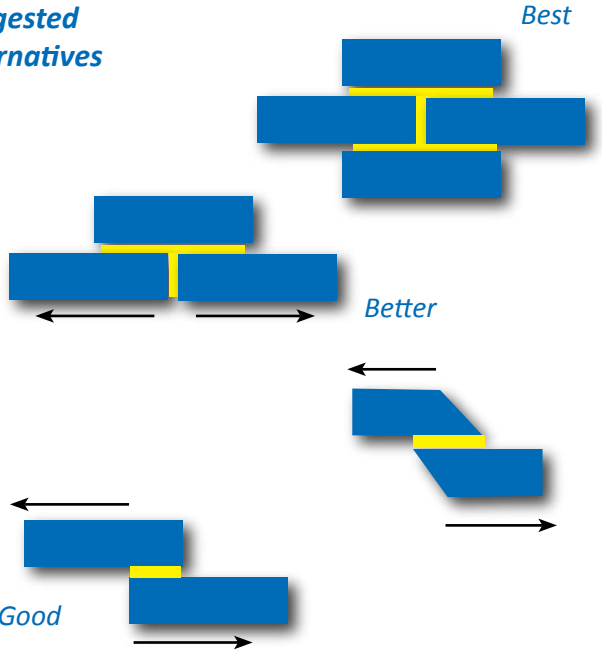


Handy Tip: If joint design cannot be modified, opt to use a toughened adhesive with high peel-strength.

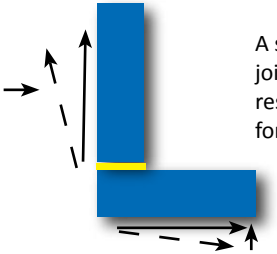
Straight Butt-Joint: Bad ☹☹☹

Problems occur because this type of joint is not very stable; a slightly off-centre force will cause a crack to propagate through the joint.

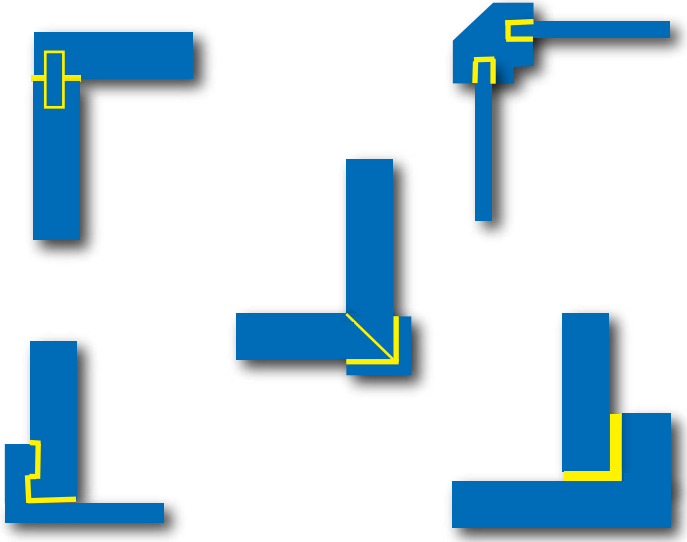
Suggested Alternatives



Corner Butt-Joint: Bad ☹☹☹



A similar problem can occur with a corner joint, if an indirect force is applied, it can result in the introduction of a cleavage force into the joint.



Surface Preparation

Most materials can be bonded without surface pre-treatment unless surfaces are grossly contaminated. To achieve maximum performance and repeatable results, it is advisable to carry out a certain level of surface preparation or use a particular adhesive.
Bold text in table= preferred choice.

Permabond CSA: This activator is for use with Permabond cyanoacrylates to accelerate cure rate, particularly on less active surfaces or where adhesive requires curing on the outside of a joint.
Permabond Polyolefin Primer (POP): Essential for priming hard to bond surfaces such as polypropylene, polyethylene, silicone and PTFE. Bond with Permabond cyanoacrylate adhesive.

Metal	Preparation	Anaerobic	Cyano	UV	Epoxy	Structural Acrylic
Aluminium	Abrade and degrease. Aluminium has a weak oxide layer which is best removed to achieve a high-strength bond.	**Yes**	Yes	Yes*	**Yes**	**Yes**
Brass	Abrade and degrease. Alternatively etch with ammonium persulphate (contact Permabond for further details).	**Yes**	Yes	Yes*	**Yes**	**Yes**
Cast Iron	Abrade and degrease. Remove all surface contamination, rust and loose particles.	**Yes**	Yes	Yes*	**Yes**	**Yes**
Copper	Abrade and degrease. Alternatively etch with ammonium persulphate (contact Permabond for further details).	**Yes**	Yes	Yes*	**Yes**	**Yes**
Mild Steel	Abrade and degrease.	**Yes**	Yes	Yes*	**Yes**	**Yes**
Stainless Steel	Abrade and degrease. No surface preparation may lead to a weak bond.	**Yes**	Yes	Yes*	**Yes**	**Yes**
Zinc	Degrease. If possible, etch with hydrochloric acid (contact Permabond for further details).	**Yes**	Yes	Yes*	**Yes**	**Yes**
Zintec	Degrease. Toughened, slightly flexible adhesives tend to work best on this surface.	Yes	Yes	Yes*	Yes	**Yes**

