GUIDE TO BONDING

PLASTICS - COMPOSITES - METALS

PLEXUS®

Structural Adhesives

PLEXUS GUIDE TO BONDING PLASTICS, COMPOSITES AND METALS

CONTENTS

PREFACE

New structural materials create challenging assembly problems.

Today's designer has an exciting variety of advanced composites and materials available for product design. High performance plastics, composites and corrosion-resistant metals offer more choices than ever before.

New material advances bring with them a new generation of adhesive bonding challenges and opportunities. ITW Plexus has the proven experience to solve difficult bonding problems.

This bonding guide is aimed at design engineers and technicians who have the task of joining together today's most advanced materials. With detailed information on adhesive types, joint design and substrates, this guide offers the designer help in choosing the correct solution for their application.

Plexus® Adhesives offer a proven solution to the structural bonding of most advanced materials. They are designed to bond high performance plastics, composites and metals and combinations of dissimilar materials

Ease of use and rapid curing provide and effective assembly method for today's automated manufacturing operations.

Top

Illinois Tool Works Inc.
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WHO IS ITW?

Illinois Tool Works Inc. (NYSE:ITW) designs and produces an array of highly engineered fasteners and components, equipment and consumable systems, and speciality products and equipment for customers around the world. A Fortune 200 diversified manufacturing company with more than 90 years of history, ITW's approximately 600 decentralised business units in 44 countries employ nearly 49,000 men and women who are focused on creating value-added products and innovative customer solutions.

Founded in 1912, ITW's recipe for success has been consistent: value-added products and outstanding service win the day with customers. We place a high premium on the development of highly engineered products and systems–most of which are developed in tandem with our customers. And we continue to ensure that our customers receive timely, cost-effective service for the innovative products we provide.

ITW Plexus is a business unit of ITW and makes up one of the five member companies of ITW Performance Polymers.

At ITW Plexus we carry the ITW philosophy through all that we do and ensure that the products we supply are innovative and of the highest quality.

PLEXUS® Structural Adhesives

ITW PERFORMANCE POLYMERS

Top

3) ADHESIVE CONCEPTS

Introduction

This section provides a basic knowledge of adhesives and the common terminology used in this industry. This section contains three parts:

- General Terms
- Types of adhesives
- Adhesive Comparison

General Terms

Adherend	An Adherend is the solid material in the adhesive joint other than the adhesive (also referred to as substrate)
Adhesion	Adhesion is the process by which two surfaces are held together by interfacial forces (surface attraction) or mechanical interlocking
Adhesive	An adhesive is a substance which is capable of holding materials together in a **useful** fashion by means of surface attraction. Surface attraction results from placing a thin layer of adhesive between two objects.
Bond Line	The bond line is the space or gap between two substrates which contains the adhesive.
Cohesive Failure	Cohesive failure is a failure mode where the failure is within the body of the adhesive, i.e. when adhesive is seen on both substrates in the same location
Composite	Composite is a general term for an assembly of dissimilar materials used together to give greater strength than the individual components would on their own, or the same strength or lighter. GRP (glass reinforced plastic) is an example of a modern day composite where resin and fibers are mixed together to give superior strength performance.
Cure	When an adhesive cures, it is converted from a liquid to a solid state. This may be accomplished by cooling, loss of solvents or internal chemical reaction. Curing generally implies some type of physical or chemical change in the adhesive, while hardening or melting is reversible.

Fixture Time	Fixture time is the interval of time between mixing a two part adhesive and the time a bonded assembly can be removed from the mould without distortion.
Rheology	Rheology is the ability of a material to flow and deform. Adhesives with good rheology flow easily and break cleanly at the end of a bead.
Stiffness	Stiffness is a materials ability to resist deformation when a load is applied.
Strain	Strain is the elastic deformation resulting from stress.
Stress	Stress is the internal resistance to change in shape and size.
Substrate	A substrate is a material, which is held by an adhesive. Substrate is a generic term for objects that are being bonded.
Substrate Failure	Substrate failure is a failure where the substrate fails itself before the adhesive bond.
Tension	Tension is the stress resulting from pulling a material apart.
Thermoplastic	A Thermoplastic is a material that will soften when exposed to heat and can be reworked or re shaped before hardening when cooled.
Thermoset	A Thermoset is a material that solidifies when cured by mixing and/or heating and, once cured, cannot be remelted or remoulded.
Toughness	Toughness is a measure of a materials ability to absorb energy.
Viscosity	Viscosity is the resistance to flow or degree of thickening of a fluid.
Working time	Working time is the time between mixing the two components and when the adhesive becomes no longer useable i.e. skins over and will not 'wet out'
Wetting	Wetting is the intimate contact of a liquid and a surface. Good wetting is only possible if there is good attraction between the surface and the liquid. Proper wetting of a mating surface is essential for good bonding.

Top

TYPES OF ADHESIVES

Heat-Cured Adhesives	Any adhesives which must be heated to promote curing.
Holding Adhesives	Holding adhesives are used to hold surfaces together, but not permanently. They do not have to withstand a great deal of force. Adhesive tape is a good example of a holding adhesive.
Hot Melt Adhesives	Hot melt adhesives are applied in the molten state and then harden. The adhesive substance is melted, applied to the surface, and then the parts are joined. Once the adhesive cools and solidifies, the joint is complete.
Instant Adhesives	Any adhesive which cures within seconds to minutes
Locking Adhesives	Locking adhesives or sealants are used to prevent the loosening of threaded parts. Locking adhesives are placed on the threads of a bolt to prevent it from becoming loose from vibration.
Pressure Sensitive Adhesives	Pressure sensitive adhesives form bonds easily when pressure is applied. Pressure sensitive adhesives are used on self-sealing envelopes and double-sided tape. The joint is made with very little pressure.
Retaining Adhesives	Retaining adhesives are used to prevent the twisting or sliding of non threaded parts. Retaining adhesives are very similar to locking adhesives except they are used on non-threaded parts.
Sealing Adhesives	Sealing adhesives are used to prevent the passage of air, water, oil, etc. between two surfaces. The caulking around windows is an example of a sealing adhesive.
Structural Adhesives	Structural adhesives are capable of withstanding a significant load. The term 'significant load' has never been defined, but the implication is that the adhesive must be able to withstand a great deal of stress. In fact, it could be said that in the absence of unnaturally high forces, the substrates could be considered to be permanently joined.
Ultraviolet adhesives	Any adhesives which cure when exposed to UV light

Top

ADHESIVES COMPARISON

TYPE	ADVANTAGES	LIMITATIONS
Solvent Cements	Low price per packed volume Excellent wetting and penetration Many types available for substrates Easy applied to large surfaces Easily sprayed Moderate clamp pressure needed Long shelf life No special equipment required.	Usually low strength Poor gap cure Poor creep resistance Shrinkage up to 70% Slow drying time (evaporation) Many must be applied to both surfaces in most instances Poor temperature, moisture, and solvent resistance Attack many plastics Flammable Difficult to automate Environmentally unfriendly Expensive on a dried solids basis
Hot Melts	Moderately priced Good gap-filling capabilities Rigid to flexible bonds available Versatile formulations Fast setting	Usually low strength Poor wetting Poor creep resistance Usually low solvent resistance Low heat resistance – degrade as heat rises Stringy Parts must be mated before adhesive cools Short part life Messy, can burn workers Requires special dispensing equipment Difficult to automate.
Silicones	Moderately priced Good gap-filling capabilities Good for bonding glass to most other substrates Excellent sealant for low stress applications Flexible Good water resistance Range of viscosities Good selection of colours Excellent temperature resistance – 200 to 260^{o}C	Low strength Limited solvent resistance Too flexible for structural loads Slow curing Most need moisture to cure Corrosive One component, short shelf life Give off odours when curing Hard to clean Expensive to automate.
Urethanes	Moderately priced Excellent toughness and flexibility Good flexibility at low temperatures Excellent adhesives for a wide range of materialise One-two component, room- or heat-cure available Varying cure times.	Poor temperature resistance Sensitive to moisture both in cured and uncured state May undergo reversal with heat and moisture Two component mixing or single component toxicity Short pot life Require special equipment to mix and dispense.
Epoxies	Usually low priced Good gap filling capabilities	Adhesives thin during curing cycles

	High strength: can be filled with metals Wide range of formulations Versatile Good temperature and solvent resistance	Two component mixing and measuring required Exact proportions needed for optimal strength Single component usually requires refrigeration and heat cure Slow fixturing Short pot life creates waste Special equipment needed to weigh, mix and dispense
Anaerobics	Moderately priced High strength on some substrates Rapid cure at room temperature Good solvent and temperature resistance Versatile Range of viscosities Non toxic No mixing required Dispenses easily from package Easily automated	Limited gap cure Not recommended for many plastic or rubber substrates Won't cure where air contacts adhesive – wet fillets Primers required for many materials 150-200^{o}C temperature limitations. Generally brittle
Cyanoacrylates	Rapid cure at room temperature Single component adhesive Excellent adhesion to rubber Good adhesion to metal High Tensile strength No mixing required Indefinite pot life Dispense easily from package	Higher priced Limited gap cure Low solvent resistance Low temperature resistance Bonds skin Poor impact and peel resistance No water, chemical or environmental resitance
Methacrylates	Moderately priced Good gap fill Excellent impact resistance and flexibility Excellent peel and shear strengths Substrate versatility Medium/fast cure Tolerant of dirty surfaces Can be dispensed from most packages Good flexibility at low temperatures	Some odour problems Flammable

STRUCTURAL ADHESIVES

Structural or performance adhesives are load-bearing adhesives. That is they add strength to the products being bonded. Structural adhesives are used to build products as varied as office furniture, boats, trains, cars to name a few. There are approximately ten adhesive families commonly referred to as structural adhesives: Acrylic, Anaerobic, Cyanoacrylate, Epoxy, Hot Melt, Methacrylate, Phenolic, Polyurethane, Solvent cement and Tapes.

