

Epoxy Resins

DO'S & DON'TS

by

Gary Hunter

EAA Technical Counselor

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INTRODUCTION

- Private Sport Pilot / Homebuilder since 1976
 - Vari-Eze Serial #1183 - completed 5/84
- The Shell "Answer Man" for Epoxy Resins (29 years)
- Crew Chief for Bruce Bohannon's
 - "Pushy Galore" - retired to EAA's AirVenture Museum
 - The "EXXON Flyin' Tiger" - holding 30 world records
- Owner Proprietor of Gary Hunter Composites
 - specializing in custom composites for homebuilts
- I'm with the [EAA](#) - and I **AM** here to help you !!!
 - as a technical counselor

PREFACE

➤ **Resolution Performance Products**

formerly Shell Epoxy Resins, LLC

www.resins.com

➤ **Huntsman Advanced Materials**

Formerly Ciba Geigy Specialty Products & Vantico

www.huntsman.com/advanced_materials/

➤ **The Dow Chemical Company**

www.dow.com

➤ **Reichhold Chemical Company**

www.reichhold.com

➤ **Air Products & Chemicals**

Resin manufacturers sell in bulk to major accounts like:

- 3M Company
- PPG Industries
- Akzo-Nobel
- Behr

Drum quantities are sold through distributors like:

- Ashland FRP Supply - www.ashchem.com
- GLS Composites One - www.composites1.com
- Seegott, Inc., etc. - www.seegott.com

(List price for a typical base resin \$16 / gal - min. 55 gallons)

(List price for base curing agent \$32 / gal - min. 55 gallons)

Distributors sell to Formulators like:

- EPOXICAL / Composite Polymers Design - www.epoxi.com
EZ-Poxy and CPD Resins (old RAE formulations)
- Gougeon Brothers – www.gougeon.com
West System and ProSet
- MGS - www.mgs-online.com
MGS 285 Resin / H235F & H287S
MGS 335 Resin / H335F & H340S
- PTM&W - <http://www.ptm-w.com>
AEROPOXY
- Poly-Fiber - www.polyfiber.com
Poly-Epoxy, Alpha Poxy, Superfil

SELECTING

- Aircraft designers list approved resin systems
 - Hopefully – they were used to build a flying prototype
 - Or, at least thoroughly tested to specific standards
- Find a way to sample candidate resin systems for testing
 - Visit other builders in your area – watch them work with it
 - Ask suppliers for small evaluation quantities – test it yourself.
- Resins suppliers should supply product information
 - Technical Data Sheets and MSDS upon request
 - Evaluate the availability and quality of the data
 - Compare performance attributes
 - Compare cure requirements

SELECTING

- Consider the “track record” of the system
 - How many flying examples ?
 - Cure characteristics
 - Any health and safety concerns ?
 - Technical support
- Locally available resins are enticingly convenient, but
 - Savings on shipping are often offset by higher prices and sales taxes
- If it sounds too good to be true, it probably is.

JOE BLOE PRODUCTS

(name changed on purpose)

JOE BLOE Resin A / Resin B / Hardener C

DESCRIPTION: Low odor, minimum toxicity epoxy systems for infusion of large scale composite parts at ambient curing temperatures. Ideal mixed viscosity (approx 250 cps @ 25°C) to quickly wet thick reinforcements. Long working life in laminates with quick cure and hardness development. **High T_g without post cure.** Mix ratio 100:22 by weight (4:1 volumetric mix). 100% solids.

PHYSICAL
PROPERTIES
(neat):

Resin A

Resin B

Hardener C

Viscosity, cps
Color, Gardner
Weight per
Gallon
Equivalent
Weight

420
2 max
9.27 lbs
160-170

520
1+max
9.28 lbs
190-195

90
5 max
8.24 lbs
44

MY DATA

Calculated ratio	Resin A / Hdnr C	Resin B /Hdnr C
By weight	26.7	22.8
By volume	30	25.7
By ratio	3.33:1	3.9:1

MIXED SYSTEM
PROPERTIES:

Rsn A/ Hdnr C

Rsn B/ Hdnr C

Mix Ratio, Resin to
Hardener

100:22 (wt)

100:22 (wt)

Mixed Viscosity, cps

220

270

Pot Life, minutes @
25°C

60 (150 grams)

80 (150 grams)

Working Time in
Laminate, hours

2 - 3

2.5 - 3.5

Thin Film Set Time
@ 25°C

4 - 5 hrs.

5 - 6 hrs.

Time to saturate 5
plies 26 oz.

9.5 mins.

