CPD

Infusion Product Guide

Polytek®
Development Corp.

Why Epoxy?

Under the CPD brand, Polytek Development Corp. manufactures a variety of epoxy resin systems that are well suited to the infusion process. Before delving into specifics let's take a moment to consider why you should select an epoxy for your next infusion project.

Versatility

Epoxy resin systems can be formulated with various curing agents, diluents, fillers and other additives to product an almost unlimited range of properties. The tremendous versatility of epoxy makes it possible to tailor the handling and mechanical properties of an epoxy resin system to what is needed.

No Volatile Loss

Epoxy resin systems formulated for the fabrication of structural composites are typically 100 percent solids. No byproducts, volatile or otherwise, are formed as these systems polymerize. By and large, there are no VOC (Volatile Organic Compound) issues associated with the handling of epoxy resin systems.

Chemical Resistance

Properly cured epoxy resin systems have excellent chemical resistance to acids, bases and solvents. In contrast to other organic polymers, epoxy resin systems are particularly resistant to caustic substances, which makes epoxy the ideal choice for long lasting parts.

Low Shrinkage

Epoxy resin systems exhibit little shrinkage during cure and allow for the precise reproduction of mold surfaces. The dimensional stability provided by an epoxy resin system gives rise the fabrication of composite parts and structures with lower ingrained stress levels. As a result, finished pieces are stronger and more durable than those produced using organic polymers that exhibit higher values of shrinkage.

Adhesion Reinforcement

The supreme advantage of epoxy is its excellent adhesion to almost any surface. Epoxy adheres tenaciously to a broad range of substrates, particularly those that are frequently used as reinforcement in composite parts and structures.

Carbon Fiber

Carbon fiber commonly has an epoxy binder. This binder further promotes the adhesion of epoxy to the substrate and makes an epoxy the ideal resin system for the fabrication of carbon fiber composites.

Kevlar®

Kevlar® typically does not have a binder. However, the superior adhesion characteristics of epoxy make it preferable to other organic polymers for the fabrication of Kevlar® composites.

Fiberglass

More so than carbon fiber and Kevlar® composites, fiberglass composites are susceptible to attack by water vapor. Water vapor attacks the interface between resin and reinforcement and leads to degradation of the composite structure. In the long term, epoxy provides a barrier against water vapor that is superior to other organic polymers and can be used to fabricate more durable fiberglass composites. Fiberglass is available with a wide variety of binders. Many binders have been formulated to promote the adhesion of specific organic polymers to fiberglass. It is important to select a grade of fiberglass with an epoxy compatible binder when using an epoxy resin system to construct fiberglass composites.

Core Material

Where core material has been incorporated into the design of a laminate to produce a lightweight composite structure, using an epoxy resin system can provide further weight savings. The superior adhesion characteristics of epoxy eliminate the need for a resin-rich mat between the structural reinforcement and the core material.

Selecting an Epoxy Resin System for Infusion

Various options need to be weighed when selecting an epoxy resin system for the infusion process. The considerations that need to be made fall into two categories: end-product requirements and processing requirements.

End-Product Requirements

End-Product requirements are those that apply to the function and/or use of the finished composite part or structure.

Operating Temperature

The operating temperature or service temperature of the article to be manufactured is paramount to the selection of an epoxy resin system. The heat deflection temperature (HDT) of the system selected must be greater than or equal to this intended operating temperature.

Service temperature less than 210°F – **See Table 1**

Service temperature between 210°F and 310°F – **See Table 2**

Service temperature greater than 310°F – **See Table 3**

Other Physical Properties

Other physical properties such as the desired compressive, flexural, and tensile strengths should be considered when selecting an epoxy resin system for infusion. Please refer to the physical properties listed in the lower half of Tables 1, 2 and 3 to determine if one of the CPD infusion systems meets your end-product requirements. If one of these systems does not meet your end-product requirements, we can custom tailor an epoxy resin system to meet your needs.

Process Requirements

There are five main process requirements for manufacturing a composite part or structure.

1. Cure Cycle

The first process requirement that should be considered when selecting an epoxy resin system for infusion is the desired cure cycle. Please review the capabilities of your equipment, tooling and ancillary materials when choosing a cure cycle. Please also consider the temperature your mold must withstand.

Room Temperature Cure

Composite Polymer Design offers a variety of two-part epoxy resin systems that can be cured at room temperature, 68-77°F (20-25°C)*

Elevated Temperature Cure

CPD also offers one-part and two-part epoxy resin systems that must be cured at an elevated temperature.