The seven most commonly used are:

- Acrylic
- Anaerobic
- Cyanoacrylate
- Epoxy
- Hot Melt
- Methacrylate
- Polyurethane

Acrylic Adhesives have formulations that tolerate dirtier and less prepared surfaces generally associated with metals. They challenge epoxies in shear strength, and offer flexible bonds with good peel and impact resistance. Acrylics are two-part adhesives, the resin is applied to one surface and an accelerator or primer to the other. The two parts can be pre-applied and later mated. Once mated, handling strength is typically achieved in a few minutes. Curing can be completed at room temperature. Newer versions of acrylics are now available in two component formulations than are mixed together prior to application.

Anaerobic adhesives are one of the most easily applied structural adhesives. Because the curing mechanism is trigged by deprivation of oxygen (hence the name ‘anaerobic’ or ‘without air’), anaerobic adhesives will not cure prematurely. These adhesives are based on acrylic polyester resins and are produced in viscosities ranging from thin liquids to viscous thixotropic pastes. Although they have high cohesive strength, they have low adhesive strength and are not suited to permeable materials. Anaerobics do not fill gaps well and may require primers. They are generally used as thread fasteners.

Cyanoacrylate Adhesives Cyanoacrylate Adhesives (superglues) are also easily applied and offer extremely fast cure rates. Cyanoacrylates are relatively low viscosity fluids based on acrylic monomers and, when placed between closely fitting surfaces, some will cure to a strong joint in two to three seconds. Cyanoacrylates’ ability to bond plastics and rubbers to themselves or to other substrates is their biggest advantage. On the other hand, cyanoacrylate adhesives exhibit poor impact resistance, are vulnerable to moisture and solvents, and are suitable only for bonding small areas. In addition, they do not fill gaps well, require precise mating of bonded surfaces, and are relatively expensive. They also have poor solvent and water resistance.

Epoxy Adhesives have been available longer than any engineering adhesive and are the most widely used structural adhesive. Epoxy adhesives are thermosetting resins which solidify by polymerisation and, once set, will soften but not melt on heating. Two part resin/hardener systems will solidify on mixing (sometimes accelerated by heat), while one part materials require heat to initiate the reaction of a latent catalyst. Epoxies offer very high shear strengths, and can be modified to meet a variety of bonding needs. Generally epoxy bonds are rigid: they fill small gaps well with little shrinkage.

Hot Melt Adhesives have moved out of their traditional applications into areas of low-stress product assemblies. They form flexible and rigid bonds, achieve 80% of their bond strength within seconds, bond permeable and impermeable materials, and usually require no elaborate surface preparation. Hot melts are insensitive to moisture and many solvents, but they soften at high temperatures.

Methacrylate Adhesives provide a unique balance of high tensile, shear and peel strengths with the maximum resistance to shock, stress and impact across a wide temperature range. Methacrylates can generally be used without surface preparation when joining plastics, metals and composites. They are two component reactive materials based on methyl methacrylate monomer that, when mixed together, have a controlled cure speed based on the appropriate application process. Methacrylates are tolerant to off ratio mixing and remain strong and durable under severe environmental conditions. They resist water and solvents to form an impenetrable bond.

Polyurethane Adhesives are named after the polymer type formed on completion of the reaction. The adhesives are usually two component, one side is always isocyanate based, the other formulated from one of several core reactants often amines or glycols. They are known for toughness and flexibility even at low temperatures. They have fairly good shear strength and excellent water and humidity resistance, although uncured urethanes are sensitive to moisture and temperature.

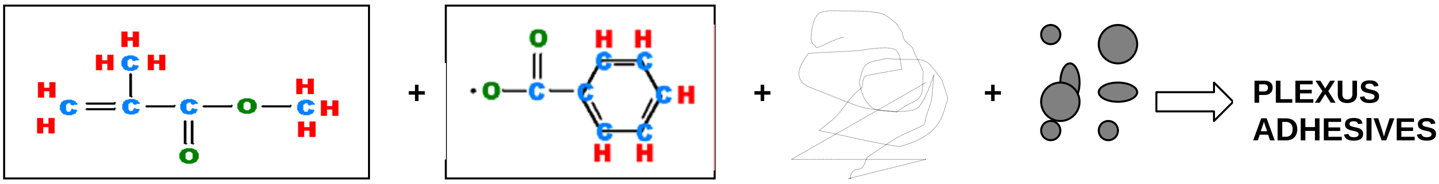
Top

4) WHY BOND WITH PLEXUS ADHESIVES

Plexus adhesives are two component methacrylate adhesives that have been developed to perform under a wide range of conditions. This is achieved by improving curing, bonding, adhesion and toughening mechanisms.

The improved adhesion mechanism of Plexus methacrylates consists of the low viscosity monomer solvating the surface of most thermoplastics and composites prior to the curing mechanism beginning. The monomer can solvate most surface contaminants which limits the need for any surface preparation prior to applying the adhesive.

Plexus methacrylates have a unique combination of polymers and impact modifiers which enable them to be strong yet flexible. The resulting high tensile strength along with impressive elongation (over 100% at 23^{o}C) makes Plexus adhesives competitive with both polyurethanes and epoxies.

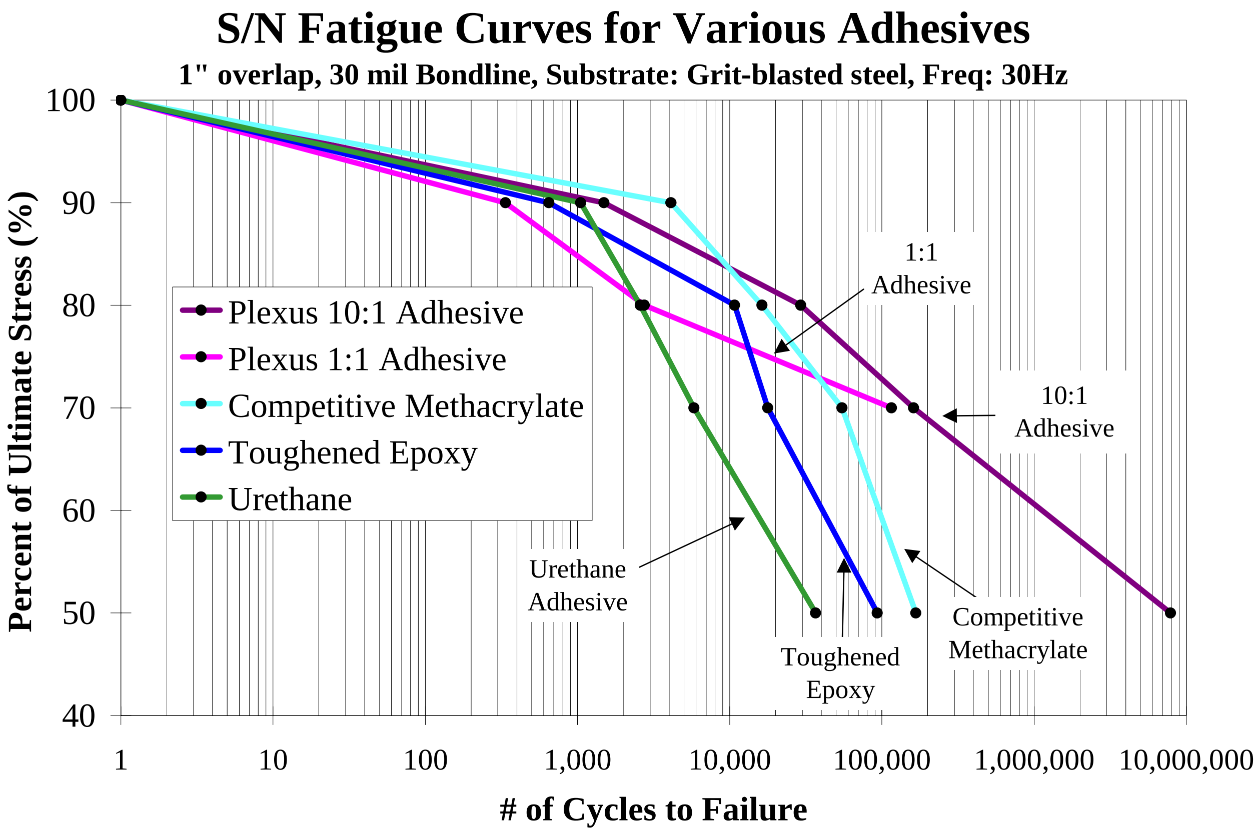


Methyl Methacrylate Peroxide (free radical) Elastomeric Tougheners Impact Modifier

The total combination of all these factors along with good rheology, thixotropic properties, ease of use, good gap filling capabilities, low VOC's and no solvents, results in a range of structural methacrylate adhesives that can be successfully used in marine, construction and automotive markets on a wide range of substrates.