10.5 mins

Resin A/ Hardener C Resin B/ Hardener C

CURED
PHYSICAL
PROPERTIES
(neat):

(1 ply 34 oz biaxial,
2 plies 26 oz uni,
65% glass)

Barcol Hardness	58	56
Tensile, D-638	55,000 psi	45,000 psi
Tensile Modulus	2.85 psi x 10 ⁶	2.73 psi x 10 ⁶
Tensile Strain at break, %	0.87	0.9
Flex, D790	1.65 psi X 10 ⁶	1.61 psi X 10 ⁶
Water Absorption, %	0.14	0.15
HDT	205°F	185°F

SELECTING

PRODUCT	Mix Ratio Pbv / pbw	Mixed Visc CP	Pot Life @ 77F	Tg °F RT / PC	Tensile (ksi) RT / PC	\$ / lb (8/98) ¹
EZ 10 / EZ 83	47 / 44	1300	2 hrs.	151 / 196	8.2 / 10	6.80
EZ 10 / EZ 84	47 / 44	800	2 hrs.	151 / 196	8.1 / 10	6.80
EZ 10 / EZ 87	47 / 44	1500	5 hrs.	142 / 196	8.4 / 10	6,80
CPD 4426 / 9376	33 / 27		60 - 65 min			5.36
CPD 4426 / 9377	33 / 27		120-140 min			5.36
EPOLITE 2318 / 2316	37 / 32	1200	65 min.	N/a / 184	N/A / 10.9	7.34
EPOLITE 2427 A&B	45 / 44					11.43
MGS 285 / H235F	50 / 45		40 min.	/ 221-230		7.68
MGS 285 / H287S	50 / 45		4 hrs.			8.11
MGS 335 / H335F	45 / 38		15 min.	/ 167 - 176	N/A / 10 -11.5	6.17
MGS 335 / H340S	45 / 38		6 hrs.		N/A / 10 -11.5	6.02
Aeropoxy PR2032 / PH3665 S	33/27		120-140			5.36
Aeropoxy PR2032 / PH3660 M	33 / 27		60-65			5.36
Aeropoxy PR2032 / PH3665 F	33 / 27		30			5.36
Pro-Set 125 / 229 Hardener	35 / 30	400	77 min			9.70
West 105 / 205	20 / 18	500	10-15 min		7.55 / N/A	7.92
West 105 / 206	20 / 18	500	30-40 min			7.92
Poly-Fiber - Poly Poxy	40 / 33		105 min	143 / 160	8.8 / 9.6	6.11
Poly-Fiber - Alpha Poxy	33 / 25				N/A	3.25
DOW DER 330 / 749	17.5 / 15 ²		45 min.		N/A	3.48
EPON 862/EPI-CURE 3234	18 / 15	775	35 min.	150 / 250	10 / 12	2.33 ³

¹ Price per pound is calculated on the mixed system from prices in AS&S and Wicks Catalogs

² Mix ratio in the Wicks catalog is incorrect - use this one instead

³ Price is based on list drum prices from Shell Distributors

SELECTING

DO

Follow recommendations of the Aircraft Designer

Conduct your own evaluations - “play with it” Compare published literature / test data

Obtain Material Safety Data Sheets

Value a resin with a proven track record

DON'T

Believe everything you hear or read

Base your decision on cost or availability

STORING

- Epoxy resins and curing agents do not “go bad”.
- ALL liquid epoxy resins are "**super cooled liquids**", and as such, they have a tendency to crystallize with time.
- GENTLE warming to 120-140°F will melt the crystals
 - Hot tap water is generally sufficient given enough time.
 - Avoid microwave ovens for this operation.
 - Upon cooling it will remain a free flowing liquid.
- EZ-Poxy 83, 84, and 87 curing agents can crystallize too.
- Curing agents react with CO₂ and absorb moisture
 - Sunlight will cause them to darken

STORING

DO

- Keep products in tightly sealed containers
- Maintain storage temperature at $70 \pm 15^{\circ}\text{F}$
- Avoid direct contact with concrete floors
- Keep curing agents away from directly sunlight

DON'T

- Dispose of old epoxy resin or curing agents needlessly
- Leave pump reservoirs open to atmosphere continuously
- Believe Mfgr's 1 year shelf life limitations

SAFETY

- **ALL** epoxy resins AND curing agents can sensitize you
 - Most common symptom is a rash
 - More severe allergic reactions can cause death
- **ALL** epoxy resin and curing agents are toxic by the true definition of the word
 - Toxicity is a function of dosage
 - Too much of anything will hurt you
- **ALL** curing agents are corrosive to the skin & eyes
 - DOT non-corrosives too !!
 - Once sensitized, you become allergic.
- These are industrial chemical compounds and must be treated accordingly.