Methods:
Abrade and degrease: Abrade with Scotchbrite, wire wool or carborundum paper. Alternatively gritblast. Degrease with a solvent such as **Permabond Cleaner A**, acetone or isopropanol (which is particularly suited to more sensitive plastic materials).
Permabond A905: This is a surface activator for anaerobic adhesives, suitable for use on non-metallic surfaces or on less active metals to accelerate cure speed.

*UV curable adhesives can be used on most surfaces, although one substrate must be clear to allow UV light through to cure the adhesive.

For reactivity of metals (which affect anaerobic adhesive cure speed) see table on page 4, 'Adhesive Selection'. This will determine whether A905 should be used to attain desired cure speed.

Plastic/Rubber	Preparation	Anaerobic	Cyanoacrylate	UV	Epoxy	Structural Acrylic
ABS †	Can be bonded as received.	Yes (Use A905 first)	**Yes**	Yes*	Yes	**Yes**
Acetal †	Abrasion can help. Prime with Permabond POP primer if bonding with cyanoacrylate.	Yes (Use A905 first)	**Yes**	No	No	No
Acrylic †	Can be lightly abraded.	Yes (Use A905 first)	**Yes**	Yes*	Yes	Yes
EPDM	Bond as received.	No	**Use 105**	No	No	No
HDPE / LDPE / Polypropylene	Prime with Permabond POP primer and bond with cyanoacrylate. For other adhesives surface treat via flame, corona or plasma treatment equipment.	Flame treat & A905 first	Yes	Yes*	**Yes**	**Yes**
Nitrile Rubber	Bond as received.	No	Yes	No	No	No
Nylon® (polyamide)	Dry out at 60°C for several hours or overnight. Abrade surface. Can be difficult to bond if unfilled.	Yes (Use A905 first)	No	Yes*	Yes	Yes
Polycarbonate †	Bond as received	Yes (Use A905 first)	**Yes**	**Yes**	Yes	Yes
PVC	Bond as received	Yes (on UPVC) Use A905 first	**Yes**	No	No	No
Silicone	Prime with Permabond POP primer and bond with cyanoacrylate	No	**POP & 105**	No	No	No

Handy tip: Check a discreet area of plastic for compatibility with adhesives / cleaners as some are prone to stress cracking.

Material	Preparation	Anaerobic	Cyanoacrylate	UV	Epoxy	Structural Acrylic
Carbon Fibre	Light abrasion and degrease.	No	Yes	No	**Yes**	**Yes**
Ceramic	Degrease. Remove glaze by abrasion.	Yes (Use A905 first)	Durability could be poor	Yes*	**Yes**	**Yes**
Ferrite	Degrease with Permabond Cleaner A.	Yes (Use A905 first)	Yes	Yes*	**Yes**	**Yes**
Glass	Degrease with Permabond Cleaner A.	No	Durability could be poor	**Yes**	Yes	Yes
GRP	Abrade and degrease.	No	Yes (depending on gaps)	No	**Yes**	**Yes**

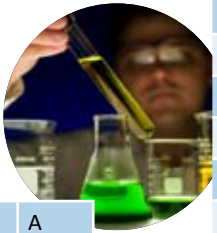
*One substrate must be clear for UV light to pass through. †Prone to stress cracking

Chemical Compatibility (Anaerobics)

Few industrial chemicals have a damaging effect on Permabond's anaerobic adhesives. However strong acids, alkalis or polar solvents in high concentrations (or if hot) could have some effect.

Code:

A: Most Permabond products are suitable
B: For concentrations up to 10% most adhesives can be used
C: Only use high-strength Permabond products
X: Not suitable for Permabond anaerobic adhesives.



Liquids:

Acetic acid	B
Acetone	A
Alcohols	A
Ammonia sol.	C
Animal fat	A
Battery acid	B
Bleach	A
Bromine	X
Carbolic acid	B
Carbonic acid	B
Cement	A
China Clay	A
Chromic acid	C
Citric acid	C
Copper sulphate	A

Creosote	A
Cyanide sol.	B
Detergents	A
Dielectric fluid*	A
Dye stuffs	A
Ethyl acetate	A
Ferric chloride	B
Fertilizer*	A
Formaldehyde	C
Glycerine	A
Gypsum	A
Hexane	A
Hydrochloric acid	C
Ink	A
Insecticide*	A

Isocyanate resin	A
Jet fuel	A
Kerosene	A
Lactic acid	A
Nitric acid	X
Oil (fuel)	A
Oil (hydraulic)	A
Oil (linseed)	A
Oil (lubricating)	A
Oil (mineral)	A
Ozone (wet)	X
Paraffin	A
Perfume	A
Petrol	A
Petroleum jelly	A
Photo developer*	A
Phosphoric acid	C
Sewage	A
Shellac	A
Sodium hydroxide	C
Starch	A
Sugar	A

Sulphuric acid	C
Sulphurus acid	C
Toluene	A
Trichloroethane	A
Turpentine	A
Water (fresh/sea)	A
Water (heavy)	A
Xylene	A

*Test first as some brands/types are more aggressive than others.

