PRO-SET®

August 2021

EPOXIES FOR

Laminating, Infusion, Tooling and Assembly

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Cuda built by Z Rodz and Customs. Photography by McGaffin Photography for Wheel Hub Magazine.

BCT Mobbing built by TruckHouse.
Photography by Max Hall @mountain.max.

CONTENTS

Use PRO-SET Epoxy to create strong, lightweight composites that can withstand the harshest environments. PRO-SET meets your highest goals in composite performance.

PRO-SET Epoxies for Laminating, Infusion, Tooling and Assembly offer improved handling characteristics, excellent cure profiles, and rapid order fulfillment at competitive prices.

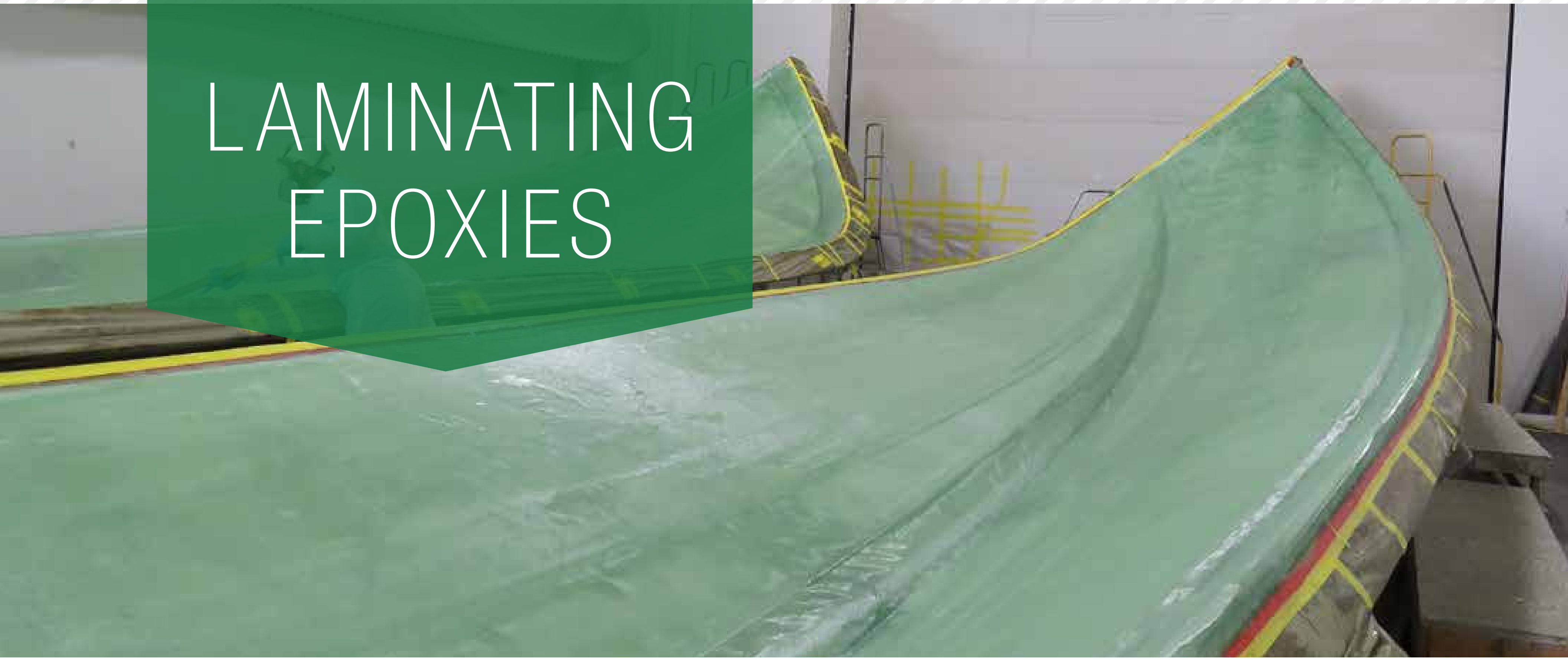
This guide provides an overview of the PRO-SET product lineup with a comparison of resin and hardener handling characteristics and cured properties, and a general PRO-SET Epoxy Handling Guide. Refer to the individual combined Resin/Hardener Technical Data Sheets for detailed handling, ratio, mechanical and thermal property information.

Custom Formulation

PRO-SET can formulate custom resin and hardener systems tailored to your specific processes and performance needs, working closely with you throughout the development of your custom formulation. Turnaround times are generally rapid, with only slightly extended lead times required once your custom formulation is placed into production. PRO-SET custom formulations usually require minimum volumes, and these products are typically made available under our Custom Formulations category, unless the customer specifies them as proprietary.

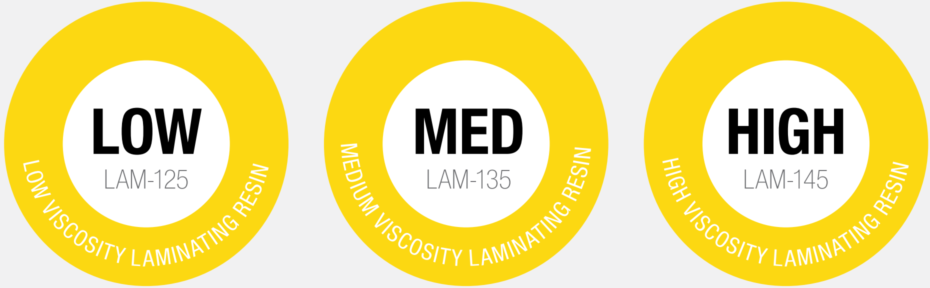
Fire Retardant resins for laminating and infusion are available as Special Order Formulations. Contact the Gougeon Technical Staff or visit prosetepoxy.com for details.

LAMINATING EPOXIES



PRO-SET Laminating Epoxies are a versatile system of liquid resins and hardeners designed to meet a wide range of wet lay-up laminating applications.

CHOOSE RESIN BY VISCOSITY



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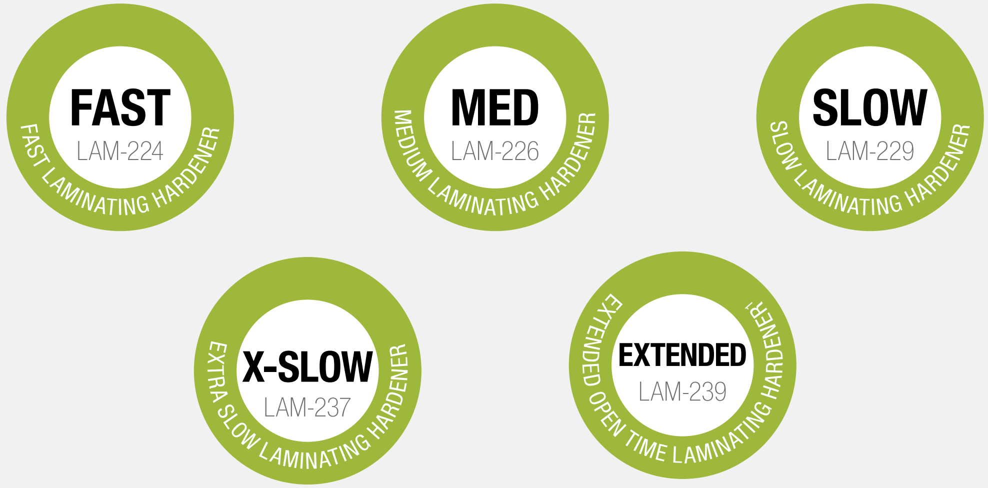
CHOOSE HARDENER BY SPEED



Use PRO-SET Laminating Epoxies to produce lightweight, high-performance composite structures that will withstand long-term cyclic loading in the harshest environments. These epoxies bond to core materials, wood, metal and all reinforcing fabrics. They offer excellent moisture resistance, toughness and superior resistance to heat and fatigue. **PRO-SET Laminating Epoxies develop excellent physical properties at room temperature** and may be post-cured for enhanced performance.

Laminating Epoxies can by dyed, upon request, to provide for visual quality control. A yellow dye in the resin and a blue dye in the hardener, when properly metered and thoroughly mixed, will result in a consistent shade of green.

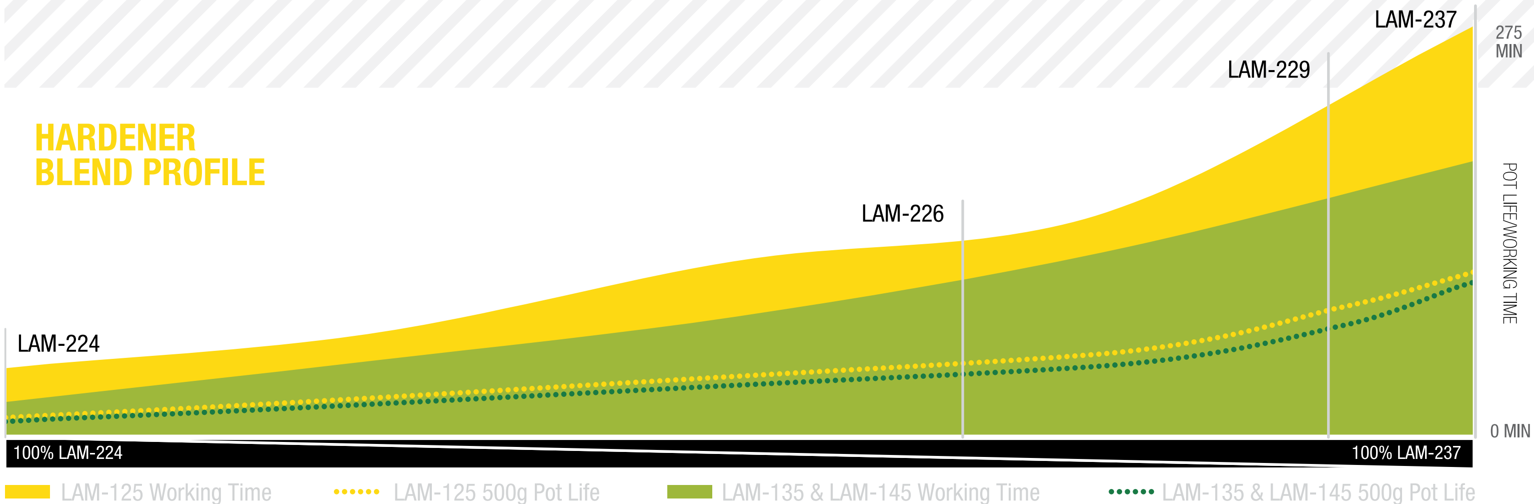
RESIN

		LAM 125[1]	LAM 135[1]	LAM 145[1]
Mix Ratio by Weight	R:H	3.5:1	3.5:1	3.5:1
Mixed Viscosity @ 77°F (25°C) ASTM D2196	cP	514-754	1048–1544	1420–2059
Mixed Density @ 72°F (22°C)	lb/gal (g/cc)	9.78 (1.15)	9.74 (1.16)	9.74 (1.16)
Shear Thinning Index ASTM D2196	RPM Rotation			1.37
Compression Yield ASTM D695	psi (MPa)	~14,200 (96)	~14,800 (101)	~14,800 (101)
Tensile Strength ASTM D638	psi (MPa)	~10,200 (70)	~11,000 (74)	~11,000 (74)
Tensile Modulus ASTM D638	psi (GPa)	~4.49E+05 (3.19)	~4.51E+05 (3.19)	~4.51E+05 (3.19)
Tensile Elongation ASTM D638	%	~6.2	~6.1	~6.1
Flexural Strength ASTM D790	psi (MPa)	~18,500 (124)	~19,700 (128)	~19,700 (128)
Flexural Modulus ASTM D790	psi (GPa)	~4.53E+05 (3.12)	~4.69E+05 (3.03)	~4.69E+05 (3.03)
Tg Ultimate via DMA[2] ASTM E1640[3]	°F (°C)	>193 (89)	>216 (102)	>216 (102)

Test specimens are cured at room temperature to gelation and 180°F (82°C) for eight hours, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications.