SAFETY

DO

GET and READ the Material Safety Data Sheets !!

Wear Nitrile Gloves - avoid Latex

Use Barrier Creams on your forearms

Ventilate the shop any amount possible

DON'T

Be cavalier about proper safety precautions

Teach others your bad habits

DISPENSING & MIXING

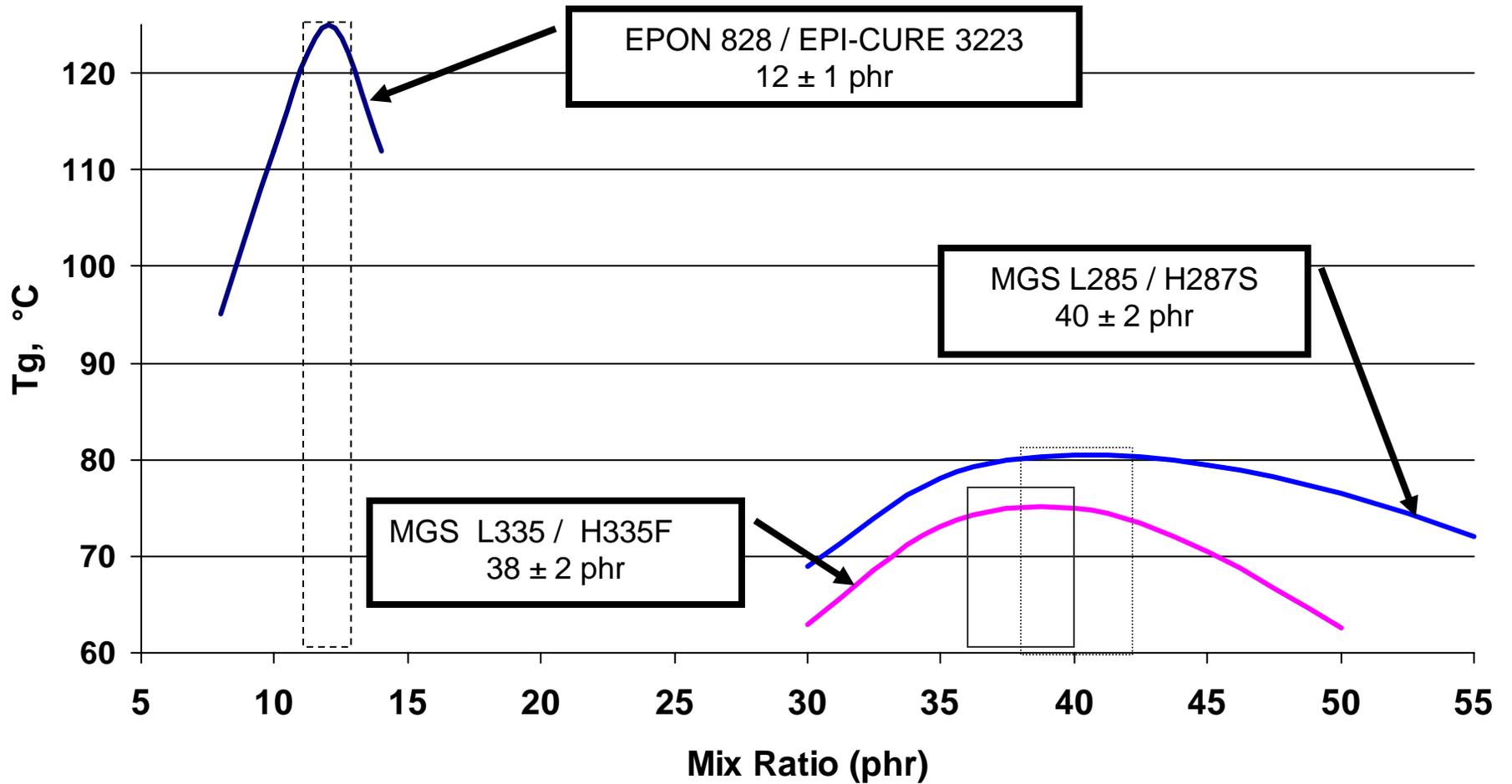
- Rutan's beam balance works just fine - if built well.
 - Most important to have good bearings
- Electronic digital balances are the most versatile.
 - They work with ALL resin systems - 5 minute too
 - www.balances.com have balances under \$100
 - 2000 X 1 gram capacity recommended
 - Daily calibration is quick and easy.
 - Resins and curing agents can remain in original containers that makes de-crystallizing easier.
- A "well maintained" pump is really convenient - BUT
 - You will still need a good balance to calibrate it.
 - Sometimes, you can't detect a malfunction until long after the fact.

