DATA SHEET

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Title:	**ADHESIVES**
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THEORY OF ADHESIVES

Once upon a time it was thought adhesion was only a mechanical attachment: liquid adhesive flowed in pores or cavities in the adherends (materials being cemented), hardened into a solid and locked them together. This is now thought to contribute something to the strength of the bond, but not to be the main reason adhesives adhere. In the 60s' studies were undertaken and a new theory of adhesion emerged called the Adsorption Theory. Mr. Webster defines adsorption as: the adhesion of the molecules of a gas, liquid, or dissolved substance to a surface. This theory held that adhesives stuck primarily because of intimate intermolecular contact; thus if any two materials were placed close enough together, they would adhere - if true then adhesion requires no chemical bonding, nor mechanical interlocking. Proponents pointed to the intermolecular forces that hold the solid matter of the world together, which suggested adhesion is a matter of physical adsorption - an attraction mechanism inherent in any surface known as surface attachment.

Adhesion is considered to be due to chemical and physical forces, but exactly how these forces come into play is still an active subject of debate amongst the theorists. This much is known for sure - adhesion requires actual wetting of adherents with an adhesive, so that the detail irregularities of the surface are filled - even apparently smooth surfaces are full of irregularities at molecule level.

When welding we change the inherent molecular structure of the materials being bonded together, and the weld material by applying heat. We fuse the three materials together by temporarily altering their molecular structures with heat forming a new molecular structure at the weld when it cools.

When cementing joints the intermediate material - the adhesive uses its ability to achieve intimate intermolecular contact through the "wetting" of the surfaces of each material being joined to form a surface attachment.

Water can be termed an adhesive, because it exhibits limited surface attachment. It fails to hold because it has extremely low shear strength, and it evaporates. Silicone bathtub sealant is another material, although not classed as an adhesive, which exhibits surface attachment. I use it to mount replacement motors in locomotives - it permits alignment before it sets, it dampens vibration, and though not considered an adhesive, holds the motor in place.

DEFINITION OF AN ADHESIVE

Adhesives are substances capable of holding materials together by surface attachment.

CATEGORIZING ADHESIVES

There are two major categories of adhesives, Natural, and Synthetic. The synthetic adhesives have virtually taken over the adhesives market, mainly because they are high-strength, moisture-

CATEGORIZING ADHESIVES - continued

resistant and can be produced in many readily usable forms.

NATURAL ADHESIVES

The only Natural adhesives used in model railroading are rubber based such as ***Elmer's RUBBER CEMENT***, all other adhesives are synthetic.

Just a note here - the term glue is widely misused to refer to all types of adhesives, but strictly speaking a glue is a natural protein derivative adhesive, that is, a gelatine-like adhesive made from animal or vegetable protein.

SYNTHETIC ADHESIVES

Virtually all of synthetic adhesives are made up of polymeric resins. Polymers are substances composed giant molecules formed by the union of two or hundreds of thousands of simple molecules. The simple molecules that will undergo such a change are known as monomers, and their union is called polymerization. The monomer molecules may be all alike, or there may be two or more varieties of monomer involved in the formation of a single polymer. Many polymeric materials offer a high degree of strength, and often the flexibility necessary in adhesive applications.

Synthetic adhesives can be further categorized into two main sub-categories: Thermosetting and Thermoplastic. A third category, which sometimes straddles the two, is the elastomer-based adhesives. Lets look at the first group, which includes contact, and epoxy cements.

SYNTHETIC THERMOSETTING ADHESIVES

These are adhesives that won't soften with heat, therefore they don't weaken in high heat applications. Adhesives included here are the contact, epoxy, and polyurethane cements.

a) Contact Cements

Contact cements are neoprene or synthetic rubber based. They are so named because of their application method. Adhesive is applied to the surface of the materials being cemented. After a waiting period to permit evaporation of the carrier, the two surfaces of adhesive are brought together and upon contact form a bond. The joint which results has good flexibility (high shear strength), and high bond strength (500 PSI). There are two types of contact cement, both capable of forming strong, flexible joints.

The first type uses neoprene in naphtha or toluol carriers. These adhesives are fast drying, but are highly flammable, give off toxic fumes, and should be used only in well-ventilated areas. Examples of these include ***Lepage's CONTACT CEMENT***, or ***Goodyear's PLIO-BOND***.

