

DO's & DON'Ts of Epoxy Resins

by

Gary Hunter

EAA Technical Counselor

Introduction

- The intent of this forum is to:
 - Debunk some mis-information
 - Give you an understanding of the big picture
 - Make you a smarter builder

Agenda

- Epoxy Vocabulary
- Overview of the Epoxy Market
- Selecting the right resin for you
- Storing your epoxies
- Health and Safety
- Dispensing, Weighing and Mixing
- Temperature Control
- Curing
- Getting Help
- Recommended Reading
- Q&A

Epoxy Vocabulary

- Epoxies
 - Generic word for epoxy resins and hardeners
- Hardener
 - curing agent, crosslinker, the B side
- Resin System
 - application specific formulation comprised of :
 - Resins, Diluents, Additives and Hardeners

Overview of the epoxy market

- ~ 500 MM lbs. are produced annually by:
 - Hexion – formerly Shell Chemical
 - Dow Chemical
 - Huntsman – formerly Ciba Geigy
- About 250 MM lbs. go in to coatings

Overview of the epoxy market

- Bulk quantities are sold directly to:
 - 3M Company
 - PPG Industries
 - Akzo-Nobel
- Drum quantities are sold through distributors
 - Ashland FRP Supply
 - Composites One
 - Seegott

Overview of the epoxy market

- Distributors sell to formulators like:
 - Composite Polymers Design
 - EZ-POXY
 - Gougeon Brothers
 - WEST SYSTEM & PROSET
 - MGS
 - MGS 285 / H235 and MGS 335 / H335
 - PTM&W
 - AEROPOXY
 - JEFFCO

Overview of the epoxy market

- Formulators do not manufacture epoxies
 - They simply blend / combine:
 - Resins
 - Diluents
 - Hardeners
 - Additives
 - To meet the requirements of the application

Overview of the epoxy market

- Many formulators:
 - Don't have full testing capabilities
 - Rely on suppliers to conduct testing for them
 - Steal data from suppliers literature

Selecting the right resin system

- Consult the designers approved list
- Obtain product information from the mfgs.
 - Product Data Sheets
 - MSDS
- Compare the quality of the information
- Buy small quantities of candidate systems
 - Test them in your own way
 - Use it to make small parts

Selecting the right resin system

- Avoid deviating from designers list
- Don't believe everything you read or here
 - If it sounds to good to be true....

COMPARISON OF LAMINATING RESINS AVAILABLE FROM VENDORS

PRODUCT	Mix Ratio Pbv / pbw	Mixed Visc CP	Pot Life @ 77F (100 grams)	Tg °F RT / PC	Tensile (ksi) RT / PC	Price / lb. June '06	
EZ 10 / EZ 83 Slow	47 / 44	1300	2 hrs.	151 / 196	8.2 / 10	5.91	
EZ 10 / EZ 84 Slow Low Visc.	47 / 44	800	2 hrs.	151 / 196	8.1 / 10	5.91	
EZ 10 / EZ 87 Slowest	47 / 44	1500	5 hrs.	142 / 196	8.4 / 10	5.91	
CPD 4426 / 9376 (RAEF) Fast	33 / 27		60 - 65 min	DISCONTINUED		5.91	
CPD 4426 / 9377 (RAES) Slow	33 / 27		120-140 min			5.91	
JEFFCO 1307LV / 3102 Fast	25 / 22	900	10-15 min	165°F HDT	9.0	7.45	
JEFFCO 1307LV / 3176 Medium	25 / 22	500	20-25 min			7.13	
JEFFCO 1307LV / 3176 Slow	25 / 22	1200	30-25 min				
MGS 285 / H235 Fast	50 / 40	~ 400	40 min.	na / 221-230	na / 10-11.5	9.26	
MGS 285 / H286 Medium	50 / 40	~ 400	2 hrs.				
MGS 285 / H287 Slow	50 / 40	~ 400	4 hrs.			9.56	
MGS 335 / H335 Fast	45 / 38	~ 600	10-15 min.	na / 167-176		7.86	
MGS 335 / H340 Slow	45 / 38	~ 300	> 4 hrs.			7.66	
Aeropoxy PR2032 / PH3630 Fast	33 / 27	860	30 min.	na / 194		8.87	
Aeropoxy PR2032 / PH3660 Med.	33 / 27	925	1 hr.	na / 196	na / 9.8	8.87	
Aeropoxy PR2032 / PH3665 Slow	33 / 27	950	2 hrs.	na / 194		8.87	
Pro-Set 125 / 226 Hardener Fast	33 / 30	675	37 min	134 / 184	7.96 / 11.07	10.15	
Pro-Set 125 / 229 Hardener Slow	33 / 30	400	77 min	133 / 161	7.55 / 9.97	10.15	
West 105 / 205 Fast	20 / 18	975	9-12 min	129 / 142	7.8 / na	10.02	
West 105 / 206 Slow	20 / 18	725	20-25 min	126 / 139	7.3 / na	10.02	
West 105 / 207 Special Ctg Hdnr	33 / 28	775	22-27 min	118 / 123	7.5 / na	10.02	
West 105 / 209 Extra Slow	33 / 28	725	40-50 min	121 / 134	7.3 / na	9.65	
Poly-Fiber - Poly Poxy	40 / 33		105 min	143 / 160	8.8 / 9.6	7.95	
Poly-Fiber - Alpha Poxy	55 / 50	Not recommended for load bearing structures					5.61
DOW DER 330 / 749	17.5 / 15	~1500	45 min.	na	na	3.48	
<i>EPON 862 / EPI-CURE 3234</i>	<i>18 / 15</i>	<i>775</i>	<i>35 min.</i>	<i>150 / 250</i>	<i>10 / 12</i>	<i>2.33</i>	

