

# Which Epoxy for Your Project

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28 July AirVenture 2021

# What to Look For in a Resin

- Primary interest is mechanical properties and structural performance
  - strength, modulus, Tg, hardness, elongation
- Handling characteristics during construction, ie, ease of lamination
  - down hand lamination or vacuum infusion
- Pot life and cure times play an important role in resin selection
- Safety is equally important in resin selection
  - exposure limits for skin irritation & inhalation concerns
  - carcinogen, mutagen issues

# The Good, Bad & the Ugly

- Good: mechanical properties,  $T_g$  & laminating properties
- Bad: Skin Irritant, Respiratory Irritant, Corrosive
- Ugly:
  - 4,4' Methylenedianiline commonly called MDA. Medical concerns over MDA regards its liver toxicity and carcinogenicity. OSHA exposure limits are set at only 8 parts per billion (this is equivalent to about 24 seconds out of a century).
  - Styrene monomer (known carcinogens & mutagen)

# Ugly: Safe-T-Poxy, now EZ Poxy

- The original Applied Plastics Co. name is non sequitur.
- Contains MDA and styrene monomer
- As stated, MDA is not good and led to Rutan Aircraft and Scaled Composites to cease use.
- Styrene monomer is used as a diluent (commonly use as a reactive diluent in polyester and vinyl ester resins) but is not reactive in epoxy resins.
- Styrene monomer has been on the OSHA hit list for many years but the composites industry fights back and has a very strong lobby in D.C.
- Hexcel Corp., acquired the product line and made it part of their Epolite® laminating series. Anne Jackson managed the product line while at Hexcel. Anne now works at Endurance Technologies. She recently stated to me at a trade show that EZ Poxy is the same chemistry as Safe-T-Poxy/Epolite. The EZ Poxy resin system is the only one that uses MDA and styrene.

# Ugly Cont.

## EZ Squadron Article

### Answering the Epoxy Question

From DP84, Page 4 (April, 1996)

- ❖ It seems several laminating materials have gone the way of the buffalo, disappearing from market shelves only to reappear briefly in small quantities before dying out for good.
- ❖ It has put some homebuilders in a tailspin, stranding them with partly built aircraft and a possible compatibility problem. While the good news is that new products are on the horizon, the bad news is that homebuilders will have to decide what tradeoffs they are willing to accept.
- ❖ RAF reported in CP 77 that its sister company Scaled Composites (SCI) would no longer use Safe-T-Poxy as it was found to contain MDA (a known carcinogen) and styrenes (highly allergenic). "We buy resin in 55 gallon drums, sometimes 10 drums at a time," explained Mike Melville, "and we have 100 employees now. We don't want to subject our employees to even the threat of MDA contamination." The same goes for homebuilders", he continued. "They have to know, even if it's the smallest of a million, that Safe-T-Poxy contains a known carcinogen."
- ❖ In addition, Hexcel sold its Resins Group business, which included Safe-T-Poxy, to another company. The new owners decided not to continue the resin line, and Safe-T-Poxy suddenly became a thing of the past.

Unfortunately alternate epoxies recommended by RAF in CP 77 have since been discontinued. SCI scrambled to find a MDA-free replacement and now uses a laminating system called Pro-Set distributed by Gougeon Brothers Inc. located in Bay City, MI.

# Reluctance to Change:

- “Saf-T-Poxy / E-Z Poxy is Rutan approved system”
- Resin the plans call for
- Resin has been used for 30+ years with no structural failures
- Very easy to use
- Only issues have been with onset of skin sensitivity
- Readily available and affordable
- ‘Old Timers’ claim they built their plane with it and it works just fine
- Most news groups endorse it (except EZ Squadron - ez.org)

# The Three Recommended Resins

(Available from Aircraft Spruce and Wicks)

- The following resins meet or exceed the physical properties of the E-Z Poxy without the 'adverse effects'
- Gougeon Brothers Inc. (GBI) ProSet Epoxy 125 or 135
  - Hardeners: LAM-226 (med), LAM-229 (slow), LAM-237 (extra slow)
- Martin G. Scheufler GMBH (MGS) L285
  - Hardeners: 285F (fast), 287S (slow)
- PTM&W Aeropoxy PR2032
  - Hardeners: PH3660 (fast), PH3665 (slow)
- With all three of these resins room temperature curing results in good properties; some curing at elevated temperatures, or post curing, will result in the highest achievable strength and Tg.
- GBI is the only manufacturer that claims that one may blend the hardeners to adjust cure times. MGS is clear that one cannot mix components of the 285 and 335 resins together. PTM&W is silent

# About GBI WEST SYSTEM®

- WEST SYSTEM® is a reformulated laminating resin originally developed for wood cold molding.
- It is not recommended in aircraft structural applications as the average Tg is 130°F. One can achieve 142°F with 205 fast hardener and post curing.
- Most popular hardener is the 206 for longer working times. The Tg is 126°F at room temperature cure. However, one can achieve a 10° bump in Tg with a post cure.
- WEST System is excellent for use with micro filler. Further, it is readily available from local retailers.
- However, I do not recommend the use of GBI 410 Microlight filler as it is a plastic micro-sphere and not a glass micro-sphere. It has the potential to swell under certain surface heating conditions.
- WEST SYSTEM may be used for non-structural applications such as instrument panels and interior consoles.

