Liquid Adhesives and Thin Bonding Products for Harsh Environments

The single most important variable when considering an environmentally resistant adhesive is operating temperature.

Whether in aerospace or ground-based applications, innovative, engineered liquid adhesives and thin bonding products (pressure-sensitive foam tapes and adhesive transfer tapes) that maintain properties in harsh environments have significant advantages for joining many substrates, including metals, plastics, rubbers, and glass. Compared to mechanical fastening and thermal joining, adhesives distribute rather than concentrate stress loads, accommodate flex and vibration, separate potentially reactive metals, and form seals that conform to joints and protect them from corrosion.

The single most important variable when considering an environmentally resistant adhesive is operating temperature. Other important factors are humidity and exposure to solvents and ultraviolet (UV) light. For outdoor, non-aerospace applications, the maximum temperature — even inside a closed automobile or truck cab on a hot, sunny day — is not likely to exceed 140°F and winter minimums will range from freezing to -25°F. Outdoor applications also will be exposed to water, UV, and perhaps salt spray, corrosive chemicals, solvents, and/or fuels. Most common adhesive products are well within their performance ranges in outdoor environments.

Applications involving water require adhesives with special resistance to wet and humid environments. Boats and other marine equipment, pools, spas, and water/wastewater treatment, handling, and testing systems may need further resistance to the effects of solvents, fuels, and other corrosive liquids that are part of the environment in which they operate.

Other applications may encounter higher temperatures or stronger solvents or chemicals. For example, certain medical devices must be designed to withstand repeated sterilization processes that use autoclaving and cleaning solutions. Electric motors, generators, electricity transmission components, and under-hood automotive components may operate at temperatures exceeding the boiling point of water and be exposed to highly corrosive chemicals.

Pressure-sensitive foam tapes and adhesive transfer tapes can accommodate expansion/contraction cycles.

Sealing tapes provide excellent holding strength as well as resistance to harsh environments and bi-metallic corrosion.

Products that undergo thermal cycling expand when heated and contract when cooled. Because dissimilar materials, such as metals and plastics, usually have very different coefficients of expansion, a rigidly fastened joint can experience stresses that cause buckling, cracking, and failure. Flexible, softer adhesives, such as urethanes, silicones, and modified silanes, have an advantage in these applications because they can absorb thermal stress and have outstanding thermal and chemical resistance. Pressure-sensitive foam tapes and adhesive transfer tapes — can also accommodate substrate expansion/contraction while maintaining outstanding durability and performance, cycle after cycle. In many situations, adhesives and thin film bonding products are superior to rivets, spot welds, thermal joining, rigid liquid adhesives, and other permanent fasteners.

Liquid Adhesive Applications

New formulations of liquid adhesives deliver stronger, tougher, and more reliable bonds on metals, plastics, composites, polyolefins, and other substrates than traditional fasteners or welding while offering excellent resistance in severe operating environments. They are available in fast-cure, easily dispensed formulations with superior moisture resistance, excellent hot strength, and chemical resistance.

Application and curing can be automated to speed production and reduce labor costs. With their combination of strength and ability to operate in harsh environments, these general-purpose structural adhesives are widely used in agricultural and construction equipment, specialty vehicles, furniture, appliances, signage, tubs and spas, and architectural/building components where metal-to-metal, rubber-to-metal, plastic-to-metal, and glass-to-metal bonding can be a challenge.

Similarly, adhesive formulations for low-surface-energy materials are capable of bonding fiberglass, gel coat, thermoplastics, polycarbonate, ABS, PVC, polyethylene, and polypropylene. Flexible adhesives have fast fixture times, good bond clarity, and UV resistance so important in outdoor applications.

Thin Bonding System Applications

Flexible, pressure-sensitive acrylic foam tapes and adhesive transfer tapes offer unique application opportunities because of their high holding strength, excellent resistance to harsh environments, and prevention of bi-metallic corrosion. These systems save time and money with fast and easy assembly that eliminates drilling, grinding, refinishing, screwing, welding, and cleanup. In addition to tapes, adhesive peel-and-stick masks can be die-cut to precisely fit any shape, size, or profile. Pressure-sensitive adhesives bond parts instantly, eliminating the need for fixtures and long cure times. Because of their viscoelasticity, tape adhesives absorb shock and flexing and improve fatigue resistance caused by environmental factors such as wind, vibration, and substrate expansion and contraction caused by temperature cycling.

One of the most demanding applications of a thin bonding system is on **aircraft exteriors**. Several commercial aircraft models bond stainless steel anti-chafing strips to aluminum wing flaps with adhesive transfer tape. These strips help prevent abrasion and chafing between the flap and the underside of the wing during deployment of the flaps for takeoffs and landings.