Resins Shown in Yellow are approved for construction of Vari-Eze, Long-EZ's or Cozy's Resin Systems in White appear to be no-longer available from Vendors – prices shown are from July 1998
Resin System in Italics is what I use – probably too fast for most builders.

Storing your epoxies

- Epoxy resins do not “go bad”
 - Stored properly, they are good for many years
- However, epoxies will “crystallize”
 - It is a “super cooled liquid”
- Gently warming to 120-140°F will melt the crystals
 - Immerse sealed container in hot tap water
 - Avoid microwaves for this operation

Storing your epoxies

- Properly stored, epoxy hardeners are good for many years.
- However, hardeners can have a limited shelf life due to:
 - Moisture Absorption
 - Reaction with CO₂
 - Exposure to UV light
 - causes them to darken or change colors

Storing your epoxies

SPECIAL CASE

- EZ-Poxy Hardeners 83, 84 and 87 can crystallize too.
- Gently warming to 120-140°F will melt the crystals
 - Immerse sealed container in hot tap water
 - Avoid microwaves for this operation

Health and Safety

- Get and read the MSDS
 - Material Safety Data Sheets
- Quality and completeness of MSDSs vary
 - Omissions due to Trade Secrets
 - Insufficient data
 - Just plain lazy or deceptive
- No matter

Health and Safety

- ALL epoxy resins and hardeners are:
 - SKIN and EYE IRRITANTS
 - Severity varies
 - Usually produces a rash
 - SENSITIZERS
 - Repeated exposure may lead to allergic reactions
 - Allergic reactions can be life threatening
 - Once sensitized, you cannot go near epoxies again

Health and Safety

- HANDS

- Wear disposable nitrile rubber gloves
- Latex gloves are known for causing allergic reactions that might be confused with epoxy

- FOREARMS

- Wear Long Sleeves
- Use Barrier Creams

Health and Safety

- EYES

- Safety glasses with side shields
- Goggles for contact wearers

- RESPIRATORY SYSTEM

- Generally, exposure levels are very low - but
- Ventilation is helpful for odor of EZ-Poxy
- Sensitive persons should consider a respirator

Dispensing and Mixing

- “RUTAN” BEAM BALANCE
 - Reliable and Economical
- DIGITAL ELECTRONIC BALANCE
 - They work for all resin systems
 - Daily calibration quick and easy
 - Resins and Curing Agents can remain in their original containers
 - www.balances.com - ~ \$100 (2000 X 1 gm)

Dispensing and Mixing

- RATIO PUMPS

- A well maintain pump is convenient, but
- You still need a digital balance for calibrations
- Sometimes, you cannot detect a malfunction until it is too late

Dispensing and Mixing

- MIXING CUPS

- Use Dixie “All Occasion Drink Cups”
- Plastic cups are OK, but they can melt & make a mess
- Do not use wax lined cups

- MIXING