The second type of contact cement also uses neoprene as a base, but uses a water-based carrier, which is non-flammable, and doesn't give off toxic fumes. An example of this one is ***Home Hardware's LATEX CONTACT CEMENT***.

SYNTHETIC THERMOSETTING ADHESIVES - continued

Latex contact cement is preferable because it is safer and healthier to use in the usually closed areas of our model railroad areas.

b) Epoxy Cements

These adhesives come in the two part form - a resin, and a catalyst. These are the strongest of all synthetic adhesives, often capable of bond strengths that exceed a ton per sq. in. They harden entirely by chemical action. There is no solvent evaporation so they don't shrink. They work as well on non-porous materials (metal) as on porous ones (plastic). They also fill gaps well.

Adhesives in this category include ***Lepage's 5-MINUTE EPOXY, Elmer's SUPERFAST EPOXY***, ***Goldbergs JET & EPOXY PLUS***, and ***Ambroid's HOBBYPOXY***.

c) Polyurethane Cements

Polyurethane adhesives are extremely flexible and are used in bonding other rubber-like or flexible material. An example is ***Dow Corning URETHANE CEMENT***.

This is the only adhesive that works well on Delrin plastic which is a very flexible and "slippery" plastic. Delrin plastic is used in parts such as MDC and Athern wheelsets, Atlas diesel handrails etc.

SYNTHETIC THERMOPLASTIC ADHESIVES

Thermoplastic adhesives under normal temperatures can supply the strength needed for a variety of uses. They can be softened by heat, and when they soften, they tend to loose strength. However, when cooled, they reharden without undergoing any chemical change or permanent strength loss. This category includes vinyl resins, acrylic resins, aliphatic resins, and cellulose derivative adhesives. These are the most commonly used adhesives in model railroading, and include: hot, white, yellow glues, plastic, and ACC (Cyanoacrylate) cements. Let's take a closer look at them.

a) Polyvinyl Resin Adhesives (White Glue)

White glues such as: ***Elmer's GLUE-ALL***, and ***LePage's BONDFAST*** are polyvinyl resin glues. Vinyl resins contain a vinyl (CH2=CH-) group in their molecules, and comprise the largest class of thermoplastic adhesives. They exhibit bond strengths of 2800-3500 psi. They are somewhat flexible when set which allows them to resist bending and peeling forces. They set in 30-80 minutes and cure in 24 hours. They are water soluble, so can be diluted to adjust their strengths. They have the consistency of corn syrup which makes them good gap fillers.

SYNTHETIC THERMOPLASTIC ADHESIVES - continued

b) Aliphatic Resin Adhesives (Carpenter's Glue)

Yellow glues such as ***Elmer's CARPENTER'S GLUE*** and ***LePage's SURE GRIP****;* also, white glues such as: ***PIC FLEX-WHITE*** and, ***PIC RIGID-WHITE*** are Aliphatic resin adhesives. They all exhibit bond strengths of 3000 psi+. Some are more flexible than others. That allows them to resist bending and shearing forces. They set in 20-40 minutes, and cure in 24 hours. Some are heat and moisture resistant. They are not water soluble. They have the consistency of corn syrup which makes them good gap fillers.

c) Hot Glues

Hot glues such as ***Bostik's THERMOGRIP*** have low bond strengths of 50-100 psi so are generally unsuitable for applications where strength is important, however, they remain very flexible when set. Setting time is almost instantaneous as they begin to set when they begin to cool. They can be hard to control when applying and another potential problem may be the temperature when applied - care should be taken that the heat does not damage materials being cemented.

d) Plastic Cements

Plastic cements such as ***Testors; Ambroid; Kibri*** and ***Vollmer*** are Allyl Isothiocyanate based adhesives. They exhibit good bond strength, but they are very brittle when cured thus do not resist bending or shearing forces well. They have setting times of 30 seconds to one minute and cure in 8 hours.

e) ACCs, CYAs or Cyanoacrylates

The Cyanoacrylates, monomers that polymerize spontaneously in place form excellent bonds almost instantly to a variety of surfaces. Their name comes from cyano meaning from the cyanogen group which with other elements forms various cyanides. In the adhesive it acts as the hardener; and acrylates which are resins derived from acrylic acid, a liquid organic acid that polymerizes readily. Acrylic resins are any group of transparent thermoplastic resins, these resins form the body of the adhesive.