DISPENSING & MIXING

- Gel time cannot be adjusted by the mix ratio, but rather by:
 - changing the curing agent type, or
 - thoroughly blending “Fast” & “Slow” curing agents
- Wax lined mixing containers can effect bonding
 - Use Dixie Hot Drink Cups, or Plastic Cups
- Thorough mixing is very important
 - 1-2 minutes while scraping sides and corners
 - Excessively vigorous mixing induces entrained air
 - Large batches can justify motorized mixers
 - Boat propeller types are preferred over Jiffymixers
- Mix ratio does effect resin performance properties
 - Heat and Chemical Resistance
 - Physical strength characteristics

DISPENSING & MIXING

Curing Agent Mix Ratio vs. Glass Transition Temperature



DISPENSING & MIXING

DO

Select a comfortable dispensing method and stick with it
Calibrate your equipment on a regular basis and log it
Keep records of “what” was used “where” and “when”
Mix Fast & Slow curing agents thoroughly before adding to
the pump reservoir

DON'T

Eye-ball or guess mix ratios or curing agent blends
Use wax lined mixing cups
Change mix ratio to adjust cure speed
Use a Jiffymixer to stir your resin

TEMPERATURE CONTROL

Temperature effects:

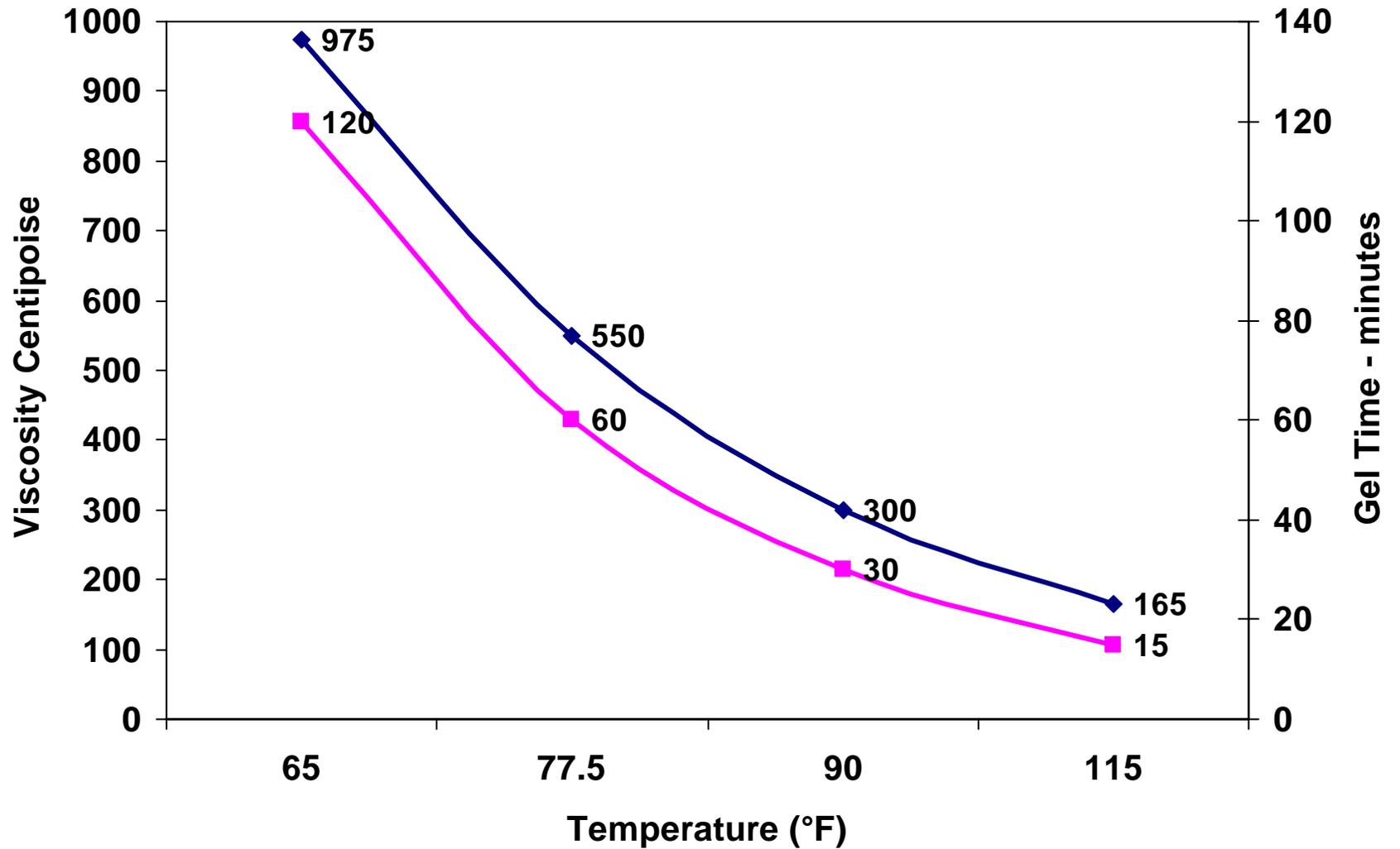
Viscosity - which effects:

- Wet out - which effects:
 - Resin / glass ratio - which effects:
 - Part weight and strength

Reactivity - which effects:

- Working time and
- Crosslink density which effects:
 - Part strength & fuel resistance

Temperature vs. Viscosity & Reactivity



TEMPERATURE CONTROL

- Lab conditions are always best - but not always practical
- Temperature
 - Preferably 70-80F - absolutely nothing below 65F
- Humidity
 - Avoid foggy or rainy days and dewy mornings and evenings particularly in an open shop environment.
- An air-conditioned shop will help finish the project faster



Jerry Schneider' Shop 2.jpg





TEMPERATURE CONTROL

DO

Make a deliberate effort to manage temperature

Invest in an Air Conditioner / Heater Combo

Be conscious of how temps can effect the work

Schedule jobs around temperature conditions

DON'T

Start a project if temps can drop below 65F within 12 hrs.

Do long thick lay-ups when temps exceed 85F.

CURING

- The curing of epoxies is a chemical reaction controlled by:
 - Temperature, Mass, Pressure
- Typically, the reaction “plateaus” after 7-10 days @ RT
- Most epoxies obtain adequate performance w/ RT Cures
- Optimum performance is obtained through a “Post Cure”.
- Post curing is simply baking the cured resin at an elevated temperature to drive the cure to higher state of completion
 - 4-8 hrs @ 140F is generally sufficient – 1 day in attic
- For some systems it is not necessary and others a must.
 - Follow the formulators written recommendations

CURING

- All Epoxy resins benefit from a post cure.
 - Increases the Tg / HDT, fuel resistance, physical properties
 - Increase dimensional stability in fillers due to shrinkage
 - Compensates for mixing errors, shop temps, bad batches, and quirky resin formulations.

CURING

DO

Follow Resin Formulator's Recommendations

Consider a "Post Cure" for any resin system

Slowly heat the article to Post Cure temperature

Support large items to prevent warping

DON'T

Cure wing panels one side at time under direct sun light

Allow temperatures to exceed foam core capability

GETTING HELP

- Aircraft designers provide technical support via newsletters, workshops, forums and websites.
- Resin suppliers can provide technical support through published literature, websites and workshops. SportAir, etc.
- Join a local EAA Chapters and use the EAA Technical Counselor program.
- Join an aircraft builders web forum such as:
 - **Canard types**
canard-aviators@yahoo.com
 - **Cozy Designs**
http://mailman.qth.net/mailman/listinfo/cozy_builder
 - **KR**
www.krnet.org

GETTING HELP

- **Visit other builders websites such as:**

1.) Jerry Schneider <http://home.earthlink.net/~jerskip/>

2.) John Slade <http://www.canardaviation.com/cozy/>

3.) Norm Muzzy -
<http://home.forbin.com/muzzy/cozyweb/index.html>

4.) Rick Maddy <http://www.maddyhome.com/cozy/>

5.) Wayne Hicks
<http://www.maddyhome.com/canardpages/pages/waynehicks/index.html>

- Call me – 281-277-7767

GETTING HELP

DO

Use designer's technical support resources – priority 1

Utilize resin supplier technical help resources

Involve the EAA Technical Counselor Program

Join a builders web based forum.

Share your learnings

DON'T

Believe everything you see, read or hear.

Be afraid to call me

RECOMMENDED READING

HANDLING GUIDE - Gougeon Laminating Systems

- www.gougeon.com - 517-684-7286

THE EPOXY BOOK - System Three Resins

- www.systemthree.com - 206-782-7976