[1]Average of properties for combinations with LAM-224, LAM-226, LAM-229, LAM-237 and LAM-239 Hardeners. [2]Additional post cure may be required; contact the Gougeon Technical Staff for details. [3]1 HZ, 3°C per minute

HARDENER



	LAM 224	LAM 226	LAM 229	LAM 237	LAM 239[1]
150g Pot Life @ 77°F (25°C) ASTM D2471	13 min	49-63 min	89-109 min	127-144 min	208-260 min
500g Pot Life @ 77°F (25°C) ASTM D2471	12 min	43-52 min	76-81 min	91-99 min	137-196 min
Approx. working time @ 77°F (25°C)	40 min	2–3 hr	4–5 hr	7–8 hr	10-12 hr

	LAM 239
500g Pot Life @ 85°F (29°C)	102-105 min
Approx. working time @ 85°F (29°C)	8-10 hr

Test specimens are cured at room temperature to gelation and 180°F (82°C) for eight hours, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications. Hardeners can be blended for intermediate cure times (see chart above). Contact the Gougeon Technical Staff for details.

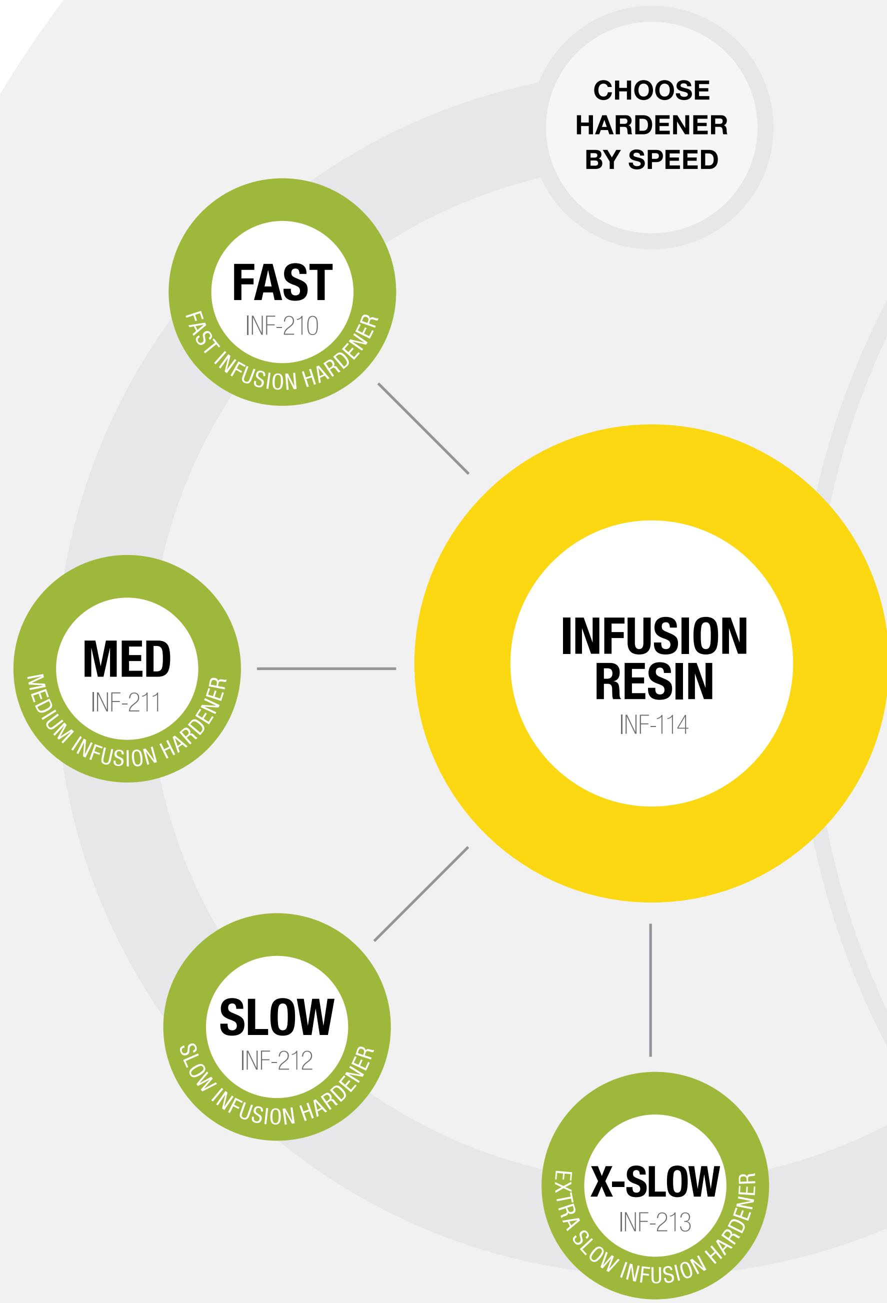
[1]Not to be blended with other hardeners. **Additional post cure required.**

INFUSION EPOXIES

PRO-SET Infusion Epoxies are super low viscosity systems with a range of hardeners to meet the demands of modern infusion processes.

PRO-SET Infusion Epoxies result in lightweight, high performance composites that will withstand long term cyclic loading in the harshest environments. PRO-SET Infusion Epoxies **develop excellent physical properties at room temperature** and may be post-cured to further enhance performance.

Infusion Epoxies can be dyed, upon request, to provide for visual quality control. A yellow dye in the resin and a blue dye in the hardener, when properly metered and thoroughly mixed, will result in a consistent shade of green.



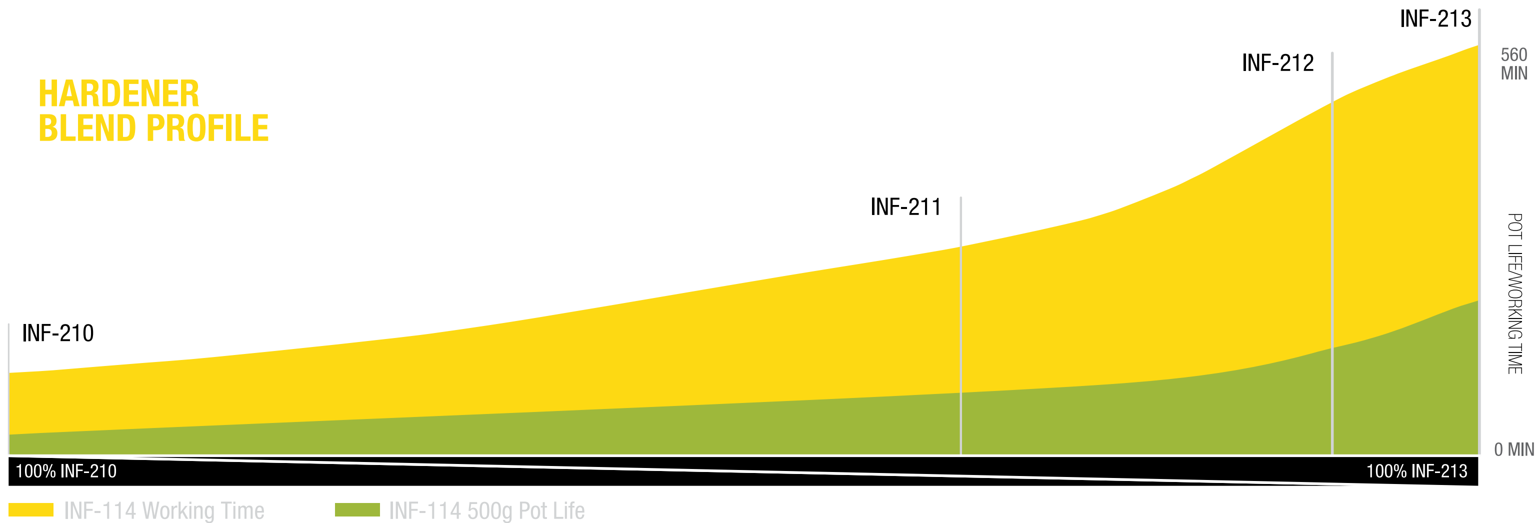
RESIN

		INF 114[1]
Mix Ratio by Weight	R:H	~3.65:1
Mixed Viscosity @ 77°F (25°C) ASTM D2196	cP	~245
Mixed Density @ 72°F (22°C)	lb/gal (g/cc)	~9.52 (1.14)
Compression Yield ASTM D695	psi (MPa)	~14,100 (97.0)
Tensile Strength ASTM D638	psi (MPa)	~10,400 (71.7)
Tensile Modulus ASTM D638	psi (GPa)	~4.90E+05 (3.38)
Tensile Elongation ASTM D638	%	~4.95
Flexural Strength ASTM D790	psi (MPa)	~18,000 (124)
Flexural Modulus ASTM D790	psi (GPa)	~4.63E+05 (3.19)
Tg Ultimate via DMA[2] ASTM E1640[3]	°F (°C)	>193 (85.2)

Test specimens are cured at room temperature to gelation and 180°F (82°C) for eight hours, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications.

[1]Average of properties for combinations with INF-210, INF-211, INF-212 and INF-213 Hardeners. [2]Additional post cure may be required; contact the Gougeon Technical Staff for details. [3]1 HZ, 3˚C per minute

HARDENER



	INF 210	INF 211	INF 212	INF 213
150g Pot Life @ 77°F (25°C) ASTM D2471	24-30 min	101-135 min	166-204 min	235-289 min
500g Pot Life @ 77°F (25°C) ASTM D2471	22-28 min	76-94 min	118-146 min	157-193 min
Approx. working time @ 77°F (25°C)	75–90 min	3–4 hr	6–7 hr	10 hr

Test specimens are cured at room temperature to gelation and 180°F (82°C) for eight hours, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications. Hardeners can be blended for intermediate cure times (see chart previous page).