Gases:

Air	A
Carbon mon/dioxide	A
Chlorine	X
Freon	C
Helium	A
Methane	A
Natural gas	A
Pure oxygen	MH052
Ozone	X
Propane	A
Steam	X

Production Line Considerations

Substrate preparation on a high-speed production line

It is helpful to receive substrate components in a consistent condition with little variation in surface finish. We would recommend checking this regularly as sometimes component suppliers switch materials, cutting oils or release agents which could necessitate changes in surface preparation technique. For large batch production, components can be degreased via large-scale jet washes on a conveyor system. It is important that such systems are not overloaded and that parts can drain off to give a consistently clean/dry surface afterwards.

Grit blasters offer a quick and easy way to abrade metal surfaces to remove oxide layers. It is important to change grit regularly to keep it sharp and free from contamination.

Surface activators, such as the Permabond CSA (for cyanoacrylates) and A905 (for anaerobics), are available in bulk for batch dipping of components. This helps to ensure a clean, reactive surface for the corresponding adhesive to bond to.

Dispensing methods

For a rapid production line, high-speed dispensing systems can easily be introduced. These can range from semi-automatic (e.g. a system which delivers a metered dose to the component after a person triggers the dispensing valve via foot pedal), to fully automatic where minimal human intervention is required. Permabond offer adhesive products in bulk packaging to fit most dispensing equipment around the world.
Two-part adhesives require more consideration to ensure the metered dose of resin and hardener is correct and that mixing is adequate. Upon installation the equipment must be properly calibrated to ensure the correct mix ratio of adhesive is being dispensed.

Automation

For high-speed production lines conveyors, robotics and X-Y machines can greatly aid increased production rates. Adhesives can easily be incorporated into highly automated systems with minimal cost.

Clamping / jigging & cure speed

It is important bonded parts are not disturbed during the curing process, at least until they have reached handling strength. Otherwise components could end up wrongly aligned or could result in a lower bond strength. To keep clamping time to a minimum, choose one of Permabond's rapid curing adhesives to speed up production rates.

- UV-curables - cure in 1-2 seconds on exposure to high-intensity UV-light
- Cyanoacrylates - cure to handling strength in 1 - 30 seconds
- Structural acrylics - quick curing grades reach handling strength in 1-4 minutes
- Anaerobics - range from two minutes up 1 hour depending on substrates
- Two-part epoxies - can range from 5 minutes to several hours depending on grade
- Single-part heat-cure epoxies - dependent on cure temperature / heating method

Curing Equipment

Permabond UV adhesives have been developed to cure quickly and easily, even with low powered lamps. This makes it a lot easier for trialling adhesives or for small users to use UV-curables without having to invest in high-tech equipment. We recommend the use of professional UV-lamps where possible, particularly for regular production items and where consistent results are essential.

Single-part epoxies require heat input either by oven, infra-red lamp, hot air gun or induction heating. Two-part epoxy cure can also be accelerated by heating bonded parts.

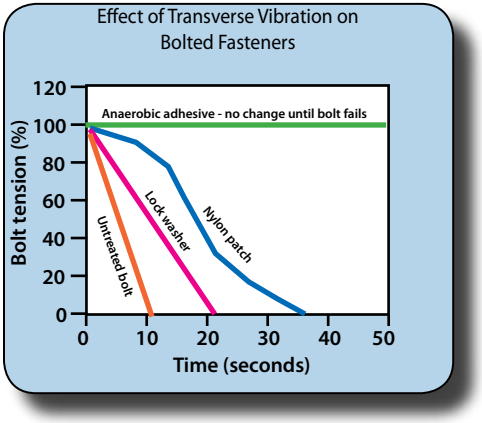
Thread Locking

Permabond threadlocking anaerobic adhesives enable you to lock screws, nuts, bolts and studs to protect against loosening caused by vibration.

Benefits

- Prevents nuts rusting on to bolts
- Permabond offer a range of strengths - low strength for large parts which may require future disassembly, medium strength and high strength permanent threadlockers to prevent theft and vandalism.
- More cost-effective than using mechanical fastenings
- Lubricates for easier assembly
- Machining tolerances can be increased
- Seals against leaks
- Stops nuts and bolts working loose through vibration

Handy Tip: For blind holes, apply the adhesive directly into the bottom of the hole, not the fastener. If there is a void then apply the adhesive to the thread inside the hole instead.