These adhesives exhibit excellent bond strength. A good joint could exhibit bond strength in the vicinity of 5000 psi. As a member of the thermoplastic group, when heated they tend to weaken, but when cooled reharden with minimal loss of strength. They form very rigid joints giving it a low resistance to bending forces. They form brittle joints when cured, and therefore do not exhibit much resistance to shear forces. When struck obliquely the joint will usually fail surprisingly easily. They are not suited for use on pants where materials with different coefficients of expansion are involved such as brass and styrene.

One nice property about these adhesives is that they are available with various setting times. Setting times can be as quick as 30 seconds, or as slow as 3-4 minutes depending on the ACC used. Curing time of 2 hours are usually the same no matter the setting time. The quick setting time comes in handy when modeling, but it has a drawback - the accelerant for ACC is water. Ever wonder why when you get adhesive on your fingers they stick together before the parts of the model being glued stick together. It's simple the natural moisture on your skin accelerates the

SYNTHETIC THERMOPLASTIC ADHESIVES - continued

setting time of the adhesive. For this reason it is important to keep these adhesives away from eyes, noses, and mouths especially those of children. Adhesive of this group are used in medical surgical procedures in place of stitches because of their speed, permanence and strength.

THE MECHANICS OF CEMENTED JOINTS

It is important to understand the mechanics of a joint so we can choose the correct adhesive for each applications to achieve maximum strength and flexibility. Two major factors which determine the strength of a joint are: **Forces Present** and **Strength of Materials**.

a) Forces In A Joint

There are four main forces that act on a joint shown in Fig 1.

SHEAR - Shear results when a "sideways" or lateral force is applied.

TENSION - Tension results when a "pulling" or longitudinal force is applied.

BENDING - Bending results when a "rotating" force is applied.

PEELING - Peeling occurs when tension and bending forces combine at the edge of a cemented joint. Joints glued with Plastic, ACC, or Epoxy glue resist shear and tension forces well, but don't stand up very well to the bending and peeling forces. On the other hand joints glued with yellow, white, contact or rubber based cements resist the bending and peeling well, but are not as resistant to shear and tension.

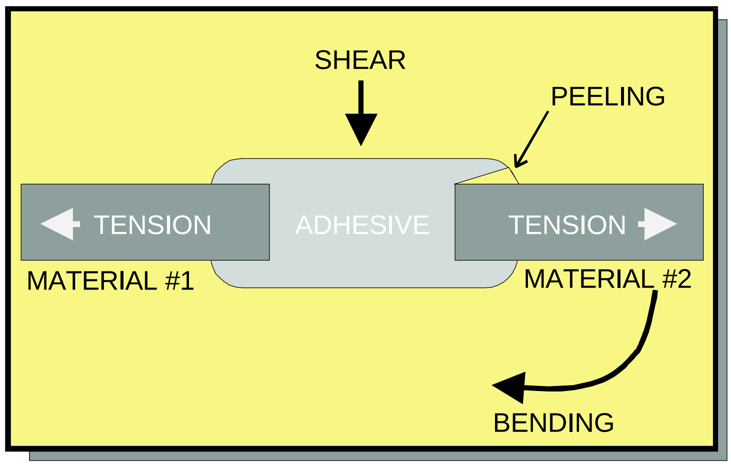

Fig 1: THE FORCES IN A JOINT

b) Strengths in a Joint.

A joint is like a chain, the chain of a glued joint is made up of five links each of varying strength. Like a chain a glued joint is only as strong as its weakest link. Let's look at the five "links" of a glued joint. The first link in the chain is the Inherent Strength of Material #1. The second link is the Bond Strength of the adhesive to Material #1. The third link is the Inherent Strength of the Adhesive. The fourth link is the Bond Strength of the adhesive to Material #2 and the final link is the Inherent Strength of Material #2.