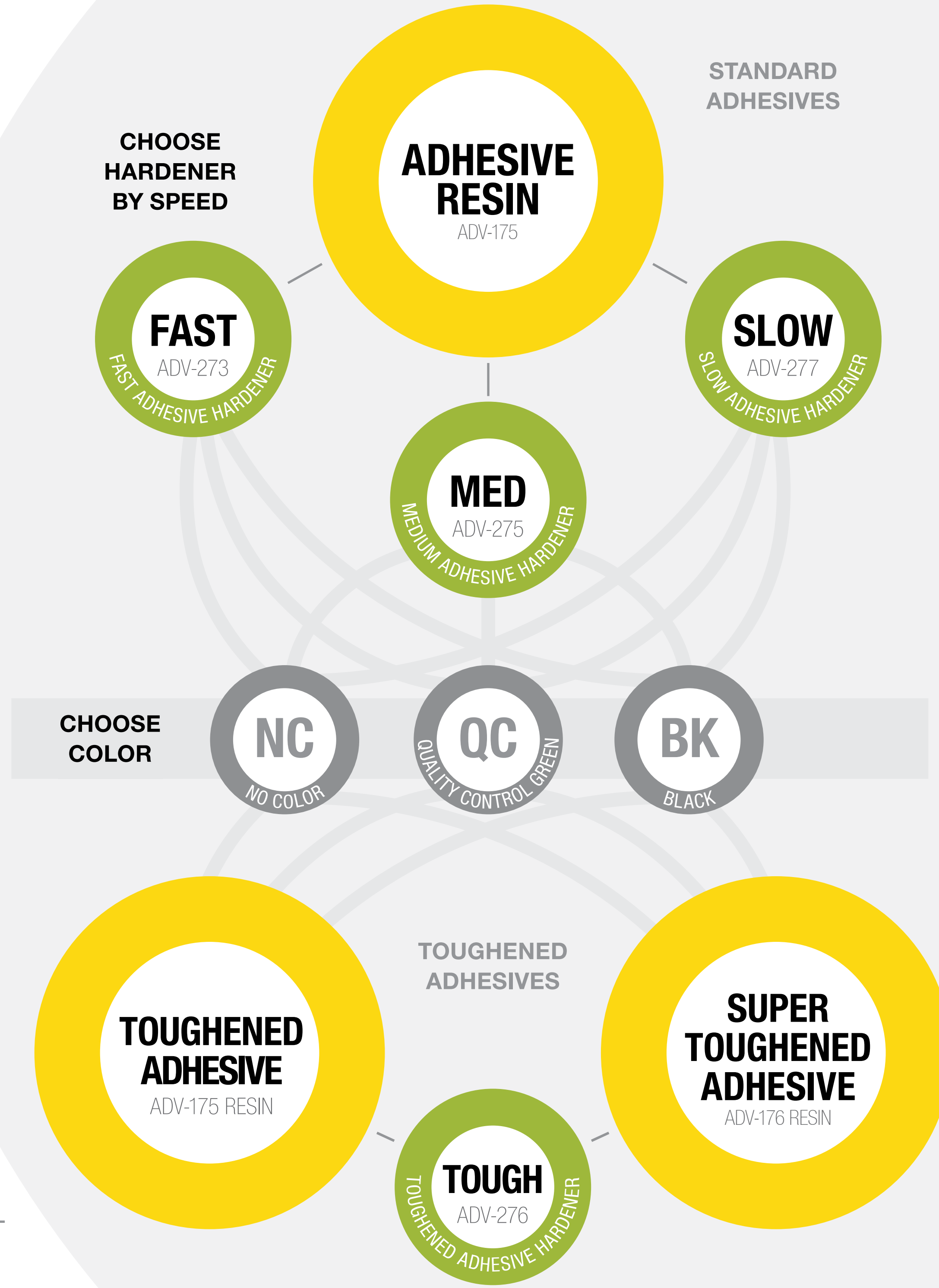
ADHESIVE EPOXIES

PRO-SET Assembly Adhesives are pre-thickened, two-part epoxy adhesives used for secondary bonding of laminated composites as well as steel, aluminum, cast iron, concrete, stone, and most woods.

Adhesives based on PRO-SET 175 Resin are paired with Fast (273), Medium (275) or Slow (277) hardener. They are suitable for most composite bonding applications.

PRO-SET ADV-175/276 and ADV-176/276 are Toughened Adhesive systems that deliver exceptional toughness and superior peel strength for heavily loaded applications and difficult-to-bond substrates including pre-preg, sheet molding compound, metals and most plastics.

All PRO-SET Assembly Adhesives packaged in cartridges, pails or drums, are available in No Color (NC), Quality Control Green (QC) and Black (BK).



STANDARD ADHESIVES

		ADV-175/ 273	ADV-175/ 275	ADV-175/ 277
Working Time, ½" bead @ 72°F (22°C)	minutes	18-22 min	64-80 min	135-165 min
Hardness ASTM-D2240	Type D	82	82	84
Compression Yield ASTM-D695	psi (MPa)	10,700 (74)	11,900 (82)	11,800 (81)
Tensile Strength ASTM-D638	psi (MPa)	6,250 (43)	7,260 (50)	7,070 (49)
Tensile Modulus ASTM-D638	psi (GPa)	3.80E+05 (2.6)	4.20E+05 (2.9)	4.20E+05 (2.9)
Tensile Elongation ASTM-D638	%	4.2	4.2	4.4
Flexural Strength ASTM-D790	psi (MPa)	11,100 (77)	11,900 (82)	12,100 (83)
Flexural Modulus ASTM-D790	psi (GPa)	3.70E+05 (2.5)	4.10E+05 (2.8)	4.00E+05 (2.7)
Lap Shear on A-366 Steel ASTM-D1002	psi (MPa)	2,280 (16)	2,330 (16)	1,980 (14)
Lap Shear on 2024T Aluminum ASTM-D1002	psi (MPa)	1,830 (13)	1,990 (14)	1,980 (14)
Tensile Adhesion to A-366 Steel ASTM-D4541	psi (MPa)	2,540 (18)	2,830 (20)	2,580 (18)
Tensile Adhesion to 2024T Aluminum ASTM-D4541	psi (MPa)	1,420 (10)	1,760 (12)	1,720 (12)
Tg Ultimate via DSC[1] ASTM E1640[2]	°F (°C)	120 (49)	138 (59)	143 (62)

Test specimens are cured at room temperature for two weeks unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications. Adhesives are available in three standard colors: No Color (NC), Quality Control Green (QC) and Black (BK).

[1]Additional post cure may be required; contact the Gougeon Technical Staff for details. [2]1 HZ, 3°C per minute

TOUGHENED ADHESIVES

		ADV 175/ADV-276	ADV 176/ADV-276
Working Time, ½" bead @ 72°F (22°C)	minutes	45-55 min	81-99 min
Hardness ASTM-D2240	Type D	85	80
Compression Yield ASTM-D695	psi (MPa)	12,200 (84)	7,770 (54)
Tensile Strength ASTM-D638	psi (MPa)	6,320 (44)	5,330 (37)
Tensile Modulus ASTM-D638	psi (GPa)	4.59E+05 (3.16)	2.97E+05 (2.0)
Tensile Elongation ASTM-D638	%	6.2	10.1
Flexural Strength ASTM-D790	psi (MPa)	13,700 (94)	9,540 (66)
Flexural Modulus ASTM-D790	psi (GPa)	4.57E+05 (3.15)	2.97E+05 (2.05)
Lap Shear on A-366 Steel ASTM-D1002	psi (MPa)	1,920 (13)	2,880 (20)
Lap Shear on 2024T Aluminum ASTM-D1002	psi (MPa)	2,440 (17)	2,860 (20)
Tensile Adhesion to A-366 Steel ASTM-D4541	psi (MPa)	2,700 (19)	4,300 (30)
Tensile Adhesion to 2024T Aluminum ASTM-D4541	psi (MPa)	2,220 (15)	3,410 (24)
Tg Ultimate via DSC[1] ASTM E1640[2]	°F (°C)	171 (77)	138 (59)

Test specimens are cured at room temperature for two weeks unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications. Adhesives are available in three standard colors: No Color (NC), Quality Control Green (QC) and Black (BK).

[1]Additional post cure may be required; contact the Gougeon Technical Staff for details. [2]1 HZ, 3˚C per minute

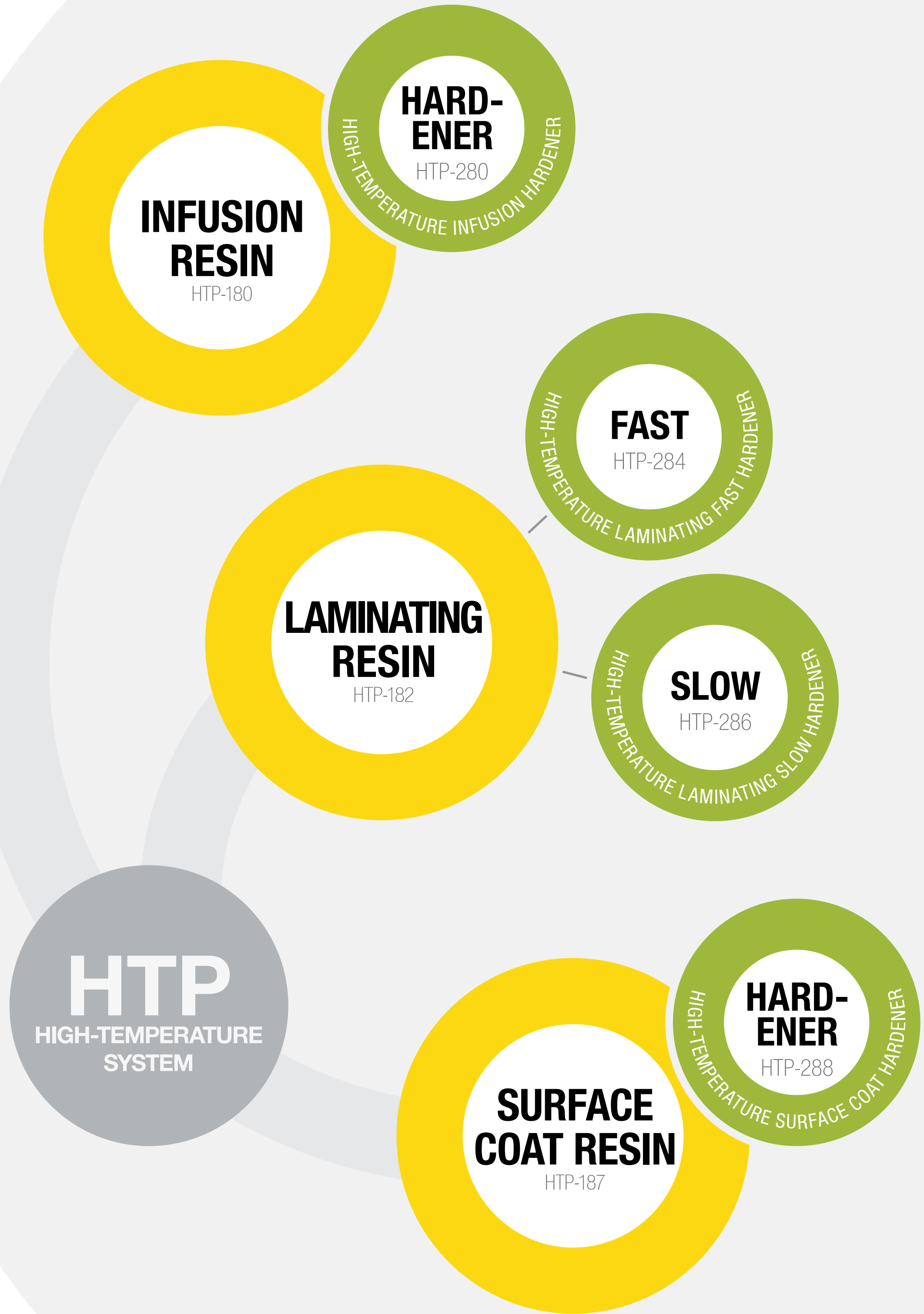
HIGH-TEMP EPOXIES

PRO-SET High-Temperature Epoxies are a system of high-performance epoxies for synthetic composite mold and part manufacturing.

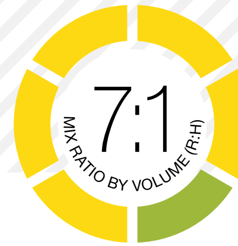
The PRO-SET High-Temperature system consists of a Surface Coat Epoxy, Laminating Epoxy and an Infusion Epoxy. When combined to manufacture composite parts, they can be demolded after 24-48 hours at room temperature before a free-standing postcure.

The T_g of this system is as high as 300°F with a proper postcure. It has low shrinkage, excellent temperature stability and part cosmetics.