# About Fuel Tank Fuel Resistance

- Claims that EZ 83 hardener is better for fuel resistance
  - Let the data speak for itself! If there is data I have not seen it.
- The most widely used chemical and corrosion resistant resins available in industry have a novolac backbone.
  - Novolac resins yield high crosslink densities for resistance
  - They have lower strain to failure performance than Bisphenol A resins (read more brittle)
- Available as coatings from several manufacturers (epoxies)
  - Sherwin Williams Cor-Cote EN 7000
  - Epoxy Systems, Inc. (Epoxy.com) #633 Novolac Epoxy Coating
  - Five Star Novolac Epoxy Coating (fivestarproducts.com)
  - Hexion Epon or Epikote novolac resins and coatings (hexion.com)
  - Rhino Fuel Tank Sealer 9700 A/B FRC (formerly Jeffco)

# Fuel Tank Fuel Resistance Cont.

- Also available as a laminating resin (vinyl esters)
  - Ashland Chemical Derakane 470
  - Interplastics CORVE8700 Series

# GBI ProSet

- Low viscosity for quick wet out of all organic and synthetic composite fabrics; especially effective with aramid (aka Kevlar®) and carbon fiber.
- Slow cure speed hardener provides 4 to 5 hours working time at 77°F (25°C). A typical laminate will be gelled in 6 to 7 hours.
- Optimized for hand wet out and machine impregnation in contact molding, vacuum bagging and light RTM (such as VARTM) applications.
- Room temperature cure properties suitable for many composite components and structures.
- Tg as high as 197° F (92° C) with proper post cure providing excellent temperature stability and great part cosmetics.
- Cost Effective - High Performance Epoxy formulation for composite manufacturing.
- Reformulated in 2013 yielding enhanced mechanical properties and lower retail pricing.

# Hexion MGS

- Laminating resin system approved by the German Federal Aviation Authority
- Best known and accepted in the light aircraft industry; these being european gliders and aircraft such as Diamond, Lancair, Cirrus, Cessna, Icon
- In the wind industry, the MGS line of Hexion resins is the global leader
- Available with the slower curing blends.
- Even unfavorable low temperature and high humidity conditions in the work environment will not effect the quality of the product and high gloss, uncontaminated, tack free surfaces are achievable every time. The resins do not contain any unreactive dilutants which with many systems result in de-gassing and bubbling of the painted finish. The MGS resins do NOT contain aromatic amines.

# PTM&W AEROPOXY

- The resin system gives excellent wet-out of fiberglass, carbon and aramid fibers.
- Special additives have been incorporated into this system to promote chemical adhesion to fabrics made with these fibers.
  - **Note:** I have not seen the interlaminar mechanical data to agree with this statement
- The AEROPOXY systems will cure completely at room temperature, or can be given an elevated temperature cure.
- It satisfies all structural, pot life and wet-out characteristics according to tests by Rutan Aircraft Factory, and RAF recommended its use for all homebuilt aircraft applications.
- AEROPOXY contains no MDA and meets or exceeds current OSHA requirements for safe use. PTM&W AEROPOXY epoxy products are made from raw materials carefully chosen to minimize or even eliminate toxic chemicals, and therefore offer the user high performance products with minimum hazard potential when properly used.
- No personal experience with the laminating resins only with the tooling surface coat. I talked to builders who are very satisfied with the results.

# What About the Properties?

- Neat (pure resin) mechanical properties are what we use to compare candidate resins
- For application in the military and aerospace industry the manufacturers' SPEC's are not trusted and each candidate material would go through laboratory studies
- American Standard for Testing of Materials (ASTM) publishes and manages the test standards
- Caution is used when accepting the manufacturers published properties as they can be embellished by post curing to the 'second heat' condition (onset of 2<sup>nd</sup> T<sub>g</sub> by post curing)

# Property Definitions

- **Shore D Hardness Scale** measures the hardness of hard rubbers, semi-rigid plastics and hard plastics. The different Shore Hardness scales measure the resistance of a material to indentation.
- **Compression Strength** is the measure of the material to resist compression under load. As composites are weaker in compression than an orthotropic (metal) material this property is of great interest
- **Tensile Strength** is the measure of the material under a linear tensile load
- **Percent Elongation** is self explanatory and is the measure of 'stretch' while under tensile load
- **Modulus** is a fancy way of reporting stiffness under tension or compression
- **Glass Transition Temperature,  $T_g$** , is the measure of the polymer when it transitions to a softer state. It is the point where material properties decline

# Property Comparison

EPOXY PROPERTIES (neat)	Test Method	Gougeon ProSet		MGS*	PTM&W	E-Z Poxy
		LAM 125/226	LAM 125/229	L285/287	PR2032/PH3660	EZ-10 / EZ-84
Mix Ratio: by Weight		100 : 28.1	100 : 27.8	100:40	100 : 27	100:44:00
by Volume		3:1		2:1	3:1	100:47:00
Hardness (Shore D)	ASTM D-2240	92	92	NA	86 - 88	
Compression Yield (psi)	ASTM D-695	16,800	16,200	17,400 - 20300	13,288	14,000
Tensile Strength (psi)	ASTM D-638	8,100	9,380	10,150 - 11,600	9,828	8,2300/10,000
Tensile Elongation (%)		2.1 - 7.2	3.5	5.0 - 6.5	1.9	3.5
Tensile Modulus (psi)		5.30E+05	5.56E+00	4.64E +05	4.18E+05	480,000
Flexural Strength (psi)	ASTM D-790	17,100	14,400	15,950 - 17,400	16,827	NA
Flexural Modulus (psi)		5.36E+05	5.40E+00	NA	4.63E+05	NA
Glass Transition Temperature (°F)	Differential Scanning Calorimeter	190	186	195	NA	151 / 196

\*NOTE: Typical data according to WL 5.3203 Parts 1 and 2 of the German Aviation Materials Manual not ASTM.

Contact INFO on WWW