2. Post Cure Cycle

The second process requirement that should be considered when selecting an epoxy resin system for infusion is post cure cycle. Not all epoxy resin systems require a post cure. However, it is typically the case with epoxy that a post cure is required to develop ultimate properties. As with choosing a cure cycle, it is important to review the capabilities of your equipment, tooling and ancillary materials when choosing a post cure cycle. Again, please consider the temperature your mold must withstand.

Supported

In the first stage of a post cure cycle, a composite part or structure made using an epoxy resin system typically needs to be supported. That is, it should remain the mold to reduce the likelihood of any deformation that may occur because of thermal shock. A supported post cure is usually conducted at temperature less than or equal to 150°F to avoid damaging the mold.

Unsupported

Prior to the latter stages of a post cure cycle, a composite part or structure made using an epoxy is typically removed from the mold and post cured free standing. An unsupported post cure is usually conducted at temperatures higher than 150°F, but should not exceed the heat deflection temperature of the epoxy resin system.

3. Viscosity

Another process requirement to consider when selecting an epoxy resin system for infusion is viscosity. CPD offers a variety of low viscosity resins that have been formulated specifically for infusion. One advantage of using epoxy versus other organic polymers is that epoxy resin systems exhibit a latent build in viscosity. That is, they atypically remain low in viscosity much longer than other organic polymers, extending the work life without compromising gel time.

Input Resin Temperature

The input resin temperature is the temperature of the resin at the point it is being infused. Typically, the input resin temperature is equivalent to the ambient temperature of the shop or facility in which the resin system is being used. In some instances, the input resin temperature is raised to further reduce the viscosity of an epoxy resin system. Composite Polymer Design reports viscosity at 77°F (25°C).

Mold Temperature

Ideally, the mold temperature should be the same as the input resin temperature to maintain a consistent viscosity.

Estimate of viscosity reduction % change with temperature change

Temperature	Percent Viscosity Reduction
77°F (25°C)	0%
100°F (38°C)	45%
120°F (49°C)	70%
140°F (60°C)	85%

4. Work Life

The work life required to infuse a composite part or structure should also be considered when selecting an epoxy resin system for infusion. CPD does not report the work life of the epoxy resin systems it manufactures, because work life generally varies with mass and temperature. Rather, CPD reports the gel time of each of its resin systems in a 150 gram mass at 77°F (25°C).

Mass Dependent

The work life of an epoxy resin system is mass dependent. In a large mass, the work life of an epoxy resin system will be reduced and in a small mass, the work life will be prolonged.

Temperature Dependent

The work life of an epoxy resin system is also temperature dependent. At an elevated temperature, the work life of an epoxy resin system will be shortened and at a reduced temperature, the work life will be extended.

Work life reduction % change with temperature change

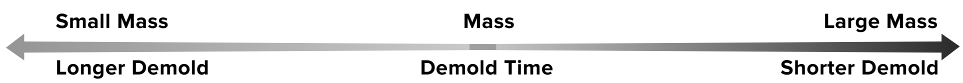
Temperature	Percent Work Life Reduction
77˚F (25˚C)	0%
100˚F (38˚C)	60%
120˚F (49˚C)	80%
140˚F (60˚C)	90%

5. Demold Time

The final process requirement that should be considered when selecting an epoxy resin system for infusion is the demold time. Demold time is the point at which the resin system has cured to a degree that a composite part or structure is strong enough to be removed from the mold. In many cases, a composite part or structure will be removed from the mold following the supported stage of a post cure cycle and in others it will be removed from the mold after a satisfactory time at room temperature.

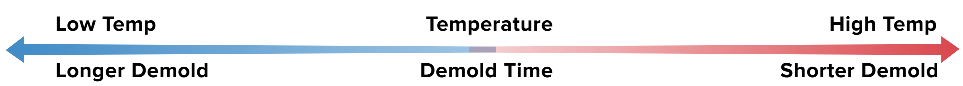
Mass Dependent

Similar to work life, the demold time of a composite part or structure made using an epoxy resin is mass dependent. In a large mass, the demold time will be reduced and in a small mass, the demold time will be prolonged.



Temperature Dependent

The demold time of a composite part or structure made using an epoxy resin is also temperature dependent. At an elevated temperature, the demold time will be shortened and at a reduced temperature, the demold time will be extended.



Type of Structural Reinforcement

Another factor that impacts demold time is the type of structural reinforcement used to build a composite part or structure. Fiberglass is a good conductor of heat, while carbon fiber and Kevlar® are better insulators. This means that, all other factors being equal the demold time of a fiberglass composite will be greater than the demold time of a carbon fiber or Kevlar® composite.