Performance Considerations	Adhesive Category										
	Cyanoacrylates	Epoxies	Hot Melts	Light Cure	Silicones	Elastomers	Urethanes	2-Part Acrylics	2-Step Acrylics	VHB Foam Tapes	Adhesive
Benefits	Wide range of bonding applications	Wide range of formulations	Versatile, fast, large gap filling	Rapid cure/ adhesion to plastics	Excellent temperature resistance	Flexible, paintable, bonder/sealant	Excellent toughness/ flexibility	Good impact resistance/ flexibility	Good impact resistance/ no-mix	High holding strength	Excellent environmental resistance
Limitations	Low solvent resistance	Mixing required	Limited heat resistance	Light cure resistance	Low adhesion resistance	High temperature resistance	Sensitive to moisture	Mixing required	Primer required	Does not provide structural bond, limited gap filling	Does not provide structural bond, limited gap filling
Temperature Resistance											
Typical for the category	-65°F to +180°F	-65°F to +180°F	-65°F to +250°F	-65°F to +300°F	-65°F to +400°F	-65°F to +200°F	-65°F to +250°F	-65°F to +250°F	-65°F to +300°F	-122°F to +230°F	-122°F to +230°F
Highest rated product	+250°F	+400°F	+330°F	+350°F	+725°F	+200°F	+300°F	+250°F	+400°F	+400°F	+500°F
Environmental Resistance											
Polar Solvents (EX, H20, ETHYLENE GLYCOL IPA, ACETONE)	Poor[1]	Very Good	Good	Good	Good	Good	Good	Good	Good	Fair	Fair
Non-Polar Solvents (EX. MOTOR OIL, TOLUENE, GASOLINE, ATF)	Good	Excellent	Good	Very Good	Poor to Fair	Poor	Good	Very Good	Very Good	Fair	Fair
Adhesion to Substrates											
Metals	Very Good	Excellent	Good	Good	Good	Very Good	Good	Excellent	Excellent	Excellent	Excellent
Plastics[2]	Excellent	Fair	Very Good	Excellent	Fair	Good	Very Good	Excellent	Fair	Good	Excellent
Glass	Poor	Excellent	Good	Excellent	Very Good	Good	Good	Good	Excellent	Good	Good
Rubber	Very Good	Fair	Fair	Fair	Good	Poor	Good	Poor	Poor	Fair	Fair
Wood	Good	Very Good	Excellent	Poor	Fair	Very Good	Fair	Good	Good	Good	Good
Overlapping Shear Strength	High	High	Low	High	Low	Medium	Medium	High	High	High	High
Peel Strength	Low[3]	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	High	High
Tensile Strength	High	High	Low	High	Medium	Medium	Medium	High	High	High	High
Elongation/Flexibility	Low	Low	High	Medium	High	High	High	Medium	Medium	Medium	Medium
Hardness	Rigid	Rigid	Semi-Soft	Semi-Rigid	Soft	Soft	Soft	Semi-Rigid	Semi-Rigid	Semi-Rigid	Semi-Rigid
Gap Fill											
Ideal (in inches)	0.001 to 0.006	0.004 to 0.006	0.002 to 0.005	0.002 to 0.010	0.001 to 0.006	0.001 to 0.006	0.004 to 0.006	0.010 to 0.040	0.002 to 0.004		
Maximum (in inches)	0.010	0.125	0.240	0.25	0.25	0.24	0.125	0.5	0.040		

1 Cyanoacrylates have very good moisture resistance on plastics.
2 Uncured liquid adhesives may cause stress cracking of certain thermoplastics, e.g., polycarbonate, acrylic, and polysulfone. Special products and process techniques are available.
3 Exception: Toughened cyanoacrylates have HIGH peel strength.

PLEASE NOTE: This chart should not be used to specify products without specific testing. It is recommended that you conduct one-part testing to ensure product performance before specifying any adhesives.

Thin bonding foam tapes are used to secure aluminum body panels to ambulance vehicle frames.

Bond durability and resistance to environmental extremes are key requirements for this application because the bond often is subjected to high skin temperatures in direct sunlight on the ground and -64°F at high altitude, a cycle that may be repeated several times a day. This application has been in use since 1984.

Another demanding and visible application of thin bonding foam tapes is on **ambulance bodies** where aluminum body panels are bonded to the vehicle frame. This application requires durability under harsh conditions and performance over an extended period of time.

Thin bonding systems attach and seal components against moisture, heat, and corrosive solutions.

Adhesive peel-and-stick components can be die-cut to precisely fit any shape, size, or profile.

There are many architectural applications for thin bonding systems, but perhaps the best example is in **curtain wall construction**. Exterior building skin panels are stiffened against wind loads by attaching unseen stiffeners to the inner surface with thin bonding tape. These bonds must sustain wind loads, daily thermal expansion and contraction cycles, and elevated temperatures. Architectural signage and traffic signs using thin foam tapes must also endure constant weathering, buffeting winds, and occasional storms. These have been in use since the early 1980s.

In transportation vehicles, there are many applications for thin bonding systems. They are now successfully used **inside automobiles** to invisibly adhere window switch plates and other plastic trim pieces to vinyl substrates, eliminating unsightly fasteners. Plasticizers compounded in soft vinyl can migrate into adhesives and significantly degrade their performance. The tapes used are specially formulated to bond strongly to vinyl and resist the effect of plasticizers.

Water resistant thin bonding systems are used to adhere **salt water keel protectors** to boats. UV resistant thin bonding systems are used on **solar electric power collectors** to bond panels to support frames and affix electric power collection buses to the assemblies. And a range of **personal electronic and medical devices** use thin bonding systems to attach and seal components against moisture, heat, cleaning solutions, and corrosive fluids.

Material Partners

Fabrico has strategic relationships with world-class materials suppliers, such as 3M and Loctite®, to assist its customers in selecting the best material for the intended use and to expedite materials sourcing. Whether adhesive films or liquids, all critical material properties are considered in any Fabrico project, including chemical, thermal, and moisture resistance.

With more than 30 years of materials experience, Fabrico engineers also understand the impact of a material selection on the overall manufacturing process, and design material systems that optimize production efficiency and improve overall cost-effectiveness.

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