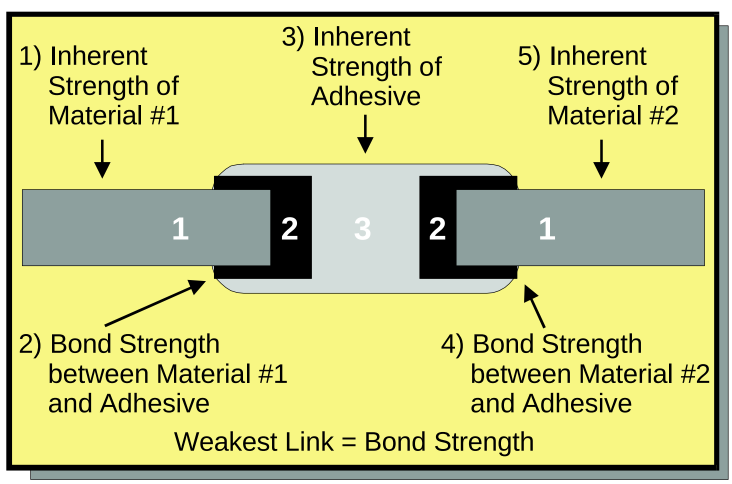

Fig 2: PARTS OF A JOINT

INHERENT AND BOND STRENGTH

Inherent Strength is the internal strength of a material as manufactured, and is generally the stronger. ***Bond Strength*** is the ability of an adhesive to achieve "Intimate Inter-Molecular Contact" or polymerization with a material and is the weakest link in the chain.

There are several factors a modeler can control when making glued joints which will determine the ***Bond Strength*** in a joint. Lets look at a few of these factors.

a) Joint Cleanliness: Make sure surfaces of material being glued are free of oil, grease, dirt or acid. Failure to do so will inhibit the polymerization process of the glue to the material.

b) Surface Smoothness: Make sure that the edges of the material forming the joint are as smooth as possible. Rough edges increase the ***"Bonding"*** area in a joint, and this area of the joint forms the weakest link in the chain.

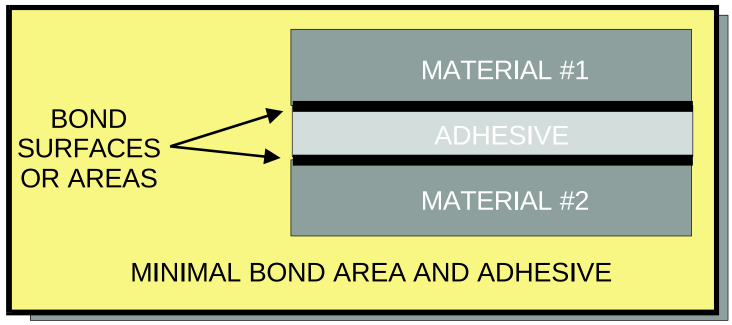

Fig 3a: ANATOMY OF A GOOD JOINT

Remember this:

SURFACE SMOOTHNESS = MINIMAL BONDING AREA = MAXIMUM BOND STRENGTH

c) Joint Dryness: Wetness reduces the bond strength of most adhesives.

d) Immobilization of Joint: Joint movement while curing bond strength.

e) Glue Selection: Adhesive bond strength ratings vary. The wicking ability of an adhesive is important to ensure maximum penetration of the adhesive into the joint cavity in order to achieve maximum bonding area, thereby increasing bond strength. The flexibility of the adhesive affects the bond strength in some cases.

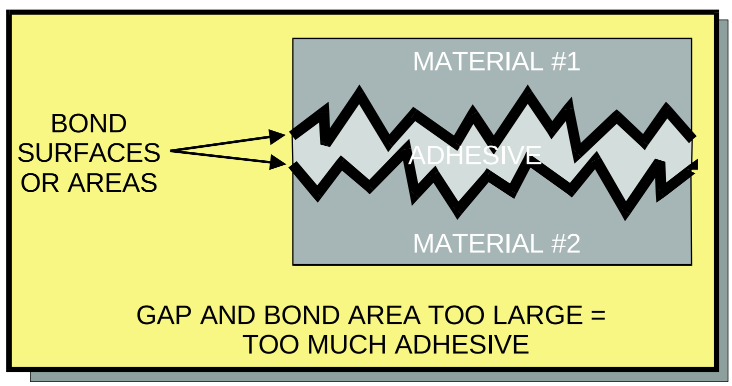

Fig 3b: ANATOMY OF A POOR JOINT

f) Joint Tightness: Ensure that joint gaps are minimal. Larger gaps between pieces require the use of more adhesive. Remember the adhesive's inherent strength is the second weakest link.

"ACC's" OR CYANOACRYLATES

ACC is a short-term used to describe the Cyanoacrylate family of adhesives. "Cyano" comes from the Cyanogen group of elements that form the various Cyanides, in ACC it acts as the hardener. "Acrylates" are acrylic resins, which are the body of the ACC. Acrylic resins are any group of transparent thermoplastic resins an example being Lucite. The "bonding" action of ACC results from instant polymerization with materials being cemented.

