Epoxies

Why shouldn't I use fast setting epoxies like Devcon 5-minute epoxy?

A number of preparators have stopped using 5 minute (quick set) epoxy because they have noticed that it quickly turns yellow, sometimes within a few months. Yellowing is a chemical change that is often an early warning sign that the polymer is degrading. In some cases yellowed joins made with five minute epoxy have been observed to stay strong for years, but in other cases it becomes deep orange, brittle or rubbery and joins have fallen apart. (see photos) As a result these preparators have decided it is too risky and that other adhesives are a better bet for permanent applications.

Is there an explanation for this?

Yes. Epoxies set by a chemical reaction between two components in a particular proportion. That means all the components have to "find each other". All epoxies need to be carefully measured (weighing is best), and mixed very thoroughly in order to have a complete reaction. In addition, as epoxy sets and becomes rigid the diffusion of the components slows and then stops (see Wilks 1987 pp.53-55 for a description of this). Quick set formulas are more likely to trap unreacted components which render the polymer chemically unstable. This is especially true if the components are measured by eye, mixed carelessly or are past their shelf life (most epoxies expire after about one year).

Tips on measuring and mixing epoxies from Bill Simpson, Chicago Field Museum:

For small batches - I use a spatula and some sort of disposable paper surface like a pad of paper. I make equal puddles of epoxy, and then mix quickly with the spatula. If you look closely, the two components make streaks in each other as they mix and so I look for any streaks when I am done. I also scrape the entire single united puddle several times and reapply it to the paper to make sure there is no unmixed epoxy around the perimeter. Using some sort of measuring "cup" is problematic for small batches as it is difficult to interpret the volume and it is difficult not to leave a bit behind in the "cup".

For larger batches - I weigh the two components and use an 8 oz waxed paper cup and stir with an aluminum rod (which has a diameter about that of a dime). Because the rod's geometry is so similar to the inside of the paper cup, I can use the rod to get down into the bottom edges of the cup and thoroughly introduce all the epoxy into the mix.

Is there something better for joining heavy elements?

Yes. For high strength applications (such as joining heavy elements) use slower setting epoxies such as Devcon 2 ton which has been shown in tests to yellow more slowly. Slow set formulas are stronger anyway- just compare the technical datasheets (link to Devcon technical data sheets). The best quality, least yellowing epoxies set very slowly over days- these include Epo-Tek 301 or 301-2, and Hxtal Y-1. Others with more reasonable setting times have also been shown to be relatively stable including Araldite AY103/HY991 (Down, 1984,1986 and 2001). Temporary tacking with quick set epoxy to hold a join while a slower adhesive sets is another possible solution.

Is there something better for quick assembly?

Yes. For quick assembly of elements that are not extremely heavy Paraloid B-72 in acetone is an excellent substitute for 5 minute epoxy. It is very sticky, with medium strength if applied properly and has been shown in tests to remain optically clear and chemically stable over time. As with any adhesive, technique matters. Try thick B-72 (50% weight/weight) in acetone. Sometimes pulling the join apart several time helps develop tack (see Koob for a description of

this technique). Another technique is to coat the contacts, allow to dry, assemble and reactivate by injecting acetone with a syringe.

This table compares Devcon rapid setting (5 minute) epoxy versus the slower setting Devcon 2-ton epoxy with the properties of an acrylic resin Paraloid (formerly known as Acryloid) B-72 in acetone.