The Infusion and Laminating Epoxy can be dyed, upon request, to provide for visual quality control. A yellow dye in the resin and a blue dye in the hardener, when properly metered and thoroughly mixed, will result in a consistent shade of green. The Surface Coat Epoxy is only available in black.



RESIN



		HTP 180[1] INFUSION	HTP 182[1] LAMINATING	HTP 187[1] SURFACE COAT
Mix Ratio by Volume	R:H	3:1	4:1	7:1
Mix Ratio by Weight	R:H	3.7:1	4.70:1	8.53:1
Mixed Viscosity @ 72°F (22°C) ASTM D2196	cP	600	~2,800	18,000
Mixed Density @ 72°F (22°C)	lb/gal (g/cc)	9.60 (1.15)	~9.77 (1.17)	10.1 (1.21)
Compression Yield ASTM D695	psi (MPa)	15,300 (105)	~14,800 (102)	21,000 (140)
Tensile Strength ASTM D638	psi (MPa)	10,800 (74)	~9,600 (66)	3,700 (26)
Tensile Modulus ASTM D638	psi (GPa)	4.34E+05 (2.99)	~4.26E+05 (2.94)	5.60E+05 (3.9)
Tensile Elongation ASTM D638	%	5.5	~4.6	0.9
Flexural Strength ASTM D790	psi (MPa)	17,800 (123)	~15,300 (105)	7,900 (54)
Flexural Modulus ASTM D790	psi (GPa)	4.14E+05 (2.85)	~4.03E+05 (2.78)	4.10E+05 (2.8)
Tg Ultimate via DMA ASTM E1640[2]	°F (°C)	304 (151)	~302 (150)	268 (131)
Tg Ultimate via DSC ASTM E1640[2]	°F (°C)	304 (151)	~304 (151)	291 (144)

Test specimens are cured at room temperature to gelation and 140°F (60°C) x 2 hrs + 275°F (135°C) x 12 hrs. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications.

[1]Average of properties for HTP-180 with HTP-280, HTP-182 with HTP-284/HTP-286, and HTP-187 with HTP-287. [2]1 HZ, 3°C per minute

HARDENER

	HTP 280[1] WITH HTP-180	HTP 284 WITH HTP-182	HTP 286 WITH HTP-182	HTP 288[1] WITH HTP-187
150g Pot Life @ 72°F (22°C) ASTM D2471	180 min	40 min	100 min	160 min
500g Pot Life @ 72°F (22°C) ASTM D2471	120 min	38 min	75 min	150 min
Approx. working time @ 72°F (22°C)	5-6 hr	1-2 hr	4-5 hr	2-3 hr

Test specimens are cured at room temperature to gelation and 140°F (60°C) x 2 hrs + 275°F (135°C) x 12 hrs. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values.
Typical values, not to be construed as specifications.
[1]Not to be blended with other hardeners.

TOOLING EPOXIES

PRO-SET Tooling Epoxy is a 2-part paste formulated for surfacing molds and plugs.

The state-of-the-art chemistry behind PRO-SET Tooling Epoxy makes it easy to use, saving on labor and yielding high-quality results. It blends quickly, spreads easily, shrinks minimally and cures within eight hours.

PRO-SET TLG-625 Low-Density Fairing Putty is formulated for filling and fairing composite structures in manufacturing and repair applications. It can be applied in thicknesses up to ½" (12 mm) without slumping or sagging. The shear thinning characteristic provides excellent feather edge application. The cured putty is very easy to sand and the filler blend minimizes airborne dust during sanding.

FAIRING PUTTY RESIN
TLG-625-R
LOW-DENSITY FAIRING PUTTY RESIN

HARD-ENER
TLG-625-H
LOW-DENSITY FAIRING PUTTY HARDENER

1:1
MIX RATIO BY VOLUME (R:H)

		TLG 625 RESIN/HARDENER
Mix Ratio by Weight	R:H	1.79:1
100ml Pot Life @ 72°F (22°C) ASTM 2471	minutes	31-39
500ml Pot Life @ 72°F (22°C) ASTM 2471	minutes	27-33
Approx working time, ¼" application 72°F (22°C)	minutes	90
Time to Sand, ¼" application 72°F (22°C)	hours	8
Compression Yield ASTM D695	psi (MPa)	3,330 (23)
Hardness ASTM D2240	Type D	62

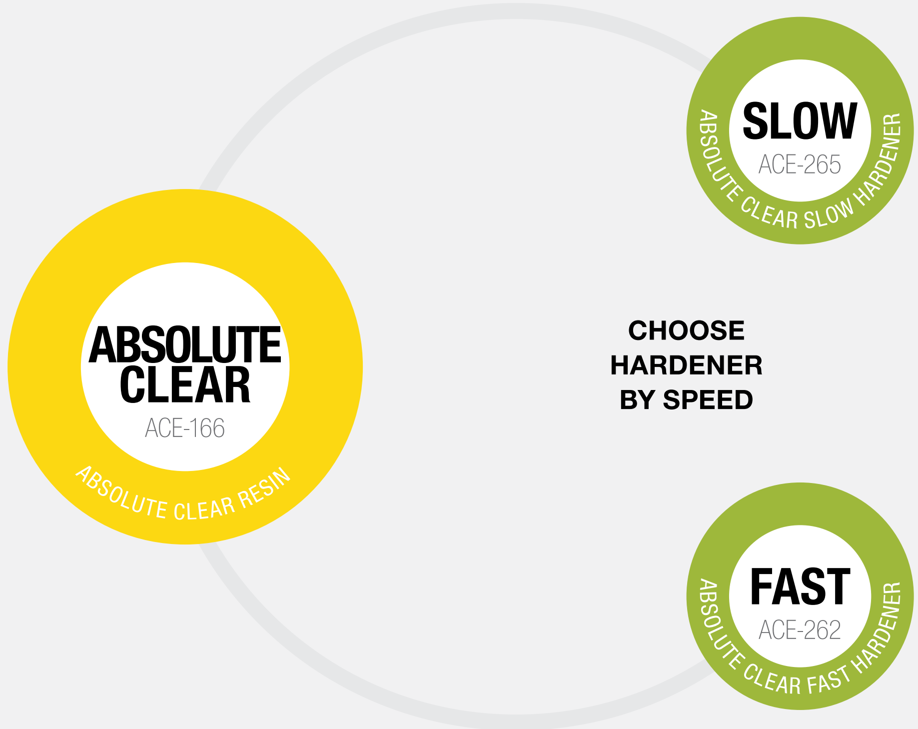
Test specimens are cured at room temperature to gelation and 77°F (25°C) for two weeks, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications.

ABSOLUTE CLEAR EPOXIES

PRO-SET Absolute Clear Epoxies are ultra-clear systems designed for high-volume production with fast tack-free times, excellent sandability and outstanding cosmetics.

Commonly used for lamination and clear coatings on wood, carbon fiber and other dark surfaces in a production setting, PRO-SET Absolute Clear Epoxy has colorless clarity and UV stability. For ultimate long-term UV stability, use with a UV stable topcoat.

Absolute Clear Epoxy is easy to process and optimized for fill coats and hand wet out of lightweight reinforcement fabrics or fibers. It provides an extremely smooth surface when cured and has excellent sandability. It reaches full physical properties with a room temperature cure.



RESIN

		ACE 166[1]
Mix Ratio by Weight	R:H	~2.35:1
Mixed Viscosity @ 72°F (22°C) ASTM D2196	cP	~1,102
Cured Density @ 72°F (22°C)	lb/gal (g/cc)	~9.64 (1.16)
Compression Yield ASTM D695	psi (MPa)	~12,600 (86.9)
Tensile Strength ASTM D638	psi (MPa)	~8,590 (59.2)
Tensile Modulus ASTM D638	psi (GPa)	~4.88E+05 (3.37)
Tensile Elongation ASTM D638	%	~3.1
Flexural Strength ASTM D790	psi (MPa)	~13,800 (95.1)
Flexural Modulus ASTM D790	psi (GPa)	~4.67E+05 (3.22)

Test specimens are cured at room temperature (72°F) for two weeks, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications.

[1]Average of properties for combinations with ACE-262 and ACE-265 Hardeners.

HARDENER

		ACE 262	ACE 265
Mix Ratio by Weight	R:H	2.31:1	2.39:1
150g Pot Life @ 72°F (22°C) ASTM 2471	minutes	19-24	26-33
500g Pot Life @ 72°F (22°C) ASTM 2471	minutes	19-24	26-32

Test specimens are cured at room temperature (72°F) for two weeks, unless otherwise noted. Neat epoxy samples are used for testing. See Resin/Hardener Technical Data Sheet for exact values. Typical values, not to be construed as specifications.

318 Drum Metering Pump and example setup. Chemical resistant hoses and plumbing fittings are not included as each setup will need to be customized for the fabricator's needs.

PROCESS EQUIPMENT

METERING EQUIPMENT

The PRO-SET 308 and 318 Positive Displacement Pump will dispense all of the INF and LAM resins and hardeners accurately at 3:1 by volume. Each pump stroke will dispense properly metered epoxy at a rate of 1 gallon/minute. The 308 resin reservoir will hold 2 gallons and the hardener reservoir will hold 1 gallon. The 318 pumps are designed to be connected to PRO-SET drums via chemical resistant hoses and plumbing fittings available at most hardware stores.

All PRO-SET INF and LAM resins and hardeners can also be batch measured and dispensed at a 3:1 volume ratio with larger dispensing systems. Consult the Technical Data Sheet to confirm the proper ratio by weight.

ADHESIVE DISPENSING GUNS

300-X MANUAL DISPENSING GUN

The manually operated, two-component dispenser is used with PRO-SET Adhesive cartridge sets to apply adhesive quickly, cleanly and accurately. The handle and trigger are die cast aluminum and shaped for comfortable operation. A 26:1 mechanical advantage dispenses the high-viscosity adhesive with ease and the gun's heavy-duty construction assures precise adhesive application and long operating life.

300-B PNEUMATIC DISPENSING GUN

The air-powered, two-component dispenser is used with PRO-SET Adhesive cartridge sets to apply adhesive in larger assembly operations. The trigger controls 484 lb. of thrust for easy and precise adhesive application. Power is supplied by a standard shop air compressor.

Top—300-X Manual Dispensing Gun
Bottom—300-B Pneumatic Dispensing Gun

300-MW MIXING WANDS

Static mixing wands attach to the adhesive set cartridges to thoroughly blend resin and hardener components as they are dispensed. The tip can be trimmed to apply the appropriate sized bead of adhesive mixture. One wand is supplied with each adhesive cartridge set. Additional wands are available.

QUALITY CONTROL DYE

Dyed resins and hardeners provide an easy, reliable method for quality assurance. Yellow dyed resin and blue dyed hardener, when mixed thoroughly, produce a consistent green tinted epoxy mixture. A streaked mixture indicates insufficient mixing. Resins and hardeners can be dyed by request at the Gougeon Brothers, Inc. factory before shipping. Simply add a QC (Quality Control) after the product number. Adhesives also have the option of BK (Black).

Quality control adhesive epoxy. The yellow resin and blue hardener combine in the mixing wand to create quality control green epoxy.

Glider built by Diloren Composites, Miami, FL.

SUPPLEMENTAL INFORMATION

SHELF LIFE AND STORAGE

Epoxy resin and hardener formulations have a long shelf life compared to many polymers. The minimum shelf life for the standard LAM, INF, and ACE products is 3 years for resins and 2 years for hardeners. For HTP it's 3 years for resins and 18 months for hardeners. For ADV and TLG resins and hardeners it's 18 months. Components of PRO-SET LAM-145 may settle during storage. We recommend a visual inspection and to stir the resin as needed.