Table 1 CPD Room Temperature Infusion Systems

Room Temperature Systems	4281A/4284B	2110A/9260B	4281A/4286B	2110A/9218B	2110A/9227B	2110A/9297B
Elevated Temperature Cure Required in Mold1	No	No	No	No	No	No
Post Cure Required[1]	No	No	No	Yes	No	No
Post Cure Recommnded[1]	Yes	Yes	Yes	Yes	Yes	Yes
Handling Properties						
Resin Viscosity at 77°F, cps	900	1,200	900	1,200	1,200	1,200
Hardener Viscosity at 77°F, cps	8	30	12	40	20	30
Mixed Viscosity at 77°F, cps	150	300	220	290	300	300
Mix Ratio By Weight	100A:22B	100A:28B	100A:22B	100A:30B	100A:28B	100A:26B
Mix Ratio by Volume	100A:27B	3A:1B	100A:27B	2.5A:1B	3A:1B	3.1A:1B
Gel Time at 77°F, 150g, min.	40	50	70	85	130	290
Physical Properties						
Color	Amber	Straw Yellow	Amber	Amber	Straw Yellow	Amber
Shore Hardness	86D	84D	86D	86D	84D	87D
Tensile Strength, psi	10,300	10,800	12,500	12,600	10,300	10,700
Tensile Modulus, psi	348,000	425,000	529,000	499,000	421,000	458,000
Tensile Elongation, %	5.9	7.2	4.3	5.8	7.2	8.8
Compressive Strength, psi	18,800	14,200	15,800	16,700	13,800	12,900
Flexural Strength, psi	15,400	18,400	20,500	19,500	17,500	17,300
Flexural Modulus, psi	413,000	479,000	437,000	494,000	469,000	397,000
HDT, Post Cured, °F	180	200	210	210	190	210
Izod Impact, Notched, ft-lb/in	1.16	1.12	1.15	1.06	1.09	1.27
Shrinkage, in/in	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

1 Tooling must be able to withstand the temperatures it will be exposed to during the cure cycle and the supported stage(s) of a post cure