Adhesive property	**Devcon 5 min. epoxy**	**Devcon 2 ton epoxy**	**Paraloid (Acryloid) B-72 50% w/w in acetone**
Setting type	Chemical reaction	Chemical reaction	Solvent evaporation
Shelf life unmixed	Most epoxies- one year	Most epoxies-one year	unlimited
Commercial formula changes possible?	yes	yes	unlikely
Measuring error possible?	Yes for all epoxies unless weighed	Yes for all epoxies unless weighed	no
Mixing error possible?	Yes for all epoxies	Yes for all epoxies	no
Working time	3-6 minutes	8-12 minutes	Indefinite- can be redissolved and reworked.
Ease of application	easy	easy	Easy but can be stringy (might require practice)
Surface wetting	Needs help spreading	Very good	Thick needs help spreading. Can thin or pre-wet with solvent.
Tackiness	Quite tacky	Increases with set	Extremely tacky
Tiny drop set time	fast	Normal or slower	Extremely fast but resoluble.
Assembly time	10-15 minutes Fast enough to hand clamp	30-35 minutes Too slow to hand clamp	Instant if porous or very good contact, can hand clamp. Can also speed with proper technique.
Full cure to maximum strength	12 hours	12 hours	can retain residual solvent a long time
Penetration into porous substrate	Less than 2 ton	Very good but could "starve" the joint	Poor but can prime with dilute B-72 in ethanol
Gap filling	yes	Yes, can also bulk with a filler	Yes, can also bulk with a filler
Traps bubbles?	Bubbles possible	Less likely to trap bubbles	Yes if applied thick
Clean up excess	Mechanical after set	Mechanical after set	Bubbles aid clean-up. Mechanical or solvent
Undoing a join	Difficult, may soften with heat.	Difficult, may soften with heat.	Easy before complete set, takes longer after complete set (can use poultice)
Strength of well-made bond (before aging)	All epoxies very strong-weaker than 2 ton	Stronger than 5 minute (hence the name)	Medium strength, less than all epoxies
Yellowing with age	Rapid yellowing, sometimes severe.	some yellowing (most epoxies tend to yellow)	No yellowing
Aging and bond strength	Not tested. Has been observed to fail in some cases.	Tested (CCI) No appreciable loss of strength.	Extensively tested- extremely stable over time, no loss of strength.

Epoxies

References:

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Davies, K., Sam Nobel Oklahoma Museum of Natural History. Personal communication.

Devcon 5 minute Epoxy Technical Data Sheet 7/23/2004

Devcon 2 Ton Epoxy Technical Data Sheet 7/23/2004

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Horie, C.V. 1987. Materials for Conservation.London: Butterworths: 170-175.

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Technical Data Sheet

7/27/2004

5 Minute® Epoxy

Description: A rapid-curing, general purpose adhesive/encapsulant.

Intended Use: Bonds metals, fabrics, ceramics, glass, wood, and concrete (in combinations)

Product features:
100% reactive, no solvents
Good solvent resistance
Bonds metals, fabrics, glass, wood, and concrete

Limitations: None

Typical Physical Properties:

Technical data should be considered representative or typical only and should not be used for specification purposes.

Cured 7 days @ 75° F

T-peel	**2-3 pli**
Impact Resistance	**5.5 ft.lb./in.(2)**
Tensile Elongation	**1%**
Shore Hardness	**85 Shore D**
Gap-Fill	**Good**
Dielectric Strength	**490 volts/mils**
% Solids by Volume	**100**
Adhesive Tensile Lap Shear[GBS]	**1,900 psi @ 0.005" bondline**
Specific Volume	**25.1 in.[3)/lb.**

TESTS CONDUCTED

Adhesive Tensile Shear ASTM D 1002
Dielectric Strength, volts/mil ASTM D 149
Cured Hardness Shore D ASTM D 2240
Cured Density ASTM D 792

Uncured

Color	**Light Amber**
Mixed Viscosity	**10,000 cps**
Mix Ratio by Volume	**1:1**
Mix Ratio by Weight	**1:1**
Mixed Density	**9.17 lbs./gal.: 1.10 gm/cc**
Working Time	**3-6 min. (28 gm @ 72°F)**
Fixture Time	**10-15 min. @ 72°F**
Functional Cure	**3/4 - 1 hr. @ 72°F**
Full Cure	**12**
Service Temperature	**Dry, -40°F to 200°F**

Surface Preparation: Clean surface by solvent-wiping any deposits of heavy grease, oil, dirt, or other contaminants. Surface can also be cleaned with industrial cleaning equipment such as vapor phase degreasers or hot aqueous baths. If working with metal, abrade or roughen the surface to significantly increase the microscopic bond area and increase the bond strength.