Store PRO-SET Epoxy resins and hardeners at room temperature (65-85°F) in sealed containers until shortly before use. As with many high-performance epoxy resins, repeated exposure to low temperatures during storage (<55°F) may cause the resin to crystallize. Be aware that containers placed near outside walls or on the floor will often be at a lower temperature than the ambient conditions.

If crystallization occurs, warm the resin to 125°F for 8 hours and stir to dissolve crystals. Hardeners may form carbamation when exposed to CO_2 and moisture in the atmosphere for extended periods of time. Prevent carbamation by keeping containers sealed and pump reservoirs covered until immediately prior to processing.

STANDARD PACKAGE SIZES

Because the densities of the various resin and hardeners vary slightly, there are slight variations in the package volume, but they are very similar to these nominal volumes for each package size.

	2:1 ACE		2:1 ADV		3:1 LAM, INF, HTP INFUSION		4:1 HTP LAMINATING		7:1 HTP SURFACE COAT	
	RESINS	HARDENERS	RESINS	HARDENERS	RESINS	HARDENERS	RESINS	HARDENERS	RESINS	HARDENERS
Cartridge	—	—	300 ml	150 ml	—	—	—	—	—	—
-0	—	—	2.3 lb .23 gal	1.1 lb .11 gal	—	—	—	—	—	—
-1	9.5 lb 1 gal	2.7 lb .33 gal	—	—	9.5 lb 1 gal	2.7 lb .33 gal	9.6 lb 1 gal	2 lb .25 gal	10.6 lb 1 gal	1.25 lb .14 gal
-2	40 lb 4 gal	12 lb 1.5 gal	44 lb 4.5 gal	39 lb 4.5 gal	40 lb 4 gal	12 lb 1.5 gal	45 lb 4.6 gal	9.5 lb 1.2 gal	50 lb 4.7 gal	5.8 lb .66 gal
-3	—	—	—	—	135 lb 14 gal	39.5 lb 4.8 gal	135 lb 14 gal	29 lb 3.5 gal	—	—
-4	500 lb 52 gal	146 lb 18 gal	485 lb 50 gal	430 lb 50 gal	500 lb 52 gal	146 lb 18 gal	500 lb 51 gal	106 lb 13 gal	500 lb 46 gal	59 lb 6.6 gal
-5	—	—	—	—	2,500 lb 260 gal	365 lb 45 gal	2,500 lb 257 gal	425 lb 51 gal	—	—

PRO-SET EPOXY HANDLING GUIDE

Refer to the PRO-SET Technical Data Sheets for specific handling characteristics, post cure schedules and physical properties for each of the resin/hardener combinations.

PRO-SET Epoxies are recommended for use by experienced fabricators. If you are new to high-strength laminating epoxies, read this guide thoroughly. If you have additional questions about the handling or use of PRO-SET Epoxies, you are encouraged to call or write the Gougeon Technical Staff. We strongly recommend that you build representative panels using the proposed laminate schedule under expected shop conditions to fully understand working characteristics and suitability of PRO-SET Epoxies for your application. Read all safety information before using PRO-SET Epoxies.

SAFETY

To use PRO-SET Epoxies safely, you must understand their hazards and take precautions to avoid them.

Resins may cause moderate skin irritation. Hardeners are corrosive and may cause severe skin irritation. Resins and hardeners are also sensitizers and may cause an allergic reaction similar to poison ivy. Susceptibility and the severity of a reaction varies with the individual. Although most people are not sensitive to resins and hardeners, the risk of becoming sensitized increases with repeated contact. For those who become sensitized, the severity of the reaction may increase with each contact. The hazards associated with resins and hardeners also apply to the sanding dust from epoxy that has not fully cured. These hazards decrease as resin/hardener mixtures reach full cure. To handle PRO-SET Epoxies safely, we recommend that you observe the following precautions:

1. Avoid contact with resin, hardeners, mixed epoxy, and sanding dust from epoxy that is not fully cured. Wear protective gloves and clothing whenever you handle epoxies. If you do get resin, hardener or mixed epoxy on your skin, remove it as soon as possible. Resin is not water soluble—use a waterless skin cleanser to remove resin or mixed epoxy from your skin. Hardener is water soluble—wash with soap and warm water to remove hardener or sanding dust from your skin. Always wash thoroughly with soap and warm water after using epoxy. Never use solvents to remove epoxy from your skin.

   Stop using the product if you develop a reaction. Resume work only after the symptoms disappear, usually after several days. When you resume work, improve your safety precautions to prevent exposure to epoxy, its vapors and sanding dust. If problems persist, discontinue use and consult a physician.

2. Protect your eyes from contact with resin, hardeners, mixed epoxy, and sanding dust by wearing appropriate eye protection. If contact occurs, immediately flush the eyes with water under low pressure for 15 minutes. Seek medical attention.

3. Avoid breathing vapors, fumes, mists, and particulates from sanding dust. PRO-SET Epoxies generally have a low VOC content, but vapors can build up in workspaces that have low ventilation. Provide adequate general ventilation and/or local ventilation to keep exposures below established limits. When ventilation cannot be made adequate to keep exposures below established limits, use a NIOSH approved respirator with an organic vapor cartridge, organic vapor cartridge + P100, or a multi-contaminant cartridge, depending on specific workplace conditions. When sanding epoxy, at a minimum, wear a respirator appropriate for particulate dust, especially when sanding epoxy that is not yet fully cured. Breathing uncured epoxy dust increases your risk of sensitization. Although epoxy cures quickly to a sandable solid, it may take over two weeks at room temperature, or post-curing, to reach full cure. Consult with your respirator and cartridge supplier to ensure proper selection of respirator and cartridge based on the ingredients listed in the Safety Data Sheet and your specific workplace conditions. Use and select a respirator according the guidelines established in OSHA 1910.134 or other applicable respiratory protection standard.

4. Do not ingest. Wash thoroughly after handling these products, especially before eating or smoking. If epoxy is ingested, rinse mouth with water. DO NOT induce vomiting. Some hardeners pose an aspiration hazard if vomited and allowed to enter the airways. Call a physician immediately.

5. Clean up spills with a scraper, collecting as much material as possible. Follow up with absorbent towels. Use sand, clay or other inert absorbent material to contain large spills. DO NOT use saw dust or other fine cellulose materials to absorb hardeners. Clean resin or mixed epoxy residue with acetone, lacquer thinner or alcohol. Follow all safety warnings on solvent containers. Clean hardener residue with warm soapy water. DO NOT dispose of hardener in trash containing sawdust or other fine cellulose materials—spontaneous combustion can occur.

6. Dispose of resin, hardener and empty containers safely. Puncture a corner of the can and drain residue into the appropriate new container of resin or hardener. Do not dispose of resin or hardener in a liquid state. Waste resin and hardener can be mixed and cured (in small quantities) to a non-hazardous inert solid. CAUTION! Pots of curing epoxy can get hot enough to ignite surrounding combustible materials and give off hazardous fumes. Place pots of mixed epoxy in a safe and ventilated area, away from workers and combustible materials. Dispose of the solid mass only if cure is complete and the mass has cooled. Follow federal, state and local disposal regulations.

7. PRO-SET products are intended for use by professional or technically qualified persons only. Regularly updated Safety Data Sheets (SDS) are available at prosetepoxy.com and from your PRO-SET distributor. Refer to the SDS and product label for specific first-aid procedures and product safety information.

For additional safety information contact Pro-Set Inc., 888-377-6738.

HANDLING PRO-SET EPOXIES

This section is intended to provide an understanding of the general handling characteristics of PRO-SET Epoxies. Refer to the PRO-SET Resin/Hardener Technical Data Sheets for specific handling characteristics, post-cure information and cured physical properties.

Combining PRO-SET Epoxy resin and hardener starts a chemical reaction that gradually changes the mixed ingredients from a liquid to a solid. Careful measuring and thorough mixing are **essential** for a complete reaction to occur.

DISPENSING

Most problems related to curing of the epoxy can be traced to either inadequate mixing or the wrong ratio of resin and hardener. To simplify metering, we recommend using calibrated pumps to dispense resin and hardener. The PRO-SET High-Capacity Positive Displacement Pumps are calibrated to dispense the proper working ratio of all PRO-SET liquid Resin/Hardener combinations.

Production quantity dispensing systems are available from several manufacturers. Contact our technical staff for recommendations.

Before you use the first mixture on a project, verify that the pumps are delivering the proper ratio. Refer to the verification procedure in the instructions that come with the pumps. Recheck the ratio periodically or any time you experience problems with curing. Production facilities should check pump ratios on a regular basis.

To measure by weight or volume, refer to the PRO-SET Resin/Hardener Technical Data sheets for the correct resin-to-hardener ratio.

Spiralon built by Dycor Prosthetics, Missouri City, TX


Melges 14, by Melges, Zenda, WI

MIXING

Mixing epoxy with error-free results involves three separate steps:

1. Dispense the proper proportions of PRO-SET Resin and Hardener into a clean plastic or paper mixing container. Never use glass or foam containers because of the danger of exothermic heat buildup. Begin with a small batch if you are unfamiliar with the pot life or working time of the epoxy.

2. Stir the two ingredients together thoroughly until blended to a uniform, homogeneous consistency. Scrape the sides, bottom and inside corners of the container as you mix. If you use a power mixer, thoroughly scrape the sides and corners of the container while mixing. Operate the mixer at a slow speed to prevent stirring air into the epoxy mixture. Note: Resin and hardener may be dyed to assure thorough blending. Refer to QUALITY ASSURANCE CONSIDERATIONS for details.

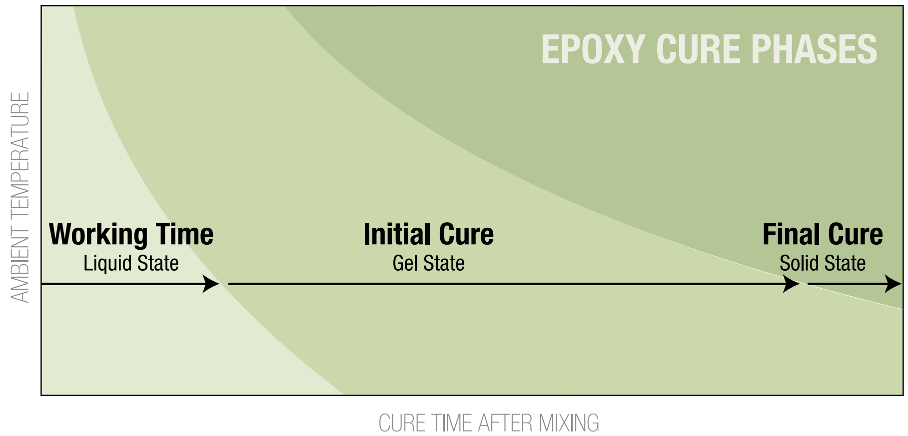
3. Mix resin and hardener thoroughly in a container before transferring it to a roller pan, impregnator or part. Transfer the mixture immediately to maximize working time. If using additives, such as pigments and fillers, thoroughly stir in before transferring the mixture from the container.

CAUTION! Heat is generated by the chemical reaction that cures epoxy. A plastic mixing container full of mixed epoxy will generate enough heat to melt the container if left to stand for its full pot life. If a pot of mixed epoxy begins an uncontrolled exotherm, quickly move it outdoors or to a safe, well ventilated area. Avoid breathing the fumes. Do not dispose of any epoxy mixture until the reaction is complete and has cooled.