Thread Ø

Small
(Up to M20
3/4")

Large
(Up to M56 2")

Product	Feature	Max. Gap	Strength	Handling Time	Max. °C
A011	Very easy to undo when necessary.	0.12 mm	Low	10-25 mins	150°C
A1042	Rapid curing. Can be dismantled.	0.12 mm	Medium	5-10 mins	150°C
A130	Slower cure. Can be dismantled.	0.12 mm	Medium	10-25 mins	150°C
HM129	Cuts through surface grime on parts which may not be as clean as they should be!	0.15 mm	High	10-20 mins	150°C
HH131	Resistant to high temperatures.	0.3 mm	High	20-40 mins	230°C

For larger diameter threads, please call the Permabond technical helpline on 0800 975 9800

Other products...

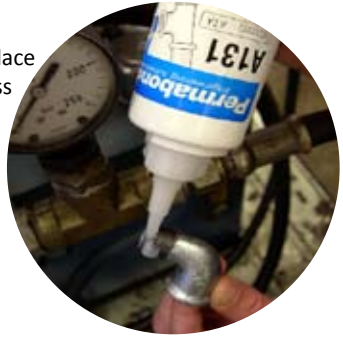
Permabond Cleaner A to remove oil, grease & dirt before adhesive application.
Permabond A905 surface activator to speed-up adhesive cure and for use on inactive surfaces.

Pipe Sealing

Permabond pipesealing anaerobic adhesives are designed to replace traditional thread sealing materials such as hemp, PTFE tape, Boss White® and Boss Green® (for potable water).

Benefits

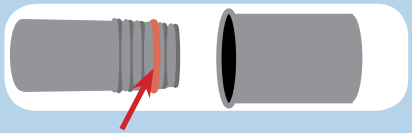
- No loose particles to clog valves
- Will not shred, creep or relax over time
- Easy to apply, allows accurate positioning of pipes and fittings
- Lubricates for easier assembly
- Seals to the burst pressure of the pipe when fully cured
- Suitable for water, gas, air and hydraulic systems
- Resistant to a wide variety of chemicals



Handy Tip: Pipe joints sealed with low-strength pipesealants can be dismantled using normal tools. Heating parts with a hot air gun or blow torch will help weaken adhesive and make parts easier to undo. Before re-using, clean pipe joints with a wire brush.

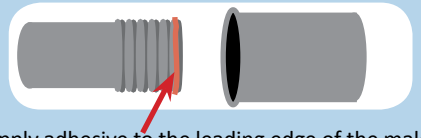
Correct assembly technique

- Taper to parallel pipe joints



Apply adhesive several threads back from the leading edge of the male component to ensure maximum contact.

- Parallel to parallel pipe joints (below)



Apply adhesive to the leading edge of the male component. EXCESS ADHESIVE SHOULD BE SEEN IN BOTH CASES AFTER TIGHTENING

Pipe Ø

Small
(Up to M56 2")

Large
(Up to M80 3")

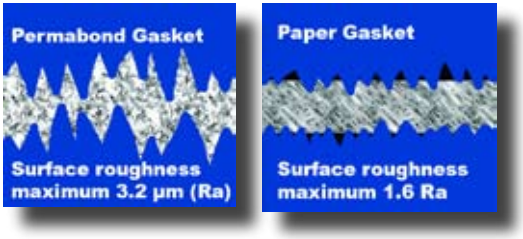
Product	Feature	Viscosity	Strength	Handling Time	Max. °C	Approvals
A131	Replaces PTFE, easy assembly	40,000 mPa.s	Low	30-60 mins	150°C	WRAS, KIWA, Australian Gas
A129	For coarse/uneven threads	65,000 mPa.s	Medium	10-25 mins	150°C	WRAS
MH052	Excellent chemical resistance, approved for use with oxygen	50,000 mPa.s	Medium	15-30 mins	150°C	WRAS, DVGW, BAM
A1044	Excellent chemical and pressure resistance	70,000 mPa.s	High	10-25 mins	150°C	WRAS

Other products...

Permabond Cleaner A to remove oil, grease & dirt before adhesive application.
Permabond A905 surface activator to speed-up adhesive cure and for use on inactive surfaces.

Gasket Making

Permabond gasketing anaerobic adhesives are designed to replace traditional cork, wood, rubber, paper and silicone gaskets.



Not only do liquid gasketing adhesives give 100% contact between metal parts, but they also allow the engineer to cut down the amount of surface-finish machining, therefore reducing costs and increasing production rate.

Benefits

- No relaxation or shrinkage so no need to retighten over time
- One adhesive will replace many pre-cut gasket shapes
- No need to handle fragile gaskets
- No disintegration so no leaks or blockages
- Vibration proof
- No long-term embrittlement
- Easy to dismantle with normal tools
- Less machining - surfaces need not be so smooth
- Non-shimming - (100% metal to metal contact - so better stress distribution).