Mixing Instructions: ---- Proper homogenous mixing of resin and hardener is essential for the curing and development of stated strengths. ----

25 ML DEV-TUBE
1. Squeeze material into a small container the size of an ashtray.
2. Using mixing stick included on Dev-tube handle, vigorously mix components for one (1) minute.
3. Immediately apply to substrate.

50 ML/400ML/490 ML CARTRIDGES
1. Attach cartridge to Mark 5 dispensing system.
2. Open tip.
3. Burp cartridge by squeezing out some material until both sides are uniform (ensures no air bubbles are present during mixing).
4. Attach mix nozzle to end of cartridge.
5. Apply to substrate.

Application Instructions:
1. Apply mixed epoxy directly to one surface in an even film or as a bead.
2. Assemble with mating part within recommended working time.
3. Apply firm pressure between mating parts to minimize any gap and ensure good contact (a small fillet of epoxy should

flow out the edges to display adequate gap fill.)

For very large gaps:
1. Apply epoxy to both surfaces
2. Spread to cover entire area OR make a bead pattern to allow flow throughout the joint

Let bonded assemblies stand for recommended functional cure time prior to handling.

CAPABILITIES:
Can withstand processing forces
Do not drop, shock load, or heavily load

Storage: Store in a cool, dry place.

Compliances: None

Chemical Resistance: *Chemical resistance is calculated with a 7 day, room temp. cure (30 days immersion) @ 75°F)*

Acetic (Dilute) 10%	Poor	Hydrochloric 10%	Poor
Acetone	Poor	Isopropanol	Poor
Ammonia	Poor	Kerosene	Excellent
Corn Oil	Excellent	Methyl Ethyl Ketone	Poor
Cutting Oil	Excellent	Mineral Spirits	Excellent
Ethanol	Poor	Motor Oil	Excellent
Gasoline (Unleaded)	Excellent	Sodium Hydroxide 10%	Poor
Glycols/Antifreeze	Fair	Sulfuric 10%	Poor

Precautions: Please refer to the appropriate material safety data sheet (MSDS) prior to using this product.
For technical assistance, please call 1-800-933-8266
FOR INDUSTRIAL USE ONLY

Warranty: Devcon will replace any material found to be defective. Because the storage, handling and application of this material is beyond our control, we can accept no liability for the results obtained.

Disclaimer: All information on this data sheet is based on laboratory testing and is not intended for design purposes. ITW Devcon makes no representations or warranties of any kind concerning this data.

Order Information:

14210 2.5 oz.
14630 9 lb.
DA051 400 ml cartridge
14250 25 ml DevTube
14200 15 oz.
14270 50 ml Dev-Pak
14098 14cc syringe

Technical Data Sheet

7/23/2004

2 Ton Epoxy®

Description: Extremely strong, medium-cure, water-resistant clear adhesive that will self-level after application.

Intended Use: Bonding parts in a structural environment or potting electronic components and assemblies

Product features:
Cures without shrinking
Cures at room temperature
Good impact resistance
Produces strong, rigid bond on metal, ceramics, wood, concrete, glass, or combinations

Limitations: None

Typical Physical Properties:

Technical data should be considered representative or typical only and should not be used for specification purposes.