POT LIFE

Selection of a resin/hardener combination may be based on the length of its pot life. Pot life is a term used to compare the relative rate of reaction or cure speed of various resin/hardener combinations. By definition, it is the amount of time a given mass of mixed resin/hardener will remain in the liquid state at a specific temperature.

For comparison, we determine the pot life of an individual resin/hardener combination based on either a 100 or 500 gram mixture in a standardized container, at a consistent temperature. **Pot life is not intended to directly correlate to actual working life or assembly time**, but indicates a resin/hardener combination's potential working time relative to other resin/hardener combinations. An epoxy mixture's mass and temperature during the manufacturing or assembly process contribute to its actual working life. See *Controlling Cure Time*.



All PRO-SET Epoxies go through the same three phases of cure. The higher the ambient temperature, the shorter each of the phases and overall cure.

CURING

The transition period of an epoxy mixture from a liquid to a solid is called the cure time. It can be divided into three phases: working time—also called open time or wet lay-up time (liquid state), initial cure (gel state) and final cure (solid state). The speed of the reaction, the length of these phases and the total cure time vary relative to the ambient temperature.

1. WORKING TIME

Working time is the assembly time of mixed epoxy. It is the portion of the cure time, after mixing, that the epoxy will remain in a liquid state and be workable. The end of the working time marks the last opportunity to apply clamping pressure to an assembly and create a dependable bond.

2. INITIAL CURE PHASE

The working time is over when the mixture passes into an initial cure phase and has reached a gel state. It may be hard enough to be shaped with files or planes, but too soft to dry sand. Post-cure heating may begin once the mixture has reached an initial cure.

3. FINAL CURE PHASE

In the final cure phase the epoxy mixture has cured to a solid state and, if not post-cured, will continue to cure over the next couple of weeks at room temperature. Post-curing at elevated temperatures will shorten the final cure phase of PRO-SET Epoxies, and is necessary for components requiring the best thermal properties.

CONTROLLING CURE TIME

Several factors affect cure time and can be manipulated to extend the length of the cure time and working time.

1. TYPE OF HARDENER

Each resin/hardener combination will go through the same cure phases, but at different rates. Choose the hardener that gives you adequate working time for the job you are doing at the temperature and conditions you are working under. PRO-SET Hardeners may also be blended to provide a custom blend with an intermediate cure time. Refer to the blend profile charts in the *Laminating Epoxies* and *Infusion Epoxies* sections.

2. MIXED QUANTITY

Mixing resin and hardener together creates an exothermic (heat producing) reaction. A larger quantity of mixed epoxy will generate more heat and yield a shorter working time and overall cure time. Smaller batches of epoxy generate less heat than larger batches and have longer cure times. Therefore, a thicker joint, laminate or layer of epoxy will cure faster.

3. CONTAINER SHAPE

Heat generated by a given quantity of epoxy can be dissipated by pouring the mixture into a container with greater surface area (a roller pan, for example), thereby extending the working time. Since the mixed epoxy will cure at a faster rate while it's in the mixing container, the sooner the mixture is transferred or applied, the more of the mixture's working time will be available for assembly.

4. TEMPERATURE

Heat can be applied to or removed from the epoxy to shorten or extend working and cure times. This can be especially beneficial when assembling very large or complicated components that require maximum working time and minimum final cure time. Be sure you fully understand the effects of heating and cooling on the mold before implementing these techniques.

Before mixing, moderate heat can be applied to the resin and hardener to shorten the epoxy's working time. Conversely, a cooler box can be used to draw heat from a roller pan to extend working time (contact PRO-SET for information about building cooler boxes). For larger operations, impregnating machines with water cooled rollers are available to extend working time.

After the epoxy is applied, a fan can be used to draw heat from the process or application and extend the epoxy's working time. The tooling itself can be designed to both extend working time and shorten cure time. It is possible to build tooling with tubing embedded. During processing, cool water pumped through the mold draws heat from the part, extending the working time. When the process is complete, hot water or steam pumped through the mold will speed the cure of the part.

Moderate heat (hot air gun or heat lamp) applied to the assembly will shorten the epoxy's cure time. Heat can be applied as soon as the assembly is completed, but most often heat should be applied after the epoxy has reached its initial cure. Heating epoxy that has not reached its initial cure will lower its viscosity, causing the epoxy to run or sag on vertical surfaces. In some processing procedures, heating too soon can lower the resin content of the laminate to unacceptable levels. In addition, heating parts that contain porous materials (wood or low density core material) can cause the substrate to "out-gas." When air in the porous material expands and passes through the curing epoxy, it can leave bubbles or pinholes in the cured epoxy.

Regardless of what steps are taken to control the cure time, thorough planning of the application and assembly will allow you to make maximum use of the working time of the epoxy mixture.

APPLICATION TECHNIQUES

PRIMARY BONDING/WET LAY-UP

PRO-SET Laminating Epoxies are designed for primary bonding of composite materials like fiberglass, carbon, aramid and various core materials. Fabrics may be wet out by hand or by roller impregnating machines. Since each resin/hardener combination will have a different viscosity, test a combination for its suitability with a particular fabric and impregnating machine setup.

Fabrics recommended for use with PRO-SET Epoxies should be classified as epoxy compatible. Avoid fabrics with styrene soluble binders or that are compatible only with styrenated resins.

VACUUM BAG LAMINATING

Vacuum bagging is an excellent clamping method for composite construction using PRO-SET Laminating Epoxies. Regulating the amount of vacuum pressure permits control of the resin/fiber ratio and can produce a more dense laminate, with a higher fiber volume. Generally, the higher the vacuum pressure, the lower the resin content. The optimum resin/fiber ratio for a particular component will be between 30% and 50%. A lower ratio will result in a lighter composite. A higher ratio will be heavier, yet yield higher moisture exclusion effectiveness. Various bleeder and absorber materials used in vacuum bag laminating can also influence the resin/fiber ratio. Building test panels is recommended to determine the proper vacuum bagging material schedule and vacuum pressure for a particular component.

INFUSION

PRO-SET Infusion Epoxies are used for resin infusion, VARTM, RTM and other closed molding applications. Choose the resin/hardener combination that will provide proper gel time for the part and process. Because of the many variables involved, these techniques require testing to determine the most suitable procedure and the proper resin/hardener combination for each part.

RELEASE FABRIC

In areas where you plan to do secondary bonding or additional coatings, use a release fabric (such as peel ply) over the lay-up. When peeled from the cured or partially cured surface, release fabric leaves a fine texture, free of contaminates and amine blush. After the laminate reaches initial cure and the release fabric is removed, the laminate surface is ready for bonding without further preparation. Using release fabric eliminates the need for washing and sanding in preparation for secondary bonding or coating. A laminate may be built up in several consecutive layups over period of days. Use release fabric after each day's lay-up and remove it prior to the next lay-up. When complete, the built up layers of laminate can be post cured together.

Not all release fabrics have an epoxy compatible coating or a texture suitable for secondary bonding with epoxy. Before building a part, test for the ability to bond to a surface prepared with the intended release fabric at the proposed post-cure temperature.

SURFACE PREPARATION

The success of secondary bonding depends not only on the strength of the epoxy, but also on the ability of the epoxy to mechanically key into the surface of the material rather than chemically bond to it. If you are bonding to a surface that has not been properly prepared with release fabric, the following surface preparation steps are critical to any secondary bonding:

1. REMOVING AMINE BLUSH

Amine blush is a by-product of the epoxy curing process. This wax-like film may form during the initial cure phase. The blush is water soluble and can easily be removed, but can clog sandpaper and inhibit subsequent bonding if not removed. To remove the blush, wash the surface with clean water and an abrasive pad. We recommend 3-M Scotch-brite™ 7447 General Purpose Hand Pads. Dry the surface with plain white paper towels to remove the dissolved blush before it dries on the surface. After washing with the abrasive pad, the surface should appear dull. Sand any remaining glossy areas with 80-grit sandpaper. If a release fabric is used, amine blush is automatically removed when the release fabric is removed.

2. CLEANING

Surfaces must be free of any contaminants such as grease, oil, wax or mold release. Clean contaminated surfaces with a silicone and wax remover, or acetone. Wipe the surface with clean paper towels before the solvent dries. Clean surfaces before sanding to avoid sanding the contaminant into the surface. CAUTION! Provide plenty of ventilation and follow all safety precautions when working with solvents.

3. DRYING

Bonding surfaces must be as dry as possible for good adhesion. If necessary, accelerate drying by warming the bonding surface with hot air guns or heat lamps. Use fans to move the air in confined or enclosed spaces. Watch for condensation when working outdoors or whenever the temperature of the work environment changes.

4. SANDING

Sand non-porous surfaces (metal, FRP laminate, cured epoxy, hardwoods, etc.) thoroughly to obtain an abraded surface. 80-grit aluminum oxide paper will provide a good texture for the epoxy to key into. Be sure the surface to be bonded is solid. Remove any flaking, chalking or blistering before sanding. Wear a dust mask! Remove all dust after sanding. Laminate surfaces can be textured by using release fabric during fabrication. This may eliminate the need for additional sanding.

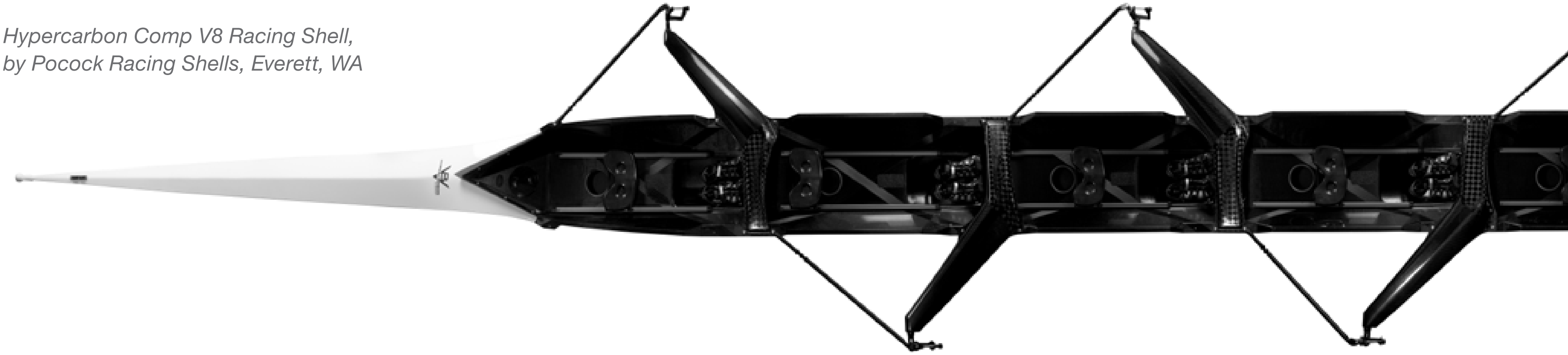
SECONDARY BONDING

Secondary bonding operations include the bonding of structural members, blocking or additional fabric reinforcing, coating, fairing or filleting to a previously cured or existing part. Once the part has cured to a solid state, a new application of epoxy will not chemically link with it, so the surface of the component must be washed and sanded (if it was not prepared with release fabric) to provide the proper surface for mechanical secondary bonds.

PRO-SET Adhesive is a two-part, thixotropic epoxy adhesive designed for secondary bonding and assembly of composite components. It cures fully at room temperature and it can be post-cured if parts are to be assembled before they are post-cured.