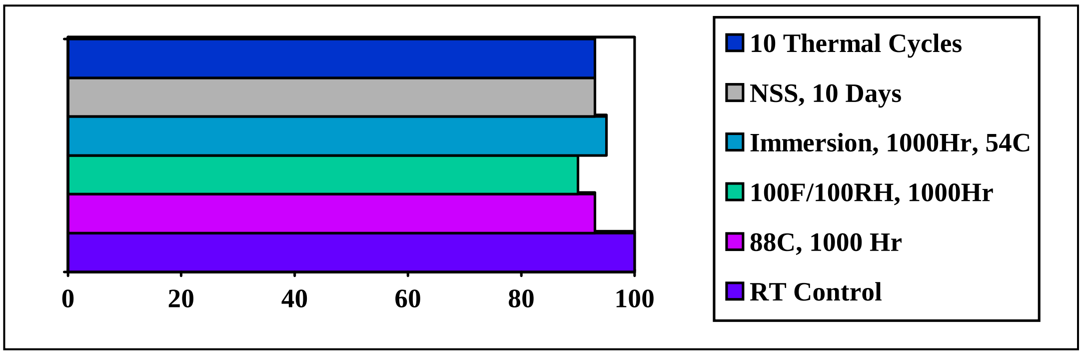
Plexus methacrylates are able to combine the properties of strength and elongation (flexibility) into a single high performance system, which gives excellent fatigue and impact resistance.

Fatigue resistance is important when a bonded joint is likely to be exposed to vibration, shock, and impact. Plexus methacrylates can out perform other adhesive technologies and systems as seen in the chart below.



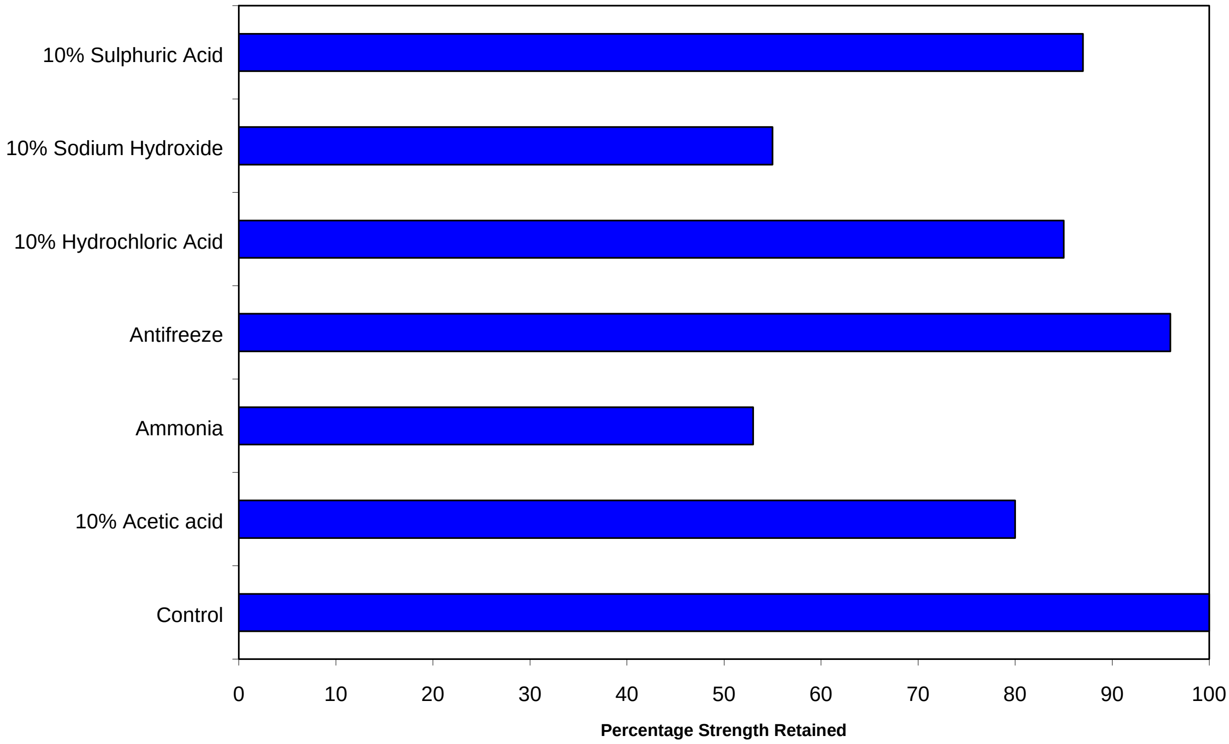
A further advantage of Plexus is the adhesives ability to withstand, environmental and chemical exposure. A high percentage of the adhesives original strength is typically retained.

Environmental



Percentage strength retained Vs room temperature control

Chemical



Percentage strength retained Vs room temperature control

Top

PLEXUS STRUCTURAL ADHESIVES

Plexus Adhesive	Mix ratio	Feature
MA300	1:1	All Purpose Adhesive. High Strength.
MA310	1:1	High Strength. Use with “Difficult to Bond” Plastics.
MA330	1:1	Pigmented MA310. Use with “Difficult to Bond” Plastics.
AO420	10:1	All Purpose Adhesive. High Toughness.
MA320	10:1	Excellent Low Temperature and Toughness Properties.
MA422	10:1	All purpose adhesive. Medium Open Time.
MA425	10:1	All purpose adhesive. Long Open Time.
MA550	10:1	Excellent Marine Adhesive. White, UV Stable.
MA556	10:1	Low Exotherm Adhesive. Bond Lines up to 1” thick.
MA557	10:1	Low Exotherm Adhesive. Bond Lines up to 1.5” thick.
MA560	1:1	All Purpose Adhesive. Long Open Time.
MA590	1:1	All purpose. Long Open Time. Bond Lines up to 1" thick.
MA820	10:1	All Purpose Adhesive. High Strength/High Toughness. No Primer Metal Bonding.
MA822	10:1	All Purpose Adhesive. High Strength/High Toughness. No Primer Metal Bonding.

MA920	10:1	Low Odor. All Purpose Adhesive. High Toughness.
MA922	10:1	Low Odor. All Purpose Adhesive. Medium Open Time.
MA925	10:1	Low Odor. All Purpose Adhesive. Long Open Time.
MA1020	10:1	Low Shrinkage, Low Odor. All Purpose.
MA1025	10:1	Low Shrinkage. Low Odor. Able to be used 1" thick.
MA3940	10:1	Use with Craze Sensitive Plastics.

Top

JOINT DESIGN

Introduction

This section discusses the terms and concepts related to joint design. It is divided into four topics:

- Types of joints
- Types of stresses
- Joint stress distribution
- Design guidelines

An understanding of the following terms will be helpful in our discussion of different types of joints.

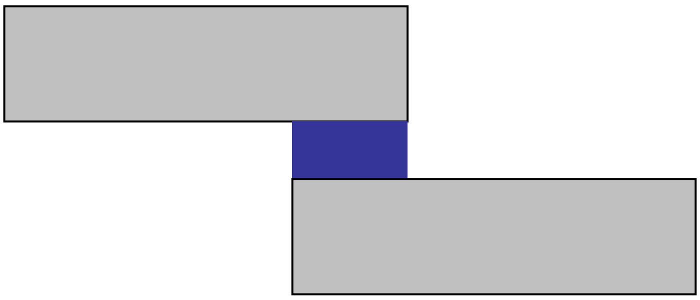
Joint A joint is the location where and adhesive joins two substrates.

Joint Geometry Joint geometry refers to the general shape of an adhesive bond.