PROPERTIES OF "ACCs"

a) Bending & Peeling Forces: ACCs form very rigid joints giving them low resistance to bending forces, and also joints that are susceptible to peeling action. Because of this ACCs are not suitable for use on joints subjected to bending or flexing actions.

b) Shear Force: ACCs form brittle joints when cured, and therefore do not exhibit much resistance to shear forces. When struck obliquely the joints will break surprisingly easily. ***ACCs*** are not the best adhesives for cementing materials with different coefficients of expansion such brass & styrene as their expansions will set up shear forces.

c) Tension Force: ACCs do resist tension forces extremely well due to their ability to achieve high bond strength.

d) Bond Strength: ACCs can achieve bond strength in the vicinity of 5000 psi if used properly.

e) Resistance to Heat: As a member of the thermoplastic group of adhesives, ACCs when heated tend to weaken, but when cooled again, they re-harden without losing much of their "bond strength".

THE "ACC" SYSTEM

ACCs are really a "system" of adhesives which includes adhesives with varying characteristics for use in different applications, plus debonders, and accelerants. There are three basic "ACC" adhesives which all exhibit different set times, viscosity's, strength, etc. Let's examine each and see where each can be used.

a) "Fast" ACCs: ACCs such as ***Satellite City HOT STUFF***, ***Pacer ZAP-A-GAP***, ***Goldbergs SUPER JET***, and ***Pic QUICK CURE*** have the fastest setting times of about 5-10 seconds. They have the consistency of water therefore have the best "wicking", or penetrating action of all the ACCs. Their thin consistency however makes them poor gap fillers, which causes them to have relatively low bond strength. Joints cemented with these ACCs must have as near a perfect fitting joint as possible to reduce gap and bond areas. These ACCs are most useful for quickly and securely "tacking" and "framing" materials being cemented by taking advantage of the rapid setting time.

b) "Medium" ACCs: ACCs such as ***Satellite City SUPER-T***, ***Pacer PLASTI-ZAP CA++***, ***Goldbergs INSTANT JET***, and ***Pic BEST CHOICE CYA+O*** have setting times of 10-30 seconds. They have the consistency of "syrup", so their "wicking" ability is poorer. When used on joints with

THE “ACC” SYSTEM - continued

small gap and bond areas these ACCs will have a high "bond strength" if joints are well prepared. Due to the poorer "wicking" ability the preferred method is to pre-fit your joints, secure the joint by "tacking" the materials using a "fast" ACC, finally cement the joint with the "medium" ACC. An alternate method if you have pre-fitted your joints is to apply the medium ACC to the materials being cemented prior to making the joint, remember however you'll have <30 seconds to fit the joint after applying the ACC. This group of ACCs is the most commonly used and are the easiest ACC to work with.

c) "Slow" ACCs: ACCs such as ***Satellite City SPECIAL T***, ***Pacer SLO-ZAP***, ***Goldbergs SLOW JET*** and ***Pic SLOW-CURE*** have setting times of 30-50 seconds. They have the consistency of "cold honey", and thus have little or no "wicking" ability. These ACCs are excellent for filling large gap and bond areas while maintaining high "bond strength". Once again pre-fit your joints "tack" the joints with a "fast" ACC and apply the "slow" ACC to cement the joint. You can also apply the ACC to the materials prior to making the joint.

d) "ACC" Accelerants and Debonders: As mentioned ACCs are a "system" of adhesives with the various applications and uses. To compliment the adhesives are "accelerants" and "debonders".

e) Accelerants: Accelerants are used to speed up the set times of the ACCs. Some available are ***Satellite City NCF***, ***Pacer ZIP-KICKER***, and ***Pic PRONTO***. They are useful where speed of set time is important, but for strength, and gap filling purposes you need to use slower setting ACCs. Some leave a residue that usually washes off.
WATER IS AN ACCELERANT FOR ACC!

If you ever wondered why your fingers stuck together long before the pieces you're trying to cement stick together, it because the natural moisture on your skin acts as an accelerant shortening the set time of the ACC. For safety it is important that you keep ACCs away from your eyes, nose, and mouth.

f) Debonders: Debonders such as ***Satellite City ULTRA SUPER SOLVENT***, ***Pacer DEBONDER***, ***Goldbergs JET DESOLV***, and ***Pic APART*** soften ACCs permitting disassembly of cemented joints and easy cleaning from hands, clothing. Most are water-based, and will not damage most plastics. The old stand-by nail polish remover will also work, but take care that it won't damage the materials you're working with.