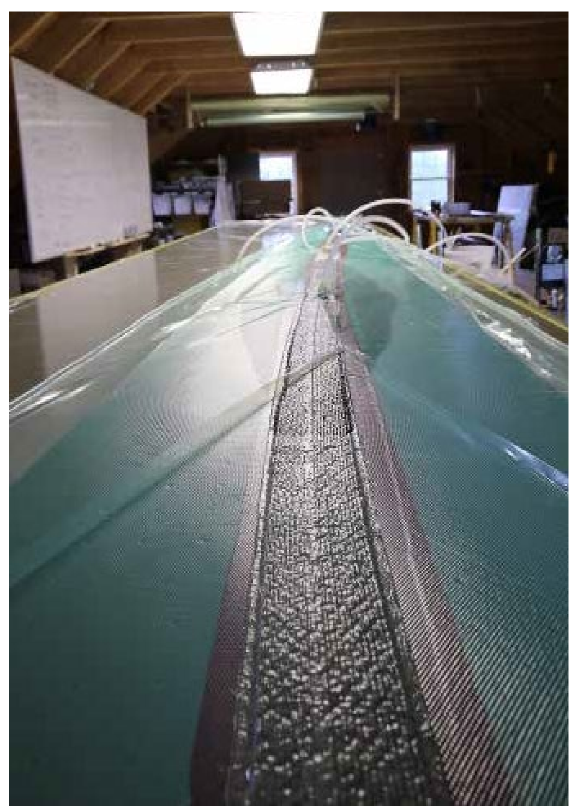


Table 2 CPD Medium Temperature Infusion Systems

Medium Temperature Systems	4310A/9239B	4310A/9234B	4310A/9235B	4310A/9231B
Elevated Temperature Cure Required in Mold1	No	No	No	Yes
Post Cure Required1	Yes	Yes	Yes	Yes
Post Cure Recommnded1	Yes	Yes	Yes	Yes
Handling Properties				
Resin Viscosity at 77°F, cps	1,200	1,200	1,200	1,200
Hardener Viscosity at 77°F, cps	15	15	20	100
Mixed Viscosity at 77°F, cps	400-600	400-600	400-600	500-700
Mixed Viscosity at 100°F, cps	200-300	200-300	200-300	250-350
Mix Ratio by Weight	100A:20B	100A:25B	100A:26B	100A:35B
Mix Ratio by Volume	4A:1B	3.2A:1B	3A:1B	2.33A:1B
Gel Time at 77°F, 150g, min.	60	110	130	500
Gel Time at 100°F, 150g, min.	25	40	50	180
Minimum Recommended Cure Temperature2 (In Mold)	68°F	68°F	68°F	150°F
Physical Properties				
Color	Amber	Amber	Amber	Amber
Shore Hardness	85D	87D	88D	89D
Tensile Strength, psi	11,800	12,600	11,900	7,100
Tensile Modulus, psi	424,000	419,000	427,000	367,000
Tensile Elongation, %	4.6	4.1	3.9	2.5
Compressive Strength, psi	15,800	16,700	15,400	13,500
Flexural Strength, psi	17,200	19,500	18,900	14,100
Flexural Modulus, psi	446,000	454,000	448,000	411,000
HDT, Post Cured, °F	259	312	314	310
Izod Impact, Notches, ft-lb/in	1.22	0.76	1.25	0.78
Shrinkage, in/in	<0.002	<0.001	<0.001	<0.001

1 Tooling must be able to withstand the temperatures it will be exposed to during the cure cycle and the supported stage(s) of a post cure cycle.

2 A post cure at temperatures in excess of the minimum recommended cure temperature is required to develop ultimate properties.

Table 3 CPD High Temperature Infusion Systems

High Temperature Systems	4310A/9232B	4303A/4303B	4307A/4303B	2134A/4307B	2135A/9529B	4305
Elevated Temperature Cure Required in Mold1	No	Yes	Yes	Yes	Yes	Yes
Post Cure Required1	Yes	Yes	Yes	Yes	Yes	Yes
Post Cure Recommnded1	Yes	Yes	Yes	Yes	Yes	Yes
Handling Properties						
Resin Viscosity at 77°F, cps	1,200	1,800	3,500	7,500	7,700	NA
Hardener Viscosity at 77°F, cps	40	200	200	200	2,800	NA
Mixed Viscosity at 77°F, cps	620	750	1,800	1,800	5,500	5,700
Mixed Viscosity at 100°F, cps	340	NA	NA	860	1,700	2,900
Mixed Viscosity at 120°F, cps	NA	200	500	380	600	500
Mixed Viscosity at 140°F, cps	NA	100	250	270	320	200
Mix Ratio by Weight	100A:20B	100A:107B	100A:88B	100A:90B	100A:6B	NA
Mix Ratio by Volume	4A:1B	100A:103B	100A:82B	100A:89B	13.8A:1B	NA
Gel Time at 77°F, 150g, min.	75	NA	NA	1,440	720	NA
Gel Time at 100°F, 150g, min.	35	NA	NA	NA	240	NA
Gel Time at 120°F, 150g, min.	NA	>180	>180	360	90	>480
Gel Time at 140°F, 150g, min.	NA	>120	>120	NA	45	>240
Gel Time at 170°F, 150g, min.	NA	120-240	120-240	NA	NA	NA
Minimum Recommended Cure temperature2 (In Mold)	68°F	170°F	170°F	160°F	150°F	250°F
Physical Properties						
Color	Brown	Brown	Brown	Dark Amber	Dark Amber	Amber
Shore Hardness	88D	87D	87D	90D	92D	87D
Tensile Strength, psi	12,900	12,100	10,500	12,200	10,200	8,600
Tensile Modulus, psi	431,000	486,000	451,000	472,000	470,000	527,000
Tensile Elongation, %	3.1	2.4	2.5	2.3	2.8	2.1
Compressive Strength, psi	16,900	25,600	14,700	21,300	27,100	NA
Flexural Strength, psi	17,900	20,500	15,300	17,900	15,600	NA
Flexural Modulus, psi	448,000	536,000	354,000	488,000	485,000	NA
HDT, Post Cured, °F	356	375	375	385	450	425
Izod Impact, Notched, ft-lb/in	1.23	1.01	1.06	1.01	1.06	NA
Fracture Toughness, K_{IC}, MPa*m ½	NA	NA	1.02	NA	NA	NA
Strain Energy Release Rate, G_{IC}, KJ/m2	NA	NA	0.70	NA	NA	NA
Shrinkage, in/in	<0.001	<0.005	<0.005	<0.002	<0.003	<0.002

1 Tooling must be able to withstand the temperatures it will be exposed to during the cure cycle and the supported stage(s) of a post cure cycle.

2 A post cure at temperatures in excess of the minimum recommended cure temperature is required to develop ultimate properties.

Disclaimer:

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