TYPES OF JOINTS

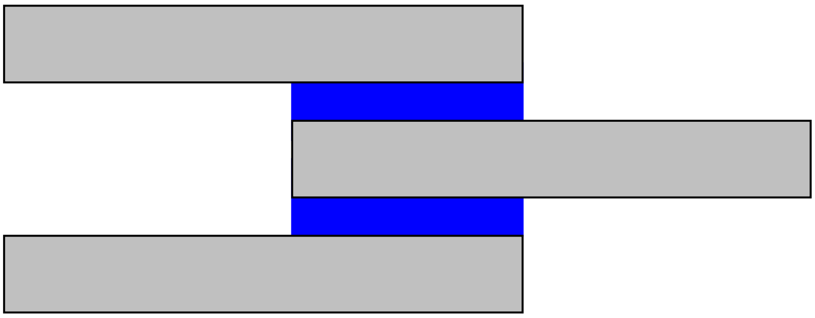
There are two main aspects to be considered when designing a joint for adhesives. Typical joint designs include:

Lap/Overlap Joint A *lap joint*, also called an overlap joint, is formed by placing one substrate partially over another substrate.

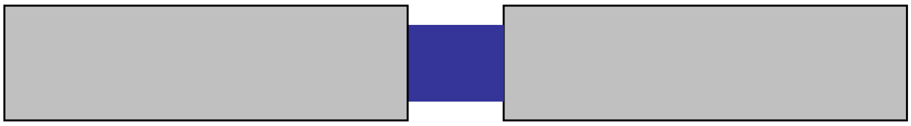


Joggle Lap Joint A *joggle lap joint* is an offset joint very similar to the lap joint.

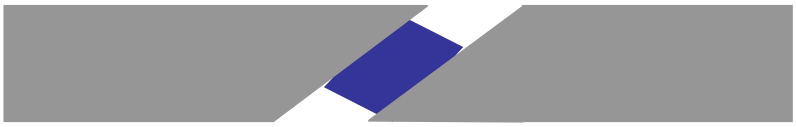
Double Lap Joint A *double lap joint* incorporates two lap shear joints in one.



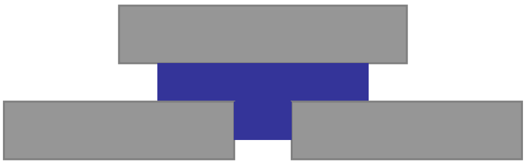
Butt Joint A *butt joint* is formed by bonding two objects end to end.



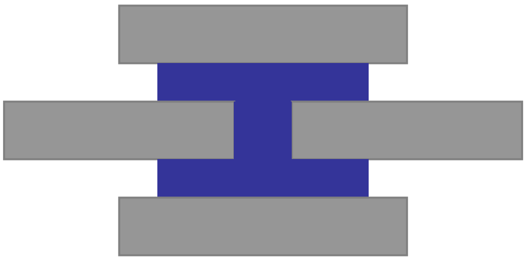
Scarf Joint A *scarf joint* is an angular butt joint. Cutting the joint at an angle increases the surface area.



Strap Joint
(Single or Double) A *strap joint* is a combination overlap joint with a butt joint

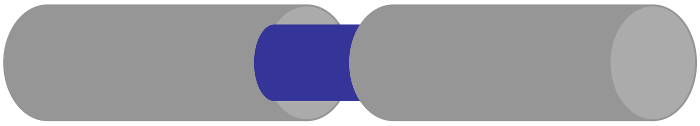


Single Strap Joint



Double Strap Joint

Cylindrical Joint A *cylindrical joint* uses a butt joint to join two cylindrical objects.



Biscuit Lid Joint A *biscuit lid joint* is a variation on a joggle lap joint

Toggle Joint A toggle joint is formed by fitting the two substrates together in a ‘tongue and groove’ type formation

Stepped lap joint A stepped lap joint is a variation of a lap shear joint

Flange Joint A flange joint is a variation on a overlap joint

Top

TYPES OF STRESSES

Stress Stress is a force applied to a bond, usually expressed in N/mm^2 (Newton's per square millimetre) or MPa (Mega Pascals)

Several types of stresses commonly found in adhesive bonds include:

Impact Stress *Impact stress* occurs when a sudden force or shock is applied to a joint.

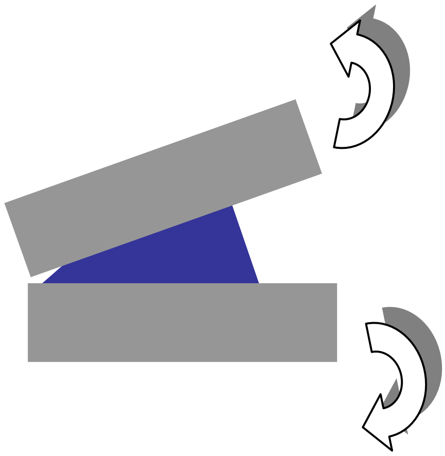
Tensile Stress *Tensile stress* tends to pull an object apart. It also tends to elongate an object.

Compressive Stress The opposite of tensile stress, *compressive stress* tends to squeeze an object together.

Shear Stress *Shear stress* is created by two surface sliding over one another.

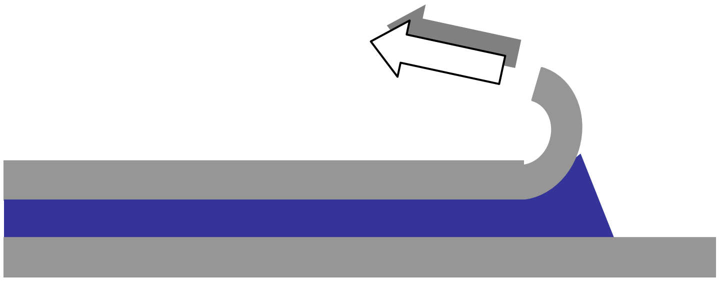
Cleavage stress

Cleavage stress occurs when a joint is being opened at one end.



Peel Stress

Peel stress occurs when a flexible substrate is being lifted or peeled from the other substrate.



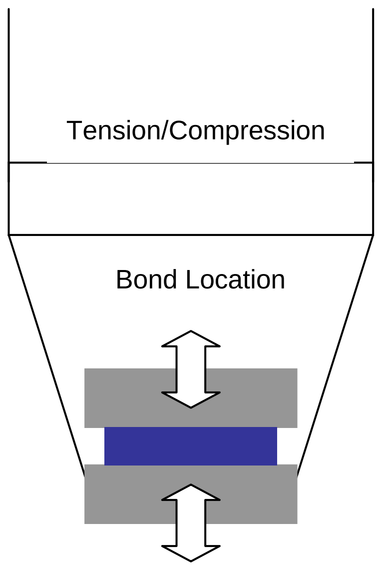
Top

JOINT STRESS DISTRIBUTION

Joint stress distribution is the location of stresses within a bond.

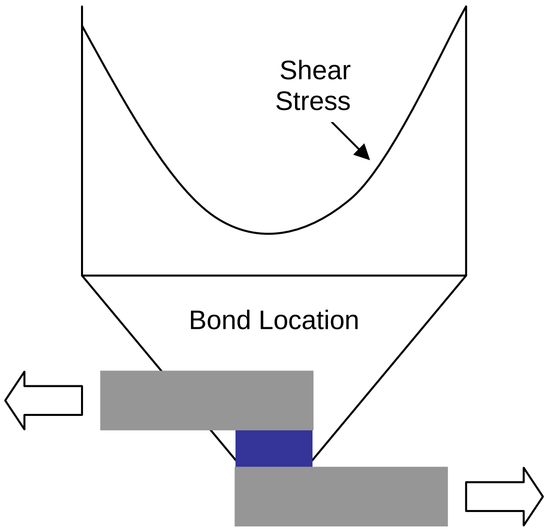
Tension and Compressive stress Distribution

When a bond experiences either *tensile* or *compressive stress*, the joint distribution is illustrated as a straight line. The stress is evenly distributed across the entire bond.



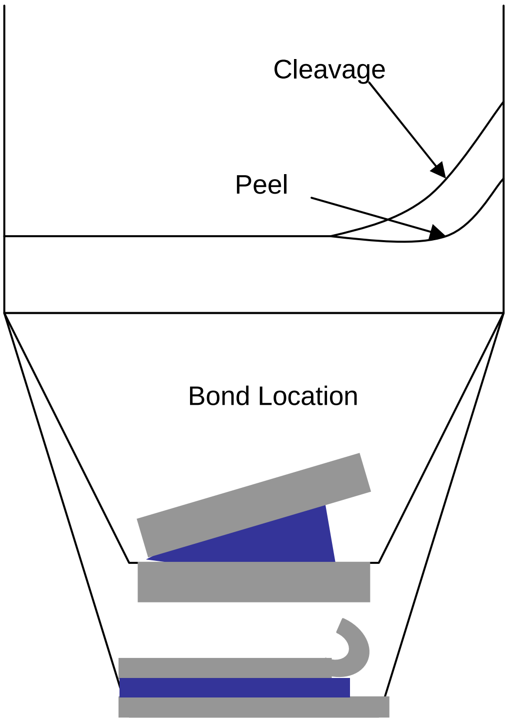
Shear Stress Distribution

Shear stresses are distributed across the bond in an entirely different way. The ends of the bond resist a greater amount of stress than the middle of the bond does.