50ml of adhesive will go how far?

Bead Diameter	Length of Bead	Glue line thickness (over 25mm width)
1.5mm ●	25m	0.075mm
3mm ⬤	6m	0.3mm

Flexibility

Highly flexible
(For softer metals or easy removal)

Toughened
(Ideal for dissimilar metals)

Rigid
(For high-temperature resistance)

Product	Feature	Max. Gap	Strength	Handling Time	Max. °C
LH197	Soft and 'rubbery'	0.3 mm	Low	20-40 mins	150°C
A136	General purpose	0.5 mm	Medium	30-60 mins	150°C
MH196	High temperature resistance, quick cure	0.5 mm	High	10-20 mins	200°C
MH199	High temperature resistance	0.5 mm	Medium	15-30 mins	200°C

Retaining

Retaining adhesives are for the permanent bonding of co-axial joints. Typical applications include:

- Bearings into housings
- Bushes
- Keyways and splines
- Gears
- Rotors
- Pulleys
- Cylinder linings

Benefits of using retaining adhesive include rapid, quick and easy assembly of parts. Tolerances can be relaxed, reducing machining times and eliminating the need for interference fits. Adhesive strength is usually higher than alternative methods of fixture. Adhesives have a better fatigue life as they prevent metal fretting (which can be an issue with interference fits).

Anaerobic adhesives have excellent dynamic performance partly due to their ability to fill air space between mating components. This ensures 100% contact between parts and a much improved stress distribution, improving both the static strength and dynamic performance. In contrast, force fits normally result in less than 25% surface contact. The graphs to the right of this page demonstrate these differences in static and dynamic joints.

Handy Tip: Apply adhesive to leading edges of both components and assemble with a rotating action. Take extra care to prevent adhesive entering mechanisms and bearing races!

Viscosity: Low → Thixotropic → Paste

Wicking

Product	Feature	Viscosity	Strength	Handling Time	Max. °C
A126	General purpose	30 mPa.s	High	10-25 mins	150°C
A1024	Lowest viscosity	7 mPa.s	Medium	10-25 mins	150°C
A1062	Can also be cured with UV-light	20 mPa.s	Low/ medium	10-25 mins	150°C

Product	Feature	Max. Gap	Strength	Handling Time	Max. °C
A118	General purpose	0.12 mm	High	10-25 mins	150°C
HM162	High-temperature and rapid cure	0.2 mm	Very high	2-5 mins	200°C
F201	Toughened, high impact resistance	0.2 mm	Very high	10-25 mins	100°C
A1046	Rapid curing, tough	0.25 mm	High	5-10 mins	150°C
HM165	High-temperature resistance	0.3 mm	Very high	20-40 mins	230°C
A134	General purpose	0.5 mm	High	10-25 mins	150°C
F202	Toughened, high impact resistance	0.5 mm	Very high	10-25 mins	100°C
HH167	Silver coloured metal repair paste	0.5 mm	High	15-30 mins	150°C

Handling time measured on steel at room temperature.

Instant Bonding - Cyanoacrylates

With just one drop of Permabond cyanoacrylate adhesive, it is possible to bond a wide variety of materials, including metal, plastic, rubber and wood in a matter of seconds. They cure by reacting with minute traces of surface moisture. They are single part so are easy and convenient to use and they cure at room temperature.

Product	Key Feature
101	Low, penetrating viscosity. Ideal for post-assembly application
102	General purpose, drinking water approved product
105	For hard-to-bond plastics and rubbers
240	High viscosity, delayed cure
731	Clear, highly flexible
737	Black, toughened, flexible and has excellent impact resistance
792	General purpose, rapid curing and very high-strength
910	Best performance on metals
920	High temperature resistance up to 250°C
943	Low odour and non-'blooming'; excellent aesthetic appearance
2011	High viscosity non-drip gel, ideal for larger gaps or vertical application
POP Primer	For priming polypropylene, polyethylene, silicone and PTFE before bonding with Permabond Cyanoacrylate
CSA	Surface activator for optional use with Permabond cyanoacrylate (accelerates cure and cures excess adhesive outside joints

Above is a small selection of the Permabond cyanoacrylate range.

Handy Tip: 'Less is more' - cyanoacrylates are very efficient so only small drops are required to obtain a high-strength bond.