TROUBLE SHOOTING "ACC's”

a) Cold Glue: Never use "cold" ACC. Allow the ACC to come to room temperature prior to use. Cold ACC slows the setting time.

b) Joint Immobilization: It is important that joints remain immobilized during the ACC's setting period. Movement in a joint during the setting period cause the "bond" strength to drop dramatically, and may even totally destroy the bond.

TROUBLE SHOOTING “ACC’s” - continued

IMMOBILIZE YOUR JOINTS USING CLAMPS, JIGS OR WHATEVER PRIOR TO APPLYING THE ADHESIVE. IF JIGS OR CLAMPS ARE NOT POSSIBLE, "TACK" THE JOINTS USING A "FAST" SETTING ACC.

c) Too Much Glue: Too much glue results in an increase in the setting time, and makes it more difficult to maintain immobilization. Using too much glue usually occurs when you use the wrong ACC with the wrong consistency. Use the right ACC and apply it sparingly.

d) Too Much Gap Area: Too much gap area created by rough fitting joints requires excessive amounts of ACC, and increases the critical "bonding" area which is the weakest area in a joint.

Prepare the surfaces to be joined carefully, pre-fit all joints, and make joint areas as smooth as possible to ensure tightness.

e) Surface Contamination: The presence of contaminants such as oil, grease, dirt, and acid results in slower setting times, and dramatically reduce the "bond" strength in the joint. Wash all joint areas with household vinegar to remove oils, and grease. Use soapy water to neutralize the acidity of the vinegar, and dry the joints thoroughly.

f) Compatability: Some ACCs may react with some materials causing marring or even worse. Always check the compatibility of the ACC with the material to be cemented on a sample piece of the material.

Observe these 6 basic steps, and your ACC joints can achieve "bond strength" up to 5000 PSI.

REMEMBER THE WEAKEST LINK IN THE JOINTS IS THE "BOND" STRENGTH BETWEEN THE ADHESIVE AND MATERIALS BEING GLUED. IF YOU WEAKEN THIS LINK, OR INCREASE THE SIZE OF THE LINK YOUR JOINT WILL BE MORE SUSCEPTIBLE TO FAILURE.

SHELF LIFE OF "ACC's"

Shelf Life At Ambient Temperature:

1/4 oz Bottle - 6 Months
1/2 oz Bottle - 9 Months
1 oz Bottle - 12 Months
2 oz Bottle - 12-18 Months
4 oz Bottle - 2 Years

In the world of adhesives, ACCs have relatively short shelf life. Improper storage will lead to shorter shelf life. Unopened bottles of ACC may be stored indefinitely in a freezer, or fridge. Once opened, bottles of ACC will progressively thicken until they harden completely. As the ACC thickens it's setting time will increase anywhere from a few seconds, to 20x the normal time. The "bond strength" is affected to some degree, but not significantly.

SHELF LIFE OF "ACC'S" - continued

NEVER RETURN AN OPENED BOTTLE OF "ACC" TO COLD STORAGE.

Each time you place a bottle of ACC in a cool area, the air trapped in the bottle cools and condenses to form water. Remember water is an hardening accelerant, so the storing in a cool place shortens the shelf life. To store your ACC simply close it up tightly and store at room temperature.

SAFETY WITH GLUES

Safety rules vary for various adhesives, but here are some basic rules that should be followed with all adhesives.

Store out of reach of children, and supervise children when they are using adhesives.

When using an adhesives make sure the area is well ventilated. Some adhesives give off very toxic and harmful odors when open, and while curing.

Always have the correct debonding agent handy in case you have an accident and get the adhesive on yourself or parts and it has to be removed.

Wear personal protective equipment such as safety glasses, or a shield, and appropriate gloves to avoid skin contact.

Some adhesives and the fumes they give off are highly flammable so avoid having open flames in the area.

Finally always read the labels on the container to familiarize yourself with the properties and safety precautions specific to the adhesive you are about use.