Cleavage and Peel Stress distribution

When *cleavage* or *peel stress* is applied to a joint, most of the stress is concentrated at one end.



Top

DESIGN GUIDELINES

Engineers must have a good understanding of how stress is distributed across a joint when force is applied to it. Several design guidelines should be considered when designing an adhesive joint

1. **Maximise Shear / Minimise Peel and Cleavage**

   Note, from the cleavage and peel stress distribution curve, that bonds do not resist stress very well. The stress is located at one end of the bond line, whereas, in the case of shear, both ends of the bond resist stress.

2. **Maximise Compression / Minimise Tensile**

   Note, from the tension and compression stress distribution curve, that stress is uniformly distributed across the bond. In most adhesive films, the compressive strength is greater than the tensile strength. An adhesive joint is less likely to fail under a compressive force than under tension

3. **Joint Width is More Important than Overlap Length**

   Note, from the shear stress distribution curve, that the ends of the bond resist a greater amount of stress than the middle of the bond does. If the width of the bond is increased, the bond area at each end also increases, producing a stronger joint.

   In this same overlap joint, if the overlapping length is greatly increased, there is little, if any, change in the bond strength because the contribution of the ends is not increased. The geometry of the ends has not changed, thus their contribution to the bond strength has not changed.

   As a general rule, increase the joint width rather than the overlap length.

Top

PLASTIC GUIDE

THERMOPLASTICS

Thermoplastics soften when heated above glass transition temperatures and can be reworked or reshaped.

Acetal

(POM) Polyoxymethylene – available in homopolymer and copolymer grades. Strong, tough, chemical resistant plastic typically used in plumbing valves, appliance parts, toys and automotive hardware for applications that are subject to wear and mechanical stress

Bonding techniques: It is extremely difficult to achieve true adhesion to acetals because of their chemical inertness. Bond strength is achieved primarily by mechanical keying to surface irregularities. Strength can be increased by abrasion or flame treating.

Acrylic

Polymethyl Methacrylate (PMMA). Acrylics plastics are lightweight, rigid, transparent materials that are tough and dimensionally stable. They can be easily fabricated and typically are used in windows, signs, lighting fixtures, decorative furniture and packaging.

Bonding techniques*:* Acrylics can be easily bonded with many types of adhesives and chemicals.

Cellulosics

(CAL, CAB, CAP) – Cellulosics are tough, moderate-cost plastics with good clarity and strength. They are typically used for toys, tools, packaging and home furnishings.

Bonding techniques: Cellulosics may have a slight acid residue on the surface. This can be neutralised with a weak basic solution of bicarbonate or ammonia. Abrading may be needed to improve adhesion.

Fluoroplastics

A class of polymers with fluorinated backbone structure, fluoroplastics include:

- Polytetrafluoroethylene (PTFE)
- Fluorinated ethylene propylene (FEP)
- Perfluoroalkoxy resin (PFA)
- Polychlorotrifluoroethylene (PCTFE)
- Ethylene chlorotrifluoroethylene copolymer (ECTFE)
- Ethylene tetrefluoroethylene copolymer (ETFE)
- Polyvinylidene fluoride (PVDF)

Bonding techniques: Most fluoroplastics are highly resistant to adhesive and chemical bonding due to their low polarity which inhibits surface wetting.

Ketone based Resins

Member resins can be used at high temperatures, have excellent chemical resistance, high strength, and good resistance to burning. Polyetherether Ketone (PEEK) is the most common commercially available Ketone. Typical areas of use are electrical wire and cable housings, appliance components, medical prostheses, and aircraft interiors.

Bonding techniques: Due to their inherent toughness, ketone-based plastics may require some surface preparation prior to bonding. Slight abrasion will increase adhesive bond strength.

Nitrile

A polymer resin which provides good gas barrier, chemical resistance, and taste and odour retention properties. These resins have moderately high tensile properties and good impact resistance. They are used principally in the packaging of food other than beverages.

Bonding techniques: Nitrile thermoplastics do not generally require bonding.

Nylon

Polyamides offer a combination of properties that include high strength at elevated temperatures, toughness at low temperatures, stiffness, wear and abrasion resistance, and good chemical resistance. Nylons are available in four classifications.

Nylon 6:	Polymerised by reactions of ring compounds that contain both acid and amine groups on the monomer
Nylon 6/6:	Polymerised by reaction of a diabasic acid and a diamine.
Nylon 10 & 11:	More flexible nylon polymers.
Nylon 6 and 6/6:	Constitute the bulk of domestic production largely because they offer the most favourable combination of price, properties, and processability.

Bonding Techniques*:* A solvent wipe or slight abrasion will increase bond properties.

Polyamideimides

(PAIS) High- temperature engineering plastics produced primarily by condensation. These materials are characterised by superior mechanical properties at temperatures up to 260^{o}C, good dimensional stability, and good creep, impact, and chemical resistance. They are used in aerospace, transportation, chemical processing, and electrical industries.

Bonding techniques**:** Abrasion is required to achieve a good structural bond.

Polyarylate

This resin class is heat-resistant with excellent toughness, UV stability, flexural recovery, dimensional stability, flame retardance, and electrical properties. Polyarylates are used in automotive applications such as headlight housings, exterior trims, and door handles. They are also found in safety equipment, electrical housings and covers, and exterior applications.

Bonding techniques: Polyarylate polymers, when blended with polyesters typically require no surface preparation.

Polybutylene (PB)

Resins that are semi-crystalline polyolefin thermoplastics based on poly and homopolymers and a series of poly copolymers. Major applications include pipe, packaging, blow molded vessels, and hot melt adhesives and sealants.

***Bonding techniques*:** PB resins require a solvent wipe, primer, and abrasion to achieve a good bond.

Polycarbonate (PC)

Polycarbonates offer an excellent balance of toughness, clarity, and high heat defection temperatures. Major applications generally require at least two of these properties. New applications for PC or blends have resulted from the replacement of traditional methods such as wood, metal and glass. Major market segments where PC has a broad range of applications are automotive, electronics, business machines, lighting, and appliances.

***Bonding techniques*:** PC's are generally bondable as is. Because of surface sensitivity, products that contain solvents may cause stress cracking and should be avoided. All adhesives should be tested on stressed parts.

Polyester Thermoplastic

Polybutylene terephthalate (PBT), polyethylene terephthalate (PET), and blends can replace such materials as ceramics, metals, composites, and other plastics because of their outstanding strength at extreme temperatures and resistance to most chemicals, weathering, radiation and burning. These materials are suitable for electrical components, electronic devices, and chemical processing equipment, as well as for parts for the aerospace, transportation, appliance and safety industries.

***Bonding techniques*:** Polyester thermoplastics and their alloys and blends can be bonded with minimal surface preparation.

Polyethylene (PE)

PE's are characterised by good chemical resistance, toughness, flexibility, good barrier properties, and low cost. Typical applications include packaging, housewares and wire and cable coatings. PE densities vary as follows

- Ultra low density (ULDPE)
- Linear low density (LLDPE)
- High molecular weight, high density (HMW-HDPE)
- Ultra high molecular weight (UHMW –PE)

Bonding techniques: Because of their nonpolar nature, these plastics require an oxidation treatment using flames, plasma, or chemical etching to enhance the adhesive bond.

Polyphenylene Oxide (PPO)

Modified PPO alloys are tough, impact resistant, and dimensionally stable plastics that have good electrical properties and are moderate in cost.
Applications for blends and alloys include internal automotive parts and components (instrument panels, seat backs, rear spoilers and wheel covers), telecommunications, business machines and appliances.

Bonding techniques**:** Modified PPO alloys can be bonded as is.

Polyphenylene Sulfide

PPS offers an excellent balance of high-temperature resistance, low flammability, dimensional stability, and electrical properties. The material can be filled with reinforcing fibers and filler for injection molding. The primary use of PPS is electrical components and connectors.

Bonding techniques**:** PPS is very inert. Bond strength is achieved primarily through keying to surface imperfections. Most bonding applications will require an abrasion to enhance bond strength.

Polypropylene (PP)

PP is characterised by low cost, good heat resistance, chemical resistance and good mechanical strength. Typical applications include housewares, packaging, medical disposables and transportation.

Bonding techniques*:* As with all polyolefins, a pre-treatment of the surface is necessary to achieve adhesion.