PRO-SET laminating resins and hardeners can be used for tabbing and taping operations either before or after post cure. Choose the resin and hardener combination that will provide the viscosity and cure speed combination necessary for the fabrics being used and to minimize drain out.

Body panels by Sankuer Composite Technologies, Sterling Heights, MI



Hypercarbon Comp V8 Racing Shell, by Pocock Racing Shells, Everett, WA

SURFACE PREPARATION FOR PAINT

Wet-sand the surface to remove any flaws and provide a texture for the paint to key into. If you are using a filling or sandable primer, use 100-grit paper. Use 220-320 grit paper if no primer is used. The thinner the paint film thickness, the finer the grit of sandpaper needed. Rinse the surface with clean water and dry thoroughly. Rinse water should sheet without beading up or fisheyeing, which could be a sign of local contamination. Re-wash with solvent if necessary and wet-sand. Allow the surface to dry thoroughly before painting.

PRO-SET Epoxies provide an excellent base for most paint systems. Linear polyurethane paints have proven to be the most durable protection over epoxy. Regardless of the paint system used, thorough preparation of the surface is essential for good paint adhesion and a smooth finish. For coating, follow the paint manufacturer's instructions.

GELCOATS

We have had good results with various in-mold polyester gelcoats. Because of their superior resistance to ultraviolet degradation, polyester gelcoats are preferred over epoxy gelcoats for exterior finish applications. Check with your polyester gelcoat supplier for recommendations and test to determine product suitability with epoxy and application technique.

Some fabricators have reported good success using a 2-part linear polyurethane paint sprayed directly onto the mold surface. This coating is allowed to cure and the epoxy laminate is applied directly to the paint.

An epoxy gelcoat is sometimes preferred for plugs and molds. Contact the Gougeon Technical Staff for custom product recommendations.

We recommend that each brand of gelcoat or in-mold coating and/or tie coat technique be tested for suitability in a specific application. If you have any questions about testing, call the Gougeon Technical Staff.

POST-CURING

POST-CURING

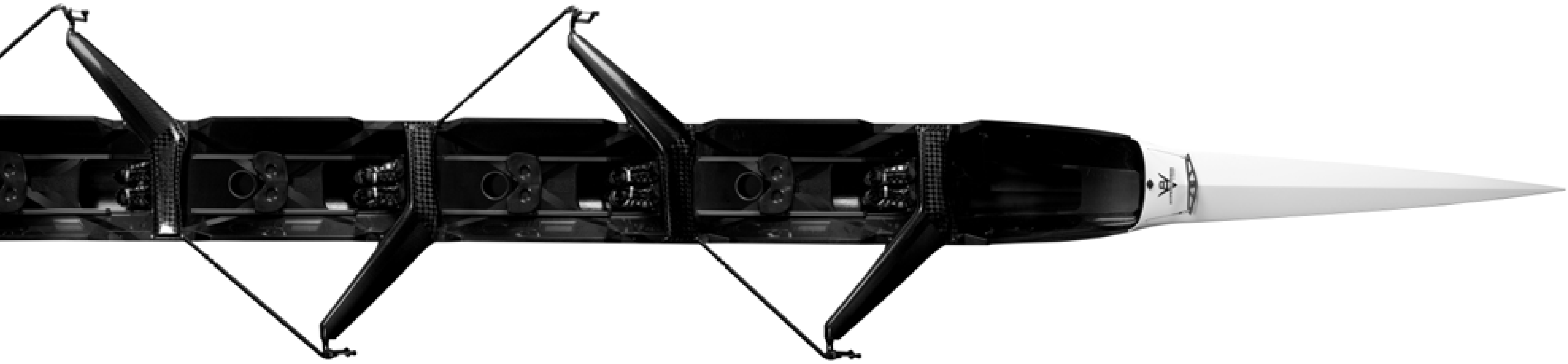
Resin/hardener combinations reach an excellent degree of cure for most applications with only a room temperature cure. Resin/hardener combinations with LAM-239 and all the HTP resin/hardener combinations require an elevated temperature post-cure to achieve optimal physical properties.

Post-curing is the controlled heating of an epoxy part—after it has reached or passed its initial cure stage—to improve the physical strength and thermal properties of the cured epoxy. Each PRO-SET Resin/Hardener combination has potential maximum cured properties that can only be achieved by post-curing the part above a minimum target temperature.

For each resin/hardener combination there is a range of post-cure schedules that will allow the laminate to reach 100% of its potential cured properties.

Published properties will not be reached if the actual post-cure schedule is below the specified temperatures.

Determine the post-cure schedule for a resin/hardener combination by the desired physical properties of the component, or by the limits of the equipment to reach or hold temperature. Thermal shock can induce flaws in the laminate. To avoid this, increase the temperature slowly and do not



exceed the maximum temperature. *Refer to the specific PRO-SET Resin/Hardener Technical Data Sheet for information on post-cure schedules and cured physical properties.*

POST-CURE SCHEDULES

During a post-cure, the temperature of the part is slowly raised to the post-cure target temperature, held for a period of time, then slowly lowered to room temperature. Post-cure schedules vary depending on the resin/hardener combination, the desired laminate physical properties, and the capability of the post-cure equipment to reach and maintain a target temperature.

Elevated temperature cure may begin as soon as the laminate is laid up, but with precautions. Keep in mind that as the uncured epoxy warms, it becomes more fluid and may drain from vertical laminates or result in a reduced resin-to-fiber ratio in some processes. In addition, in thicker laminations, the heat of the elevated temperature cure added to the exothermic heat generated by a large mass of curing epoxy may be high enough to damage the laminate or mold. Post-cure is recommended after the epoxy reaches an initial cure at room temperature.

The post-cure schedule is usually determined by the mechanical or thermal properties desired, but may also be determined by limitations of the post-cure equipment, or the ability of core materials or the mold to withstand post-cure temperatures. Although minimum recommended post-cure temperatures may be lower, 120°–180°F (60°–82°C) is the most effective range for post-curing most PRO-SET LAM and INF epoxies. HTP resin/hardener combinations require a stepped post cure of 2 hours at 140°F (60°C) plus 12 hours at 275°F (135°C) to reach maximum thermal properties.

The post-cure schedule determines the maximum potential properties a resin/hardener combination can reach. Use the resin/hardener Technical Data Sheets as a guide for determining cure schedules.

The laminate thickness and mold will determine the rate of temperature increase. A thick laminate may require a hold cycle to allow the temperature to normalize throughout the laminate. A core can insulate a portion of the laminate, causing that portion to lag behind the average temperature rise. Use thermocouples to monitor the temperature at various locations on the component during post-cure.

Increase the laminate temperature at a controlled rate so the laminate temperature does not exceed the thermal properties of the epoxy in the laminate. As the laminate is heated, the epoxy will continue to cure. The temperature ramp rate should be slow enough to allow for this additional epoxy cure, pushing the thermal properties of the epoxy up ahead of the laminate temperature. If the laminate temperature exceeds the thermal properties of the epoxy, surface distortion or laminate print through may occur.

Review the Technical Data Sheets for the product combination you are using to determine if a post-cure is required to reach your desired properties. If post curing, observe the following guidelines:

PRO-SET LAM AND INF POST-CURE GUIDELINES

1. Increase the temperature from room temperature at a rate of 15°–20°F (8°–11°C) per hour.

2. At every 40°F (22°C) increase in temperature, hold that temperature for an extra hour to allow internal laminate temperatures to equalize. Resume the temperature increase of 15°–20°F (8°–11°C) per hour.

3. Continue this cycle until the post-cure temperature is reached.

4. Hold the temperature as indicated on the resin/hardener data sheet.

5. Decrease the temperature at a rate of 20°F (11°C) per hour.

6. Hold at 95°F (35°C) for two hours to allow for normalization.

7. Turn off heat and allow to cool to room temperature. This schedule is recommended when curing a lighter laminate. The temperature ramp speed should be decreased for molds, plugs and heavy laminates. We recommend building test panels of the finished laminate schedule to determine the ideal post-cure cycle. Thermocouple wires embedded in the test laminate will measure the temperature lag during the post-cure.

PRO-SET HTP POST-CURE GUIDELINES

1. Increase the temperature from room temperature at a rate of 12°F (7°C) per hour.

2. Hold at 140°F (60°C) for 2 hours to allow internal laminate temperatures to equalize. Resume the temperature increase of 12°F (7°C) per hour.

3. Hold the temperature as indicated on the resin/hardener data sheet [275°F (135°C)].

4. Decrease the temperature at a rate of less than 20°F (11°C) per hour.

5. Hold at 95°F (35°C) for two hours to allow for normalization.

6. Turn off heat and allow to cool to room temperature. This schedule is recommended when curing a lighter laminate. The temperature ramp speed should be decreased for molds, plugs and heavy laminates. We recommend building test panels of the finished laminate schedule to determine the ideal post-cure cycle. Thermocouple wires embedded in the test laminate will measure the temperature lag during the post-cure.

HEATING METHODS

Post-cure heating techniques vary depending on the size of the part and mold, the number of parts being built or on the resources available for space and equipment. If resources are available, a fully insulated oven with an electric or vented gas or oil heater provides the greatest control over post-cure variables.

Radiant heaters that generate long wave infrared radiation can be used to heat the part without the use of an enclosure. This post-cure technique is often used on large parts, when space is limited or when a limited production does not justify the cost of an enclosure. Temperature is monitored by surface mounted thermometers and the heaters are repositioned over the component as necessary to provide an overall post-cure. WARNING! It is difficult to accurately control the rate of temperature change and maintain a uniform target temperature with radiant heating. This may result in laminate that does not have uniform physical properties. This technique may also result in more print through of the laminate.

POST-CURING IN MOLDS

Generally, parts are post-cured in the mold in which they were laminated. Molds that are subject to repeated use should be post-cured at a higher temperature than that required for the finished part. This allows the part to be post-cured in the mold at a temperature below the mold's HDT, thereby avoiding distortion of the mold, mold surface or the part during the part post-cure.

Plugs used to build molds should be post-cured at higher temperatures than the mold to avoid distortion of the plug or plug surface while the mold is being post-cured. Check plugs for fairness after post-curing and fair as necessary before the mold is fabricated.

QUALITY ASSURANCE

This section offers quality control measures that can be employed by fabricators, large and small, to assure consistent high performance of PRO-SET Epoxies.

COMMON PROBLEMS

The vast majority of problems encountered when working with an epoxy system can be traced to either improper mix ratio or insufficiently mixed resin and hardener. Metering the two components at the proper mix ratio and thoroughly blending them helps ensure consistent, high-quality results.

To a lesser extent, problems may also arise from not properly compensating for changes in temperature. It is important to understand how changes in temperature can effect the cure characteristics of epoxy and how to counteract those effects.

PROPER MIX RATIO

PRO-SET pumps are designed to meter the correct ratio of resin and hardener for standard PRO-SET combinations. With any metering system, a frequent check of the pump ratio is recommended. You can use graduated containers to check the metered volume or a scale to check the ratio by weight. If the ratio is not within the acceptable range for the products you are using, corrective action must be taken. Re-check the ratio anytime you experience problems with curing. Production facilities should check pump ratios on a regular basis.

EPOXY RATIO AND HARDNESS

Each resin/hardener combination will achieve optimum working, cure and mechanical properties at a specific mix ratio. Refer to the Technical Data Sheets for the acceptable range for the resin/hardener combination you have chosen. If the actual mix ratio deviates from this ratio range, the physical properties of the resin system will decline as the ratio deviates from the acceptable range.