ADHESIVE SELECTION CHART

Coding: CC - Contact Cement
CC* - Contact Cement (water base)
CYA - Cyanoacrylate (ACC)
DC - Dow Corning Urethane Bond
EP - Epoxy
LC - Liquid Plastic Cement
PC - Plastic Cement (tube)
RC - Rubber Cement
SC - Silicone Glass and Ceramic Cement (Elmer's Dow Corning)
WG - White Glue
YG - Yellow Glue

	GLASS, CHINA, PORCELAIN	WOOD	PAPER	METAL	STYRENE	RUBBER, CORK VINYL	DELRIN	FOIL	CARDSTOCK
GLASS, CHINA, PORCELAIN - structures - 'soft' mounting motors - 'soft' mounting weights	SC	YG WG CC EP	WG CC	CC EP	EP	CC	DC	CC	CC
WOOD - benchwork - wood kit construction - ballasting, scenery	WG YG CC EP	WG YG	WG YG RC SC	EP CYA CC	EP CYA CC	CC	DC	CC	WG YG
PAPER - structures - siding, roof - scenic backdrops	WG CC	WG YG	WG YG RC	CC EP	CC	CC	DC	CC	WG YG
METAL - metal structures/parts - metal loco kits and detail - track laying	CC EP	EP CYA CC	CC	EP CC CYA	EP CC CYA	CC	DC	CC	EP CYA

ADHESIVE SELECTION CHART - continued

	GLASS, CHINA, PORCELAIN	WOOD	PAPER	METAL	STYRENE	RUBBER, CORK VINYL	DELRIN	FOIL	CARDSTOCK
STYRENE - plastics (test glue on plastic sprue for marring)	EP	EP CYA *CC	PC *CC	EP *CC CYA	LC *CC	*CC	DC	*CC	EP *CC
RUBBER, CORK, VINYL - cork roadbed - scenic materials	CC	CC	CC	CC	CC	CC	DC	CC	CC
DELRIN - wheelsets, couplers	CC	CC	CC	CC	CC	CC	DC	CC	CC
FOIL - structures	CC	CC	CC EP	CC EP	CC EP	CC	DC	CC EP	CC EP
CARDSTOCK - structures - backdrops	WG YG CC	WG	WG	EP	EP	CC	DC	CC	WG

ADHESIVES FOR USE ON THE MODEL RAILROAD

ADHESIVE	POPULAR BRAND NAMES	COMPOSITION	PROPERTIES	SET & CURE TIMES	APPLICATION TECHNIQUE	SAFETY CONSIDERATION	STORAGE & SHELF LIFE	NOTES
WHITE GLUE	Elmer's Glue-All Lepage's Bond Fast Ambroid Se-Cur-It Weldbond John's Lab	Usually polyvinyl acetates	Water soluable Some flexibility when set 3000-3500 psi strength Good gap filler Consistency of corn syrup	Sets in 30-60 min Cures in 24 hrs	Apply sparingly in thin layers using a brush	Non-flamable Non-toxic Low odor Non-toxic fumes	Indefinite if capped and stored at room temp	Use on porous materials such as: wood; paper; cork; etc.
YELLOW GLUE	Elmer's Carpenter Lepage's Sure Grip Testors		Consistency of corn syrup Moisture proof Heat resistant Excellent strength	Sets in 30 min Cures in 24 hrs	Apply sparingly in thin layers using a brush	Non-flamable Non-toxic Low odor Non-toxic fumes	Indefinite if capped and stored at room temp	Use on porous materials such as: wood; paper; cork; etc. Because it is more heat resistant it will sand better than white glue