Styrenic resins

Plastics based on styrene resins have high heat-deflection temperatures, are hard and rigid, and have good dimensional stability. High impact grades are available. Major applications are packaging, appliances, transportation, furniture and housewares. Styrene-containing thermoplastics include:

- ABS (acrylonitrile, butadiene, and styrene)
- ACS (acrylonitrile, chlorinated polyethylene, styrene)
- ASA (acrylic-styrene-acrylonitrile terpolymers)
- PS (polystyrene)
- SAN (styrene-acrylonitrile)

Bonding techniques*:* Styrenics typically can be bonded without surface preparation.

Sulfone-based resins

Polysulfone is a transparent, heat resistant, ultra-stable, high-performance engineering thermoplastic. It has low flammability, smoke emission, and rigidity at high temperatures. Typical applications include food handling equipment, coil bobbins, and chemical processing equipment.

Bonding Techniques: Polysulfones are easily stress cracked by solvent based adhesives which should be avoided.

Thermoplastic Elastomers

TPE materials combine the processability of thermoplastic with the performance of thermoset rubber. TPE's advantages over rubber include: little or no compounding simpler processing, shorter processing times, lower energy consumption, recyclability of scrap, lower density, and compatibility with common plastics processing methods such as blow molding and thermoforming. There are five generic classes of TPE's

- Styrenic block copolymers
- Polyolefin blends (TPO'S)
- Elastomeric alloys
- Thermoplastic polyurethanes (TPU's)
- Thermoplastics polyamides

Applications include non tyre automotive, major and small appliances, building construction, and electrical insulation's.

Bonding techniques: Thermoplastic elastomers vary in their bondability due to the different alloy mixtures that may occur.

Vinyl based resins

Polyvinyl chloride is the most versatile of all plastics because of its blending compatibility with plasticizers, stabilisers and other additives. It can be used to manufacture products ranging from heavy-walled pressure pipe to thin, crystal-clear food packaging; or from house siding to surgical gloves. Vinyl-based resins consist of three types: suspension, dispersion, and chlorinated.

Bonding techniques: PVC can be bonded as is with little or no surface preparation.

THERMOSETS	Thermosetting resins solidify when cured by mixing and/or heating and, once cured, cannot be remelted or remolded.
Allyl	The most widely used commercial allyls are the monomers and prepolymers of diallyl phthalate and diallyl isophthalate and are readily converted into thermoset molding compounds and preimpregnated cloths. These resins retain their electrical properties under high temperature and humidity. Moldings are characterised by dimensional stability, chemical resistance, mechanical strength and heat resistance. Applications for allyls generally include electrical and electronics. ***Bonding techniques:*** Allyls require a solvent clean or abrasion to improve bond strength.
Bismaleimides (BMI)	BMI’s are a high-temperature resistant class of thermosetting polymeric materials and are often processed into prepregs, which can be further processed into composite structures. Original large scale use of BMI’s was in printed wireboard. They are now found in many high-performance structural composites used in the aerospace industry. ***Bonding techniques*:** Little or no surface preparation required, however each BMI should be tested prior to recommendation
Epoxy	Epoxies consist of a variety of crosslinking materials that contain the epoxy or oxyrance group. The epoxy group is reactive to a wide range of curing agents or hardeners. Curing can take place at room temperature or at elevated temperatures. The inherent properties of epoxy resins include: good adhesion to many substrates, low shrinkage, high electrical resistively, good corrosion resistance, and good thermal properties. These properties make epoxy resins useful in many applications including adhesives, laminating, potting and composite matrices. ***Bonding techniques:*** Epoxies are generally easily bonded with many different chemical adhesives. Adhesion can be improved by abrasion.
Phenolic	Phenolic resin, the reaction product of phenol and formaldehyde, is a heat-cured thermoset. The crosslinked structure formed by the reaction is the source of its excellent properties. Phenolics are best used in applications calling for heat resistance, dimensional

stability, creep resistance, and tight dimensional tolerances. They are available in two classes: general purpose, widely used in high temperature electrical, such as ovens, toasters, and wiring devices; and engineering phenolics, typically used in areas where strength, wear , hardness, electrical properties, and impact resistance are required.

Bonding techniques*:* Phenolics can be bonded as it is or by solvent wiping and abrading to enhance the bond.

Polyester

Unsaturated polyesters are extremely versatile. They can be rigid, resilient, flexible, or flame retardant. They can be unfilled, filled, reinforced, or pigmented. They are widely used in applications as diverse as boats, shower stalls, recreational vehicles, automotive exterior parts, appliances, cultured marble, corrosion resistant tanks, furniture and bowling balls.

Thermoset polyesters can be formulated in the following ways:

- **GRP -** Glass Reinforced Plastic. Often also referred to as FRP (fibre reinforced plastics). Glass reinforced thermoset polyesters can be processed by a lay up method, compression, resin transfer, injection molding, filament winding, continuous processing, or pultrusion methods.
- **SMC** – Sheet Molding Compound. Resin, glass fibre, filler, thickener, mold release, pigment and catalyst are combined and compression molded into panels or sheets.
- **BMC** – Bulk Molding Compound. Dough-like materials that are prepared with a sigma blade mixer and are compression molded into large and small parts.
- **RTM** – Resin Transfer Molding. Fills a gap between lay-up and compression molding. RTM yields smooth internal and external surfaces with thickness control that is superior to lay up.

Bonding Techniques**:** Polyester thermosets can generally be bonded as is although some adhesive products in use today require a primer. Adhesion can be increased by solvent wiping or abrasion, although abrasion can weaken the substrate.

Polyurethanes (PUR)

Polyurethane has become a generic name for plastics which use polyisocynates. The term polyurethane is usually applied to final products used in the industry. PUR’s have great diversity in processing with isocyante chemistry and polymer backbones to determine physical forms and properties of a finished product. The tailoring of products to fit applications makes it difficult to describe general or average properties. PUR's can be processed to be like rubber or stiff plastic, blown to soft or hard foams, or reinforced with various fillers and fibers. A typical processing method is reaction injection molding (RIM). RIM urethanes are fast, two-component, mixing-activated plastics and are used to mold large, complex parts at high speed.

Bonding techniques*:* Bondability of urethanes will depend on how they have been compounded and processed, but is generally good to excellent with Plexus Methacrylate adhesives. Additives used to achieve a smooth paintable surface produce variations in compatibility with adhesives.

Polyurea

Polyurea is a thermosetting polymer formed by a controlled reaction of formaldehyde with various compounds that contain amino group NH_2. The application of heat in the presence of acid catalysts converts the material into a hard, infusible product. Molding compounds are formed into rigid electrical and decorative products. They can also be filled to add strength, improve dimensional stability, and reduce molded-in stresses. Primary applications for filled urea compounds are molded dinnerware, ashtrays, razor housings, appliance components, lavatory bowls, and toilet seats.

Bonding techniques: Polyurea or RIM urea can be bonded as is using Plexus adhesives.

Alloys and Blends

These performance plastics are ideal candidates to replace such traditional materials as metal, glass and wood. Because their properties can be tailored to specific applications, alloys and blends can be developed to meet design goals. These new engineered plastics are now being used significantly in the automotive, electronics and appliance industries.

Bonding techniques: Testing of the particular alloy or blend is necessary for specific adhesive choice.

Top

PLASTIC BONDING RECOMMENDATIONS

THERMOPLASTICS

WHAT WE BOND	
ABS	
ACRYLIC (PMMA)	
CELLULOSICS	Due to the many potential variations in substrates and surface chemistries, ITW Plexus strongly recommends all substrates be tested with a selected adhesive in the anticipated service conditions to determine suitability.
KETONE BASED RESINS	
NYLON	
POLYAMIDEIMIDES	
POLYARYLATE	
POLYBUTYLENE (PB)	
POLYCARBONATE (PC) & BLENDS	
POLYESTER THERMOPLASTIC	Our knowledge and expertise allows us to advise you on substrate selection, joint design, performance criteria, process controls and application methods
POLYETHERETHERKETONE (PEEK)	
POLYPHENYLENE OXIDE (PPO) & BLENDS	
POLYPHENYLENE SULFIDE (PPS)	
POLYSULFONE	
STYRENIC RESINS	
SULFONE-BASED RESINS	
THERMOPLASTIC ELASTOMERS	
PVS & VINYL-BASED RESINS	

THERMOSETS

WHAT WE BOND	
ALLYL BISMALEIMIDES (BMI) EPOXY PHENOLIC POLYESTER POLYURETHANES (PUR) POLYUREA ALLOYS AND BLENDS	Due to the many potential variations in substrates and surface chemistries, ITW Plexus strongly recommends all substrates be tested with a selected adhesive in the anticipated service conditions to determine suitability. Our knowledge and expertise allows us to advise you on substrate selection, joint design, performance criteria, process controls and application methods

Top

COMPOSITE MANUFACTURING PROCESS GUIDE

COMPOSITE

Composite is a general term for an assembly of dissimilar materials used together to perform where the individual components would fail.