Cured 7 days @ 75° F

T-peel	**2-3 pli**
Impact Resistance	**6.5 ft.-lb./in.(2)**
Tensile Elongation	**1%**
Shore Hardness	**83 Shore D**
Gap-Fill	**Good**
Dielectric Strength	**600 volts/mil**
% Solids by Volume	**100**
Adhesive Tensile Lap Shear[GBS]	**2,250 psi @ 0.010" bondline**
Compression Strength	**11,000 psi**
Specific Volume	**25.2 in.(3)/lb.**

TESTS CONDUCTED

Thermal Conductivity ASTM C 177
Dielectric Strength, volts/mil ASTM D 149
Compressive Strength ASTM D 695
Cured Hardness Shore D ASTM D 2240
Adhesive Tensile Shear ASTM D 1002

Uncured

Color	**Clear**
Mixed Viscosity	**8,000 cps**
Mix Ratio by Volume	**1:1**
Mix Ratio by Weight	**1:1**
Mixed Density	**9.17 lbs/gal.: 1.10 gm/cc**
Working Time	**8-12 min. (28 gm @ 72°F)**
Fixture Time	**30-35 min. @ 72°F**
Functional Cure	**2 hrs. @ 72°F**
Full Cure	**12 hrs.**
Service Temperature	**Dry, -40°F to 200°F**

Surface Preparation: Clean surface by solvent-wiping any deposits of heavy grease, oil, dirt, or other contaminants. Surface can also be cleaned with industrial cleaning equipment such as vapor phase degreasers or hot aqueous baths. If working with metal, abrade or roughen the surface to significantly increase the microscopic bond area and increase the bond strength.

Mixing Instructions: ---- Proper homogenous mixing of resin and hardener is essential for the curing and development of stated strengths. ----

25 ML DEV-TUBE
1. Squeeze material into a small container the size of an ashtray.
2. Using mixing stick included on Dev-tube handle, vigorously mix components for one (1) minute.
3. Immediately apply to substrate.

50 ML/400ML/490 ML CARTRIDGES
1. Attach cartridge to Mark 5 dispensing system.
2. Open tip.
3. Burp cartridge by squeezing out some material until both sides are uniform (ensures no air bubbles are present during mixing).
4. Attach mix nozzle to end of cartridge.
5. Apply to substrate.

Application Instructions:

1. Apply mixed epoxy directly to one surface in an even film or as a bead.
2. Assemble with mating part within recommended working time.
3. Apply firm pressure between mating parts to minimize any gap and ensure good contact (a small fillet of epoxy should flow out the edges to display adequate gap fill.)

For very large gaps:
1. Apply epoxy to both surfaces
2. Spread to cover entire area OR make a bead pattern to allow flow throughout the joint

Let bonded assemblies stand for recommended functional cure time prior to handling.

CAPABILITIES:
Can withstand processing forces
Do not drop, shock load, or heavily load

Full bond strength is reached in 16 hours.

Storage: Store in a cool, dry place.

Compliances: None

Chemical Resistance:

Chemical resistance is calculated with a 7 day, room temp. cure (30 days immersion) @ 75°F)

Acetic (Dilute) 10%	Poor	Hydrochloric 10%	Poor
Acetone	Fair	Isopropanol	Poor
Ammonia	Very good	Kerosene	Excellent
Corn Oil	Excellent	Methyl Ethyl Ketone	Poor
Cutting Oil	Excellent	Mineral Spirits	Excellent
Ethanol	Poor	Motor Oil	Excellent
Gasoline (Unleaded)	Excellent	Sodium Hydroxide 10%	Very good
Glycols/Antifreeze	Excellent	Sulfuric 10%	Poor

Precautions: Please refer to the appropriate material safety data sheet (MSDS) prior to using this product.

For technical assistance, please call 1-800-933-8266

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Warranty: Devcon will replace any material found to be defective. Because the storage, handling and application of this material is beyond our control, we can accept no liability for the results obtained.

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Order Information:

14260 50 ml Dev-Pak
14355 400 ml cartridge
DA 039 10 gal white
DA 040 100 gal white
DA 048 100 gal black
14310 25 ml DevTube
14360 9 lb.