ADHESIVES FOR USE ON THE MODEL RAILROAD - continued

ADHESIVE	POPULAR BRAND NAMES	COMPOSITION	PROPERTIES	SET & CURE TIMES	APPLICATION TECHNIQUE	SAFETY CONSIDERATION	STORAGE & SHELF LIFE	NOTES
PLASTIC CEMENT (Liquid)	Testors Volimer Roco Faller Expert Faller Perfect Kibri Plastruct Micro Scale Tenax 7R Pacer Plasti-Zap	Acetone Ketone	Consistency is anywhere from watery to cold syrup Thinner brands have good penetration Brittle dry Some bond Good strength	Some set immediately Others vary from ½ to 2 mins set time Cure times vary from 12-24 hrs	Use needle applicators for thin brands Use a brush for thicker brands Apply sparingly	Flamable Toxic Irritant to skin and eyes Remove using acetone (ie. Nail polish remover)	Store at room temp Shelf life is good if kept capped	Should be used where materials being joined mate tightly Thicker brands can be thinned using acetone
PLASTIC CEMENT (Tube)	Testors Pactra Faller Uni-Fix Roco Ambroid Floquil	Acetone Ketone	Consistency of cold honey Brittle dried	Sets in 2-3 mins Cure time 24 hrs	Difficult to apply	Flamable Toxic Irritant to skin and eyes Remove using acetone (ie. Nail polish remover)	Store at room temp Shelf life is good if kept capped	These glues are thick, messy and tend to glob when used, not the best to use in tight modeling situations
CONTACT CEMENT	Walthers Goo Goodyear Pliobond Lepage's Silicone, Glass and Ceramic Cement	Synthetic rubbers with acetone solvents	Consistency of cold honey Very flexible Waterproof Good strength Good gap filler	Sets in 5-10 mins Cure time 24 hrs Takes up to 7 days to achieve max strength	Coat each piece with a thin layer and allow to air dry before joining parts When parts are brought together bonding takes place on contact and is permanent Temporary bonding can be achieved by applying the adhesive to only one part	Extremely flamable Toxic fumes Skin contact to be avoided Gives off high odor	Store at room temp Shelf life is excellent if kept sealed	Will not accept paints well Technically Pliobond is a natural rubber cement but acts like a contact cement
RUBBER CEMENT	Elmer's Rubber Cement	Natural rubbers with solvents	Consistency of syrup Flexible Waterproof Moderate strength	Same as contact cements	Apply sparingly in thin layers	Extremely flamable Toxic fumes Gives off high odor	Store at room temp Shelf life is good if kept sealed	Will not accept paints well
EPOXIES	Lepage's 5 Minute Epoxy Elmer's Epoxy Elmer's Superfast Epoxy Ambroid Hobbypoxy	Two part cement consisting of a resin and a hardener or catalyst	Consistency of cold corn syrup Brittle dry Good gap filler Heat resistant up to 250°F Strongest of all adhesives if used correctly	Sets in 5-30 mins depending upon amount of hardener used Cure time 24 hrs	Two part cement is in separate tubes need to be mixed, unless 'Siamese' twin dispenser is used	Toxic chemicals avoid skin contact, wash with alcohol to remove Gives of a mild odor	Store two parts separately at room temp	Two parts require mixing which is messy, time consuming and can be wasteful Getting the correct mix for full strength is critical

ADHESIVES FOR USE ON THE MODEL RAILROAD - continued

ADHESIVE	POPULAR BRAND NAMES	COMPOSITION	PROPERTIES	SET & CURE TIMES	APPLICATION TECHNIQUE	SAFETY CONSIDERATION	STORAGE & SHELF LIFE	NOTES
CYANOACRYLATES (Alpha-Cyanoacrylates ACC) (CYa)	Satellite City Hot Stuff Goldbergs Jet Pic Quick Cure Krazy Glue Regular Pacer Zap CA	Cyanogens (cyanide radical and acrylics such as Lucite)	Consistency of water Good penetration Use where parts are tight fitting Good for "tacking" parts together during assembly Good 'strength Brittle dry	Sets in 0-10 secs Cures in 2-3 hrs	Use Teflon needle applicator and apply sparingly allowing cement to flow into joint	Extremely flamable Highly toxic, fumes given off while curing Bonds instantly, so avoid skin contact To remove use Acetone or nail polish remover or solvent supplied by manufacturer	¼ oz - 6 mo ½ oz - 9 mo 1 oz - 12 mo 2 oz - 1 yr+ Store at room temp once a bottle is opened Unopened bottles may be stored indefinitely in a freezer at or below 0°C (32°F) NEVER RETURN AN OPENED BOTTLE TO COLD STORAGE As life expectancy passes, CYa's tend to thicken until they harden. This thickening does not effect strength.	When using the fast setting Cya, fit parts together before applying the adhesive. Make sure all surfaces are free of surface contaminations such as oil, grease, dirt and moisture. Never use these glues cold, allow them to come to room temperature before use. Moisture effects the strength of the glue, cold causes condensation in opened bottles.
	Satellite City Super T Goldbergs Jet Krazy Glue Gel II Pic Best Choice Pic Plastic CYa Pacer Zap-A-Gap		Consistency of syrup Good for filling small gaps Brittle dry	Sets in 10-20 secs Cures in 10-12 hrs	Apply sparingly to each part prior to mating parts, or apply a thin seam to mated parts			
	Satellite City Special Super Pic Slow Cure Pacer Flex Zap		Consistency of cold honey Excellent gap filler Better flexibility than faster Cyas Strengths up to 5000 psi	Sets in 20-50 secs Cures in 24 hrs	Apply sparingly to each part prior to mating parts			