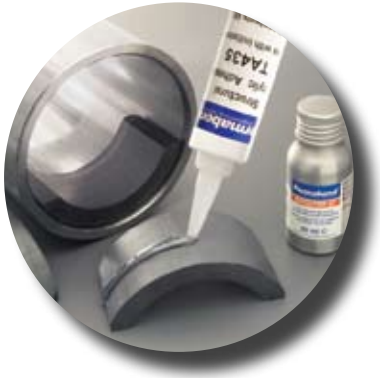
Typical applications include:

- Electronics wire tacking
- Bonding blue-tooth headsets
- Hose clips onto automotive tubes
- Bonding automotive interior trim
- Tacking parts during assembly process (temporarily)
- Joining silicone O-rings
- Disposable medical device bonding
- Bonding mobile phone casing, antennae and keypads
- Sealing batteries
- Glazing applications
- Sealing transformer laminates

Structural Adhesives - Acrylics

These are toughened, high-strength, two-part adhesives that cure rapidly at room temperature. They are ideal for bonding a wide variety of materials including metals, plastics, composites, glass and wood. Typical applications include:

- Motor magnet bonding
- Sign bonding (road / shop)
- Metal structures
- Bonding interior trim on trains, buses, cars and aircraft.



Permabond offers several types of structural acrylic adhesives:
No-mix adhesive & initiator: Initiator is applied to one of the bonding surfaces and the adhesive to the other. Suited to tight fitting parts, this system provides a long open time and a short cure time.
Bead on bead: A bead of resin is applied directly over a bead of hardener (approximately 1:1 ratio).
Single Part: Similar to anaerobic adhesives but with additional structural properties.
2-part pre-mix: mixed via static mixing nozzle.

Product	Key Feature
TA430	Resin & initiator. Suitable for very high-strength bonding of metals, plastic, ceramics and wood. Cures in 1 - 4 minutes.
TA435	Resin & initiator. Suitable for very high-strength bonding of metals, plastic, ceramics and thermoplastics. Cures in 1 - 4 minutes. Ideal where components could be subjected to thermal cycling.
TA436	Resin & initiator. Particularly suitable for magnet bonding (e.g. electric motors, loudspeakers).
TA437	Single part (initiator or accelerator can be used). Improved temperature resistance (to 200°C). Ideal for magnet bonding.
TA439	Methacrylic acid free structural adhesive for magnet bonding. Ideal for sealed electric motors. High temperature resistance.
TA440	Bead on bead. For rapid bonding of metal, ceramic, glass, wood and rigid plastics.
TA4246	No-mix resin and initiator for high strength bonding of metal, composites and plastics.
TA4300	2-part 1:1 rapid curing, gap filling, toughened. Ideal for structural bonding of aluminium and other metals, glass, composites and plastics.
TA4302	2-part 1:1 very rapid cure, can be applied bead-on-bead, or pre-mixed, multipurpose.
TA4310	2-part 1:1 mix ratio, longer handling time than TA4300, gap filling, toughened. Ideal for structural bonding of aluminium and other metals, glass, composites and plastics.

Structural Adhesives - 2-Part Epoxies

Two-part epoxies are well known for high performance, versatility and excellent environmental & chemical resistance. Permabond's epoxies have been designed to offer a variety of performance characteristics not normally associated with epoxies - such as additional toughness and high peel strength. They are suitable for the structural bonding of a wide variety of different materials and are available with a range of different room-temperature cure speeds (no oven required!).

Product	Key Feature
ET500	5-minute cure. Clear for a superb finished appearance
ET505	Toughened, high-peel strength, ideal for structural bonding applications
ET510	Fast-curing version of ET505
ET515	Clear, flexible product with excellent impact resistance and toughness
ET536	Toughened, gap filling / non-slump, grey
ET538	Toughened, gap filling / non-slump, long pot life
ET540	Improved temperature resistance and good gap fill capability

Benefits

- High peel strength increases joint design versitility
- Most are 1:1 mix ratio for easy mixing
- Excellent chemical and environmental durability
- No curing equipment required
- Will bond virtually anything and are not restricted by gap

Handy Tip: Permabond offer a low-cost 50ml dual cartridge adaptor which fits 300ml caulking guns (commonly used for sealants).

Structural Adhesives - 1-Part Epoxies

Single-part heat cure epoxies offer temperature resistance in excess of 180°C and will withstand have excellent chemical resistance as well as toughness.

Product	Key Feature
ES550	Metal-filled, high-viscosity, fast cure
ES558	Similar to ES550 but flows like solder when heated
ES562	Free flowing at curing temperature
ES566	Lower curing temperature
ES569	High-viscosity, non-slump black paste
ES578	Thermally conductive, electrically insulative

Benefits

- High peel strength increases joint design versitility
- Excellent chemical and environmental durability
- Will bond most materials
- A good alternative to welding or brazing
- Low temperature curing grade available for bonding heat vulnerable parts (such as certain plastics and electronic components)

UV-Curable Adhesives

Permabond UV-curable adhesives are single part, cure on demand adhesives suitable for bonding a wide variety of substrates. Upon exposure to UV light, Permabond UV curables will cure to a high strength in a matter of seconds. . Typical applications include:

- Bonding glass furniture
- Glass to metal structural bonding
- Acrylic display racks
- Lenses
- Solar panels
- Trophies and glass ornaments

UV-curable adhesives remain liquid until exposure to UV light, when the cure mechanism is activated and the liquid turns solid to form a high strength bond (either between materials or as a coating).
They are in many cases colourless and non-yellowing, offering a highly pleasing aesthetic appearance on bonded components. Permabond UV adhesives have been developed to offer a degree of flexibility and elongation to allow the bonding of dissimilar materials (such as metal to glass) where differential thermal expansion and contraction is an issue.