To check the cure of the epoxy we use the ASTM D-2240 method for Rubber Property—Durometer Hardness. This method is recommended for quality control purposes and not for establishing specifications. This test is performed using a durometer measuring the D scale. The indenter needle is pressed into the cured epoxy sample and the resistance is recorded on an indicator. Durometers are available from industrial supply companies like McMaster Carr or Grainger Supply. Any instrument meeting the ASTM D-2240 requirements can be used. Some resin manufacturers specify Barcol hardness readings. However, we feel the D scale Durometer is more sensitive than the Barcol tester and is more appropriate for epoxy testing. Unfortunately, there is no direct conversion from the D scale to Barcol scales.

It is often a good idea to prepare a special quality control sample for testing and to keep quality control samples of cured epoxy for future reference. It can be as easy as pouring a portion of the mixed epoxy you are using into a mold or suitable container. Label this sample and cure it under the same conditions as your project. It may be sufficient to check the hardness right on the part you are building, as long as there is a flat area large enough to use the durometer.

A fully cured sample of epoxy will usually show a durometer D scale hardness of 81-90. A sample that has not had sufficient time to cure will have a lower hardness. However, if the hardness does not increase after a reasonable amount of time, there are several possible causes which should be investigated. The temperature may be too low to allow the epoxy to cure properly, the epoxy may have been mixed at the wrong ratio, or it may have not been mixed thoroughly, resulting in localized areas of off-ratio material.

THOROUGH MIXING

When using a mechanical mixer to blend large batches of epoxy, it is crucial to scrape the sides and bottom of the container to ensure thorough mixing. Operate at low speed to reduce air entrapment.

DYED RESINS AND HARDENERS

We suggest using dyed resins and hardeners as a visual control of mixing thoroughness. A yellow dye in the resin and a blue dye in the hardener will yield a consistent shade of green when the proper ratio of resin/hardener is thoroughly mixed. Streaking due to insufficiently mixed resin and hardener is very apparent. PRO-SET has dye available to mix on-site. Instructions are provided to mix the dye at the proper ratio. If you are purchasing larger quantities of resin, we can pre-mix dyes at our plant before shipment.

COMPENSATING FOR TEMPERATURE EFFECTS ON EPOXY CURING

The working time and pot-life information for PRO-SET Resin/Hardeners combinations are shown on the Technical Data Sheets.

Low temperatures can increase working time, cure time and resin viscosity. Higher resin viscosity due to low temperatures can cause pumps to meter off ratio. It may be more difficult to thoroughly mix a very thick resin and hardener batch. It may also be more difficult to wet-out the fabric with very thick epoxy. The extended cure time can leave the epoxy vulnerable to damage if clamping pressure is removed too early.

Higher temperatures will reduce working time, cure time and resin viscosity. The fabricator should carefully evaluate the working conditions, size of job and number of workers in choosing the correct resin/hardener combination. Shop temperatures should be observed and recorded during the fabrication of parts.


Tribute 37’ built by Tribute Boats, West Palm Beach, FL

TESTING TERMINOLOGY AND METHODS

PREPARATION OF TEST SPECIMENS

All data is collected from unmodified, mixed and cured epoxy. Pure epoxy mixtures are used to eliminate the effect of fibers or filler.

All of the mechanical data reported is based on epoxy mixed at the target ratio and cured under the conditions specified in the top row of the table on the product data sheets.

The published data is based on the same test conducted several times on multiple specimens, generating average result numbers. Averages, not highest values are reported. These averages are rounded to an appropriate number of significant figures.

ASTM standards are followed for all testing. When comparing another manufacturer's product to PRO-SET, be sure to note if they used the same standardized test.

HANDLING PROPERTIES

Pot Life is the amount of time a mixture of resin and hardener has a workable viscosity while in the mixing container. Pot life is determined using 150 gram and 500 gram samples in a standardized container at 72°F (22°C), 77°F (25°C) and 85°F (29°C). Both mass and ambient temperature affect the rate at which an epoxy system will cure. Pot life should be used only for comparative purposes when evaluating an epoxy system's cure time.

Working Time is the amount of time the viscosity of the epoxy remains low enough to be processed. It is determined using a Gel Timer which employs a spindle traveling through an 1/8" thick volume of liquid epoxy. Working time is the amount of time the spindle can travel through the epoxy without leaving an indent in the curing epoxy.

Viscosity is a fluid's resistance to a shear force and can be thought of as how easily a fluid flows. A Rotational Viscometer is used to measure viscosity. A spindle rotates in the epoxy to measure its resistance. A thicker fluid will give the spindle more resistance, indicating a higher viscosity. Since temperature will affect the viscosity, we provide data points at different temperatures as well as graphs that provide viscosity data over a wide range of temperatures.

Manufacturing process and processing temperature are important considerations when determining the required mixed epoxy viscosity. Infusion processes often require very low viscosity to enable good flow whereas a wet layup may require a higher viscosity that allows thorough fabric wet out yet prevents drain out.

Thix Index or Shear Thinning Index is a ratio determined by viscosity measurements taken at 10 and 100 RPM. The low speed reflects how epoxy will flow undisturbed. The high speed measurement indicates how well it will flow when shear force is applied as is often the case during processing.

Mix Ratio is the target ratio of resin to hardener required to achieve published properties and may be different by weight and volume due to the differing densities of the resin and hardener.

Every resin/hardener combination has an optimal target and acceptable range. Please note that the target is often not in the middle of the acceptable range. Achieving the correct mix ratio can be simplified by using PRO-SET Dispensing Equipment.

Density is the mass divided by volume. We conduct these tests at 77°F (25°C) so that the density measurement in grams per cubic centimeter (g/cc) is also equal to the specific gravity.

Hardness is a material's resistance to deformation. This test is conducted with a Durometer utilizing the D scale. A Durometer forces a metal point into the material and provides a numerical reading which corresponds to the resistance at the point. The results of a hardness test are important for comparative purposes and determining the degree of cure.

Gougeon Brothers Laboratory

MECHANICAL PROPERTIES

Compression Yield strength is the stress required to cause plastic deformation. Plastic deformation is the permanent change in shape or size of a solid body without fracture, resulting from sustained stress beyond the elastic limit. Cylinder shaped specimens are placed in a test machine that applies an increasing compressive force until plastic deformation weakens the sample. The highest force recorded prior to deformation is the Compression Yield Strength.

Tensile Strength is the stress that is required to fracture the epoxy and cause a failure. Dog bone shaped specimens are placed in a test machine that applies an increasing tensile force until failure. The highest stress recorded prior to failure is the Tensile Strength.

Tensile Elongation, also referred to as strain, indicates how much the material can “stretch” before it fails. Dog bone shaped samples are placed in a test machine that applies an increasing tensile force until failure. The change in sample length is measured with an extensometer. The point at which the sample fails is the Tensile Elongation.

Tensile Modulus describes the amount of elongation (strain) that results from a specific amount of stress. This property is essentially the stiffness of the material. During the Tensile Strength test, elongation is measured and recorded at the corresponding stress before the material yields. The stress divided by the strain, in the elastic region, equals the modulus or the slope of the stress/strain curve.

Flexural Strength is a measurement of the maximum amount of bending stress a sample can withstand before fracturing. The sample is simply supported at each end and an increasing load is applied in the center. The stress caused by bending is calculated and the amount that results in failure is recorded.

Flexural Modulus is calculated by measuring the deflection of a beam during the Flexural Strength test. In a manner similar to the calculation of Tensile Modulus, the deflection and stress are used to determine the Flexural Modulus.

Lap Shear Strength measures the strength of an epoxy bonded joint when loaded in shear. The test is performed by bonding two metal coupons together with an overlap and then pulling them apart in tension in a test machine. The tensile force creates a shear force in the bond line and the resulting stress is reported as the Lap Shear strength.

Tensile Adhesion Strength is the stress required to fail a bond line with a force perpendicular to the bonded surface. An aluminum stud with a flat end is bonded to the material to be tested. A device is threaded onto the stud and applies a pulling force to the stud and against the material simultaneously. The load required to fail the bond divided by the bonded surface area and the resulting stress is reported on the data sheet as the Tensile Adhesion strength.

THERMAL PROPERTIES

Glass Transition Temperature (Tg) is a very useful property for understanding the thermal characteristics of an epoxy resin system. The Tg is the temperature at which the epoxy changes from a glassy (solid) state to a soft, rubbery state. It can be considered the point at which a measurable reduction in physical properties occurs resulting from exposure to elevated temperatures.

Be aware that Tg values can be reported after a second heat. The second heat is the process of testing the sample after it has been exposed to an initial first heat which resulted in an elevated temperature, 392°F (200°C), post cured sample. A second heat Tg value is not representative of your sample unless you have replicated the 392°F (200°C) cure schedule that was used for the first Tg test.

TG DMA ONSET STORAGE MODULUS AND PEAK TAN DELTA

The Dynamic Mechanical Analyzer (DMA) determines the Tg using a mechanical method. The test sample is placed into a three-point bending fixture and a cyclical load is applied. The temperature of the sample is increased and the change in the deflection is measured. As the temperature is increased during the test, the response of the sample changes. The sample's response is plotted using three different graphs based how the bending energy is transferred into the sample: storage modulus, loss modulus, and tan delta.

STORAGE MODULUS is the elastic response. The recovered part of the energy originally put into the sample.

LOSS MODULUS is the energy that is absorbed by the sample due to friction and internal motion.

TAN DELTA is the ratio of loss modulus to storage modulus, the dampening character of the sample.

When epoxy is below its Tg, the storage modulus is high and the loss modulus is low. The sample releases energy efficiently and does not absorb energy well due to its stiffness. When the sample gets closer to its Tg, the storage modulus decreases. Energy is now absorbed into the sample, driving the loss modulus higher.

TG ONSET STORAGE MODULUS is a conservative value indicating a measured loss of stiffness.

TG PEAK TAN DELTA is the highest measured Tg value.

TG DSC ONSET–FIRST HEAT

While a DMA measures thermal properties of a sample via mechanical means; a Differential Scanning Calorimeter (DSC) machine measures the heat flow in and out of a sample to determine its Tg. This test is conducted by placing a fully cured sample into a small pan in the DSC and heating it to 392°F (200°C) at a rate of 18°F (10°C) per minute. The heat flow into the sample is measured and compared to an empty reference pan. The difference in heat flow is measured and plotted. An inflection occurs in the plotted curve at the Tg; the Onset is measured at the beginning of this inflection.

TG DSC ULTIMATE

Ultimate Tg is the highest Tg value that can be attained for a particular epoxy system. In order to achieve this temperature resistance in an application the epoxy must be post cured at a pre-defined elevated temperature for a specific amount of time. See the Technical Data Sheet for a specific resin/hardener combination, or contact our Technical Department, 888-377-6738.

HEAT DEFLECTION TEMPERATURE

Heat Deflection Temperature (HDT) is the temperature at which the epoxy will deform under constant load.

A sample is submerged in oil at a carefully calibrated temperature and subjected to 264 psi of bending stress in the center. The temperature of the oil is then gradually raised until the bar deflects .01 inches in the center. This temperature is considered to be the heat deflection temperature.

HDT OF LAMINATE

The HDT of Laminate is the temperature at which a typical 1/8" epoxy/fiberglass laminate will deform under constant load with the same test parameters as above. The HDT of a laminate is so much higher than a neat resin that it will not deform even at the test's maximum temperature of 572˚F (300˚C).

Violin by Luis and Clark Carbon Fiber Instruments, Milton, MA

Cuda built by Z Rodz and Customs. Photography by McGaffin Photography for Wheel Hub Magazine.

PRO-SET®

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