Major constituents of composites are the reinforcement fibre and the matrix (usually a thermosetting resin)
The three main reinforcement fibres used are Glass, Carbon and Aramid.

HAND LAY UP

Simplest of moulding processes. The reinforcement mat is simply laid into an open mould on which resin is then applied with a brush and after which laminate is rolled on and allowed to cure.

Fibres – CSM (Chopped strand mat) is predominantly used.
WR (Woven roving) is used is a higher volume of fraction is required.
Resins – Polyester used predominately.
Vinyl ester, epoxy and phenolic can be used if the application requires it.

SPRAY LAY UP

Resin and chopped glass fibre are simultaneously sprayed on to an open mould. The laminate is rolled and the allowed to cure

Fibres – Grades of glass fibre roving. They have good choppability together with low static and fast wet through.
Resins– Usually only orthophthalic and isophthalic polyester resins are used.

COLD PRESS MOULDING

A press moulding technique in which light duty tooling is used, hence low temperatures and pressures are required. Reinforcement mat is placed on the lower mould and a mixed resin system is then poured over. Two halves of the mould are then closed.

Fibres – Glass fibre CFM (Continuous filament mat) and needle mat are common. WR and multi-axial reinforcements can also be used.
Resins - Polyester is most common.

RESIN TRANSFER MOULDING (RTM)

Reinforcement material is placed in the mould which are then closed and clamped together. Resin is then injected into the cavity under pressure. Cure takes place rapidly.

Fibres – Glass fibre CFM is commonly used.

Resins – Polyester and epoxy are both ideal.

AUTOCLAVE / VACUUM BAG

Pre-impregnated fibre layers are applied in a mould and rolled. Rubber or plastic bag placed over the lay up and is removed by a vacuum pump. Mould is placed into and oven (or autoclave) which applied pressure and heat to cure the resin.

Fibres – Carbon, glass and aramid fibres and prepregs of these.
Resins – Epoxy resins are used almost exclusively.

HOT PRESS MOULDING

Mass production method. A hydraulic press is used to compress the tool which is heated to about 130 – 170^{o}C before the thermoset mix and reinforcement is placed in the tool which is closed and cure is completed in 2-3 minutes.

Compounds
Sheet moulding compound (SMC)
Dough moulding compound (DMC)
Bulk moulding compound (BMC)
Fibres – Continuous strand mat of chopped strand mat with insoluble binder
Resins – Polyester or epoxy resins.

PULTRUSION

Continuous reinforcement is pulled through a device, which applies the resin. The wetted fibre is then pulled on to a heated steel die which is the shape of the part to be produced. Typically the die is heated to around 150^{o}C which cures the resin. The cured section is then pulled of the die and cut to the correct length as required.

Fibres – Most common is glass although carbon and aramid can be used.
Resins – Most common is polyester, vinylester can be used for corrosion resistance, urethane methacrylate has good fire, smoke and toxicity resistance. Epoxy gives higher performance and used primarily with carbon fibre. Phenolics are also being developed for use due to their good fire resistance.

FILAMENT WINDING

Consists of a rotating cylindrical mandrel on to which fibres impregnated with resin are wound. The applicator travels up and down the mandrel thus building up the layers of fibre.

Fibres – Glass fibre roving, carbon fibre and aramid as rovings and yarns. Woven tapes of these fibres can also be used.
Resins – Epoxy is the most commonly used.

Top

MATRIX RESINS

The main purpose of a resin system is to transfer load from fibre to fibre, along side this, the resin will also;

- Protects sensitive fibres from abrasion
- Forms a protective barrier between fibres and the environment
- Can provide shear, tensile and compression properties to the composite
- Can effect the thermo-mechanical performance of the composite.

Main matrix resin thermosets

- Orthophthalic Polyester
- Isophtalic Polyester
- Urethane Methacrylate
- Vinyl Ester
- Epoxy
- Phenolic

Polyester Resins

Polyester resins are very versatile. They are the most economic option for many applications. The curing mechanism involves the addition of chemicals (free radical catalysts) that cause the resin molecules to lengthen and solidify.
Isophthalic resins have better temperature and chemical resistance.

Urethane Methacrylate

Urethane methacrylate resins are new materials which have similar characteristics to polyester resins. They are capable of taking a lot more fillers and therefore characteristics such as fire performance can be improved.

Vinyl Ester

Vinyl ester resins are typically more expensive than polyester systems, however they share the same curing mechanisms. They bond well to Kevlar and carbon fibre reinforcements and have high strength as a cured neat resin. Vinyl esters also have excellent resistance to chemicals.

Epoxy

Epoxy resins generally offer more strength, stiffness and toughness than the other systems in common use. They are more expensive than other systems but give low shrinkage during cure, good resistance to most chemicals, good adhesion to most fibres, good resistance to creep and fatigue and maintain strength at high temperatures.

Phenolic

Phenolic resins are the oldest synthetic polymers. The newer formulations were designed to cure at low temperature and pressure through the use of acid-based catalysts. Phenolic resins have excellent fire resistance and when they are induced to burn they will release only minimal quantities of smoke or toxic fumes.

Top

COMPOSITE REINFORCEMENTS

The fibre reinforcements fall into three main types, Glass, Aramid (Kevlar) and Carbon.
The important property of the fibre is the elastic modulus, it must be stiffer than the matrix. This allows it to pick up the stress applied to the composite.

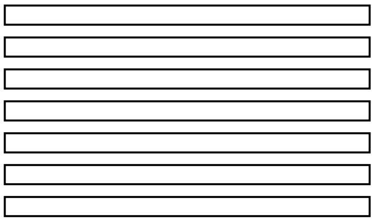
Reinforcement orientation

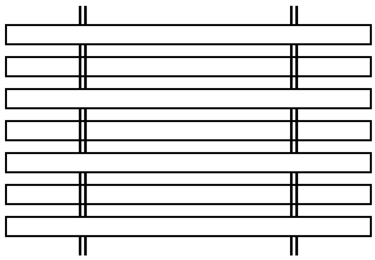
The fibres may be orientated in many ways but they fall into three main categories.

UNIDIRECTIONAL

All fibres in one direction

Rovings, Tow etc.



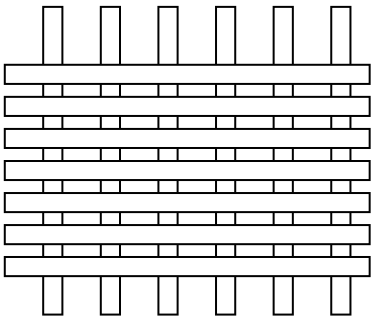


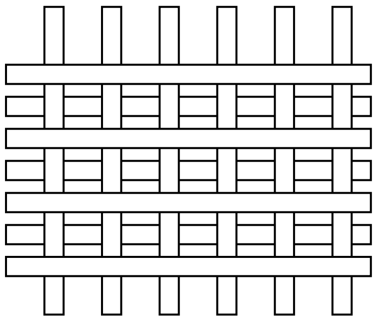
Woven or Non-woven

BI-DIRECTIONAL

Fibres 90^{o} to each other, woven or non-woven form

Non-Woven



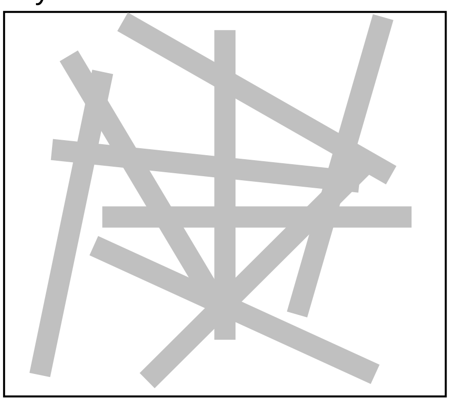


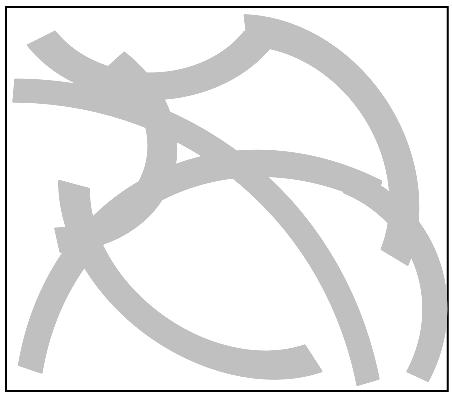
Woven

RANDOM

Randomly distributed

CSM





CFM

Glass fibres

Glass fibres can be classified into two sets.

- Have a modulus of around 70 GPa and low to medium strength – E, A, C glass
- Have a modulus of around 85 GPa and have a higher strength – R & S2 glass.