Product	Key Feature
UV610	Very high strength, ideal for bonding glass to metal e.g. furniture
UV620	Excellent clarity and resistance to yellowing, ideal for bonding glass artwork, crystal, furniture etc.
UV630	For bonding acrylic, Perspex, polycarbonate
UV640	Higher viscosity version of UV630
UV648	Plastic bonding gel, non-drip
UV670	Flexible, ideal for bonding metalised plastics and metal.
UV7141	Dual-cure, ideal for high strength bonding, will cure in shadow areas. Suitable for bonding ceramic coated glass, mirrors and metal.

Cure speed of UV-curable adhesives:
There are a number of factors which determine the cure speed of UV-curable adhesives (not just the reactivity of the adhesive itself):
-Intensity of UV-light and distance from the source
-Age of the UV bulb (UV output of bulbs reduces with age)
-Light transmittance of the materials being bonded (many plastics have UV-stabilisers which block UV rays).

Glossary

Activator (or accelerator) A substance which accelerates the cure rate of adhesive.

Adhesion Failure Failure of the adhesive to the substrate. No adhesive is left on the substrate. Improving surface preparation can help avoid this.

Ageing Adhesives can age from the effects of heat, chemical exposure and humidity. Accelerated ageing tests can be carried out in extreme environments for a quick indication as to the longevity of the adhesive.

Blooming A phenomenon associated with cyanoacrylate adhesives seen as a white powdery residue on substrate material.

Capillary Action Low viscosity adhesives will seep into narrow gaps which makes them suitable for post-assembly application.

Coefficient of Expansion A measure of the extent to which a material expands. Linear coefficient expansion units commonly used are mm/mm/°C x 10^{-6}. This is an important factor to bear in mind when bonding dissimilar materials in a temperature-changing environment.

Cohesive Failure Failure within the adhesive. On examination of failed parts, adhesive should be visible on both components.

Corona Treatment A method of surface preparation, mainly used for hard-to-bond plastics. High voltage discharge across substrate surfaces produces active electrons, helping raise the surface energy and 'wettability' to allow the material to be bonded.

Cyclic Ageing A harsh method of accelerated ageing, ideal for dissimilar materials. This usually involves heat ageing with cyclic temperatures so the effects of differential thermal expansion and contraction can be assessed.

Density The specific gravity of a material measured in g/cm³. Water is the benchmark at 1.0 (at 4°C).

Passive Surface An unreactive metal surface that is highly resistant to chemical attack. Zinc and chrome are good examples. Use of surface activator, A905 helps cure anaerobic adhesives.

Plasma Treatment A method of surface preparation, mainly used for hard-to-bond plastics. It is a mixture of electrons and positive ions in a gas which is passed over the substrate, helping raise the surface energy and 'wettability' to allow the material to be bonded.

Pot life The maximum amount of time adhesive can be used after it has been mixed (in a pot!) before it starts becoming semi-cured and too difficult to apply.

Primer A substance that improves the adhesion of adhesives to components and can help improve environmental resistance.

Refractive Index How much a beam of light alters its angle as it passes through a material. Glass is approximately 1.4 to 1.6.

Relative Humidity How saturated air is with moisture (maximum 100%). Low humidity (usually in cold environments) can affect cyanoacrylate cure.

Rheometry How a material flows, slumps etc.

Room Temperature 23±1°C (as specified by DIN/ISO). Viscosity and strength measurements are taken at this temperature.

Shadow Cure This relates to UV-curable adhesives, UVs that have a single UV- cure mechanism will not cure in areas not reached by UV light.

Shore Hardness A scale set up to asses the hardness of a material. Materials measured on the Shore A scale are soft elastomers, Shore D are tough, harder materials. The test is done with a spring-weighted pin that measures depth of penetration (units are 0-100 Sh, the higher the number, the harder the material).

Substrate Failure Failure of the substrate. This is observed as the adhesive joint remains in tact and the substrate either breaks or the surface of the substrate delaminates.

Differential Thermal Expansion & Contraction This occurs when dissimilar materials are bonded together. They are likely to have different coefficients of expansion. Using a toughened or flexible adhesive can help reduce stress on components.

Elongation How much a material 'stretches', usually measured as a percentage.

Fillet The meniscus of adhesive that can be seen on the outside of a joint. When cured, this can help increase strength and protect joints against chemical and moisture ingress.

Flame Treatment A method of surface preparation, mainly used for hard-to-bond plastics. Briefly exposing surfaces to a flame increases surface electron activity, helping raise the surface energy and 'wettability' to allow the material to be bonded.

Glass Transition Temperature (Tg) The temperature at which a normally rigid, brittle "glass-like" structure changes to a soft, elastic material. This can help determine operating temperature limits.

Handling Time / Speed the time at which adhesive has cured to a sufficient strength to allow unclamping and gentle handling of the part.

Inhibition The presence of a chemical that can cause incomplete cure of adhesive. This could be oxygen preventing full cure of an anaerobic adhesive or chemicals within a substrate which could interfere with adhesive cure.

Modulus of Elasticity Determines the point at which a material becomes deformed under tension.

Open Time The length of time freshly applied adhesive is optimal for bonding (after which strength could be compromised).

Outgassing The release of gaseous molecules from adhesive.

Oxidation This commonly occurs in metals such as aluminium and iron (seen as rust) where surface electrons are stolen. Removal of weak oxide layers prior to bonding is recommended.

Surface Tension / Surface Energy An example of a surface with low surface energy is a freshly polished car bonnet sprayed with water droplets. The water droplets stand proud. This is how hard-to bond materials such as polypropylene behave. Increasing surface energy makes the surface more 'wettable' and able to be bonded. Adhesives are developed to have as low a surface tension as possible to 'wet-out' on difficult surfaces.

Tensile Strength The strength of an adhesive joint pulled apart in tension.

Thixotropy The flow behaviour of an adhesive that causes the viscosity to reduce when stirred, mixed or dispensed but will then thicken upon standing (preventing slump and run-off).

Toughened Adhesives Can be rubber toughened to allow better flexibility, higher peel strength and better impact resistance. They are ideal for bonding dissimilar substrates where differential thermal expansion and contraction could be an issue.

Torque Strength Measurement of adhesive strength on threaded nuts and bolts. Breakout, prevailing and maximum strength can be measured to assess the 'lockability' of the adhesive. Units are usually Newton-metres (Nm) or in/lb.

Viscosity Measurement of how much a flowable substance flows. This can be measured with a spindle spinning to measure resistance, on an electronic rheometer or with a 'U' tube measuring time taken for material to flow from A to B.

Wettability / Wetting out If a substrate is 'wettable' it will allow liquid (such as adhesive) to be spread across it without droplets bunching up. If droplets do bunch up then the material could be difficult to bond and surface pretreatment may be required.

Working Time / Strength The time at which a newly bonded joint can be put into operation. The joint will have developed approximately 60% of its final strength so can be subjected to normal loading.

Conversion Tables

Weight

1 kilogram (kg)	= 1000 grams (g)
	= 2.2 pounds (lbs)
1 pound (lb)	= 16 ounces (oz)
	= 453.6 grams (g)
1 ounce (oz)	= 28.35 grams (g)
1 gram (g)	= 1,000 milligrams (mg)

Length

1 metre (m)	= 100 centimetres (cm)
	= 1000 millimetres (mm)
	= 3.28 feet
	= 39.37 inches
	= 3.28 feet
	= 39.37 inches
1 inch	= 2.54 centimetres (cm)
	= 25.4 millimetres (mm)
	= 1000 mils
1 centimetre (cm)	= 0.39 inches
	= 10 millimetres (mm)
1 millimetre (mm)	= 1,000 microns (µm)
1 mil (thou)	= 40 microns

Volume

1 US gallon	= 8 US pints
	= 3.79 litres
	= 4 US quarts
	= 0.83 UK gallons
1 Imperial gallon	= 8 UK pints
	= 4.55 litres
	= 4 UK quarts
	= 1.2 US gallons
1 litre	= 1000 millilitres (ml)
	= 0.22 UK gallons
	= 0.26 US gallons
	= 1.76 UK pints
	= 2.11 US pints
	= 33.81 fluid ounces

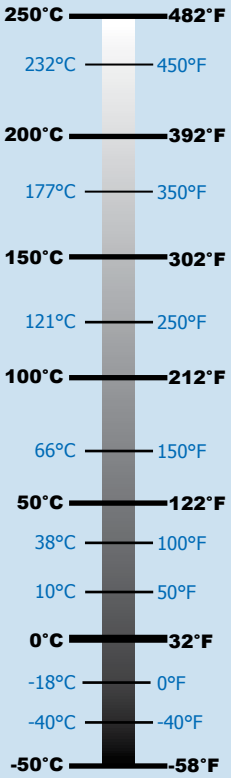
1 US pint= 473 millilitres (ml)

1 UK pint	= 568 millilitres (ml)
1 millilitre (ml)	= 1 cubic centimetre (cc)
1 cubic inch	= 16.39 cubic centimeters
1 microlitre	= 0.001 millilitres

Pressure

1 MPa	=145 psi
1 psi	=0.0069 MPa
1 MPa	=1 N/mm²
1 bar	=14.50 psi
1 psi	=0.069 bar

Temperature



Space for your notes & calculations

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