A Glass – High Alkali (essentially soda-lime silica)
E Glass – Electrical grade (a calcium alumino-borosilicate with low alkali oxide content)
ECR Glass – Chemically resistant modified E glass grade (with calcium alumino-silicate)
S Glass – High strength (with magnesium alumino-silicate and no boron oxide)

Glass fibres are commonly used for reinforcing as they have good properties, good processing characteristics and are inexpensive. E glass is the most widely used.

Glass fibre is spun on the melt and when the continuous glass fibres are produced they are transformed to;

- Continuous or woven rovings
- Yarns
- Chopped strands
- Mats
- Preforms

Carbon Fibres

Carbon fibres are the predominant reinforcement used to achieve high stiffness and strength. Carbon fibre is commonly produced from a precurser of PAN (polyacrylanitrile) fibre, which is then stretched, oxidised then carbonised. The degree of carbonisation determines properties such as elastic modulus, density and electrical conductivity. The primary characteristic of carbon fibre composites is their very high stiffness, but although modulus is the primary reason for using them they can also have superb strength performance.

Aramid / Kevlar Fibres

Aromatic Ether Amide or Aramid fibres are organic, man made fibres. They are generally characterised as having relatively high strength, medium modulus and low density. Aramid fibres are fire resistant and perform well at high temperatures. They are also resistant to organic solvents, fuels and lubricants.

Top

COMPOSITE BONDING RECOMMENDATIONS

PROCESS / COMPOSITION	PLEXUS ADHESIVE
HAND LAY UP Polyester Vinyl ester, Epoxy, Phenolic **SPRAY LAY UP** Polyester **COLD PRESS MOULDING** Polyester **RTM** Polyester Epoxy **VACUUM BAG** Epoxy **HOT PRESS MOULDING** SMC DMC BMC **PULTRUSION** Polyester Vinyl ester Urethane Methacrylate Epoxy Phenolic **FILAMENT WINDING** Epoxy	Due to the many potential variations in substrates and surface chemistries, ITW Plexus strongly recommends all substrates be tested with a selected adhesive in the anticipated service conditions to determine suitability. Our knowledge and expertise allows us to advise you on substrate selection, joint design, performance criteria, process controls and application methods

Top

GUIDE TO BONDING METALS

Metal Pure metals are rarely used today. Most metals are used in the form of alloys.

Metals typically require some surface preparation prior to bonding with most adhesives to improve adhesion. The methods of preparation fall into two categories, electrochemical and abrasive. A simple overview of the process is:

Degrease the surface, Rinse / Clean, Surface treatment ,(Abrasion / Electrochemical), Rinse or Clean, Dry.

Degreasing is important in order to remove oil and grease. If this is not removed it can prevent a good adhesive bond. Cleaning after the surface treatment is also important as any excess residue and or debris on the surface will again affect the adhesive bond strength.

Surface Pre-treatments.

Abrasion

Light abrasion of the surface gives a better key to the adhesive than does a high polish. Freshly abraded surfaces usually are better for achieving good bond strength. The two most common types of abrasion are brushing and blasting.
Brushing - Coarse stiff brush is used to rub the surface.
Blasting – Shot blasting, where small sharp pieces of the blast medium impact the surface.

Solvent Cleaning

A solvent is applied to the surface to dissolve the contaminate material. This can be accomplished by any of the following methods:
Solvent dip – Part to be cleaned immersed in the solvent, which dissolves and carries away the surface contaminates.
Solvent wipe – Using a solvent soaked material to wipe the surface of the part until clean and contaminants removed.
Vapour degreasing – Usually used on parts which have crevices or intricate surface details which may be difficult to clean with a rag. The solvent is heated so the vapour comes into contact with the part. It then condenses to a liquid which carries the contaminant back to a point of collection
Ultrasonic Cleaning – High-frequency sound waves are used to vibrate dirt away. The part is immersed in solvent which is vibrated by high frequency sound waves.

Chemical Cleaning

More severe than solvent cleaning, chemical cleaning removes contaminants from the surface by harsh chemicals. Chemical methods include:
Hot Alkaline Cleaning – Washing the part in hot soap or detergent solution. The part must be rinsed and dried

before applying the adhesive. A corrosive preventative is often applied after cleaning.
Pickling – Applying chemicals to dissolve surface oxides. Pickling removes only the surface contaminants without effecting the base material.
Etching – Chemical solution removes both the oxides and part of the underlying surface.

Conversion

Surface cleaning through a conversion process changes the original surface into a new material. Three types of conversion are:
Phosphating – A crystalline film is produced on a metal surface by a phosphoric acid solution to increase the corrosion resistance and the adhesion to the surface. When a part is dipped or sprayed with a phosphoric acid solution a small portion of the metal surface dissolves and a layer of zinc phosphate or iron phosphate crystals forms on the surface.
Chromating – Non crystalline film is produced on a metal surface by a chromic acid solution. It can reduce corrosion and for some adhesives improve adhesion.
Anodizing – Used on aluminium surfaces in a which a protective oxide is electrolytically applied. Used on aluminium only.

ALUMINIUM

Aluminium and its alloys are the most widely used non-ferrous metals as they offer the benefits of corrosion resistance, appearance, ease of fabrication, low density and high electrical and thermal conductivity.
Aluminium alloys generally have good corrosion resistance due to the fact that aluminium reacts with oxygen to form a hard microscopic layer that inhibits further reaction between corrosive elements and the base aluminium alloy.

Bonding recommendations – Most adhesives require some surface preparation prior to bonding which may take the form of abrasion, priming, solvent cleaning, chemical cleaning or even anodising.

STAINLESS STEEL

Stainless steel is an alloy of iron and chromium that has at least 10.5% chromium and may contain other alloying elements as well.
Stainless steel can be grouped into five main categories.
Austentic – Excellent corrosion resistance and toughness
Ferritic – Are magnetic and chosen when toughness is not a primary need but corrosion resistance is.
Martensitic – Magnetic alloy that is limited to low corrosion resistance requirement applications.
Precipitation-Hardening – High strength, good corrosion resistance and easy to fabricate.

Duplex – Mixed structure of ferritic and austenitic. High tensile and yield strengths with good toughness and corrosion resistance.

Bonding recommendations – Most adhesives require some surface preparation prior to bonding which may take the form of abrasion, priming, solvent or chemical cleaning.

STEEL

Steels are alloys or iron and carbon with other metals, and typically have a carbon content of 2% or less, with some alloys having no carbon at all. Steel can come in many different grades with some of the common ones being;

Carbon Steels	Molybdenum Steels
Manganese Steels	Silicon Steels
Nickel Steels	Chromium Steels

*Bonding recommendation*s – Most adhesives require some surface preparation prior to bonding which may take the form of abrasion, priming, solvent or chemical cleaning

ZINC GALVANISED STEEL

Galvanised steel is steel which has been coated with zinc either through hot dipping or electroplating. The zinc coating protects the steel by forming a barrier of relatively corrosion resistant material around the steel, and forming a self-protecting film of fairly impermeable corrosion by products when corrosion does occur.
Hot Dipping – Applies zinc by drawing the steel through a bath of molten zinc. The coating thickness can be controlled by varying the zinc temperature, immersion time and withdrawal rate of the steel.
Electroplating – Offer better control over coating thickness.

*Bonding recommendation*s – Traditionally very difficult to achieve good adhesion due to the wetability of the steel. Abrasion and or priming are common.

METAL BONDING RECOMMENDATIONS

WHAT WE BOND	
ALUMINUM ANODISED STAINLESS STEEL STEEL GALVANISED STEEL	Due to the many potential variations in substrates and surface chemistries, ITW Plexus strongly recommends all substrates be tested with a selected adhesive in the anticipated service conditions to determine suitability. Our knowledge and expertise allows us to advise you on substrate selection, joint design, performance criteria, process controls and application methods

Top

Disclaimer:

The information contained herein is intended to be used solely as a guide to assist in a better understanding of adhesives, their use and application potentials. The information is believed to be accurate, and is well suited for comparative purposes. All testing was performed using a limited number of adhesive and plastic lots. Therefore, results herein are considered as only trends and are inappropriate for specification purposes.

Any suggestions concerning the compatibility of plastics with **ITW Plexus** adhesives is based on test data and general knowledge concerning the chemical resistance of plastics. The user should acknowledge that all thermoplastics have the potential to stress crack when exposed to uncured adhesives or solvents, depending on the exposure time, part geometry, stresses, and component composition. Therefore, it is important that the end user evaluate the suitability any cleaning solvent and adhesive in their process to insure the aforementioned do not detrimentally affect the performance of the plastic. **ITW Plexus** does not assume responsibility for the results obtained by others over whose methods we have no control. It is the user's responsibility to determine suitability of any adhesive or system for the user's purpose of any application and production method mentioned herein, and to adopt all precautions as may be advisable for the protection of persons and property against any hazards that may be involved in the handling and use thereof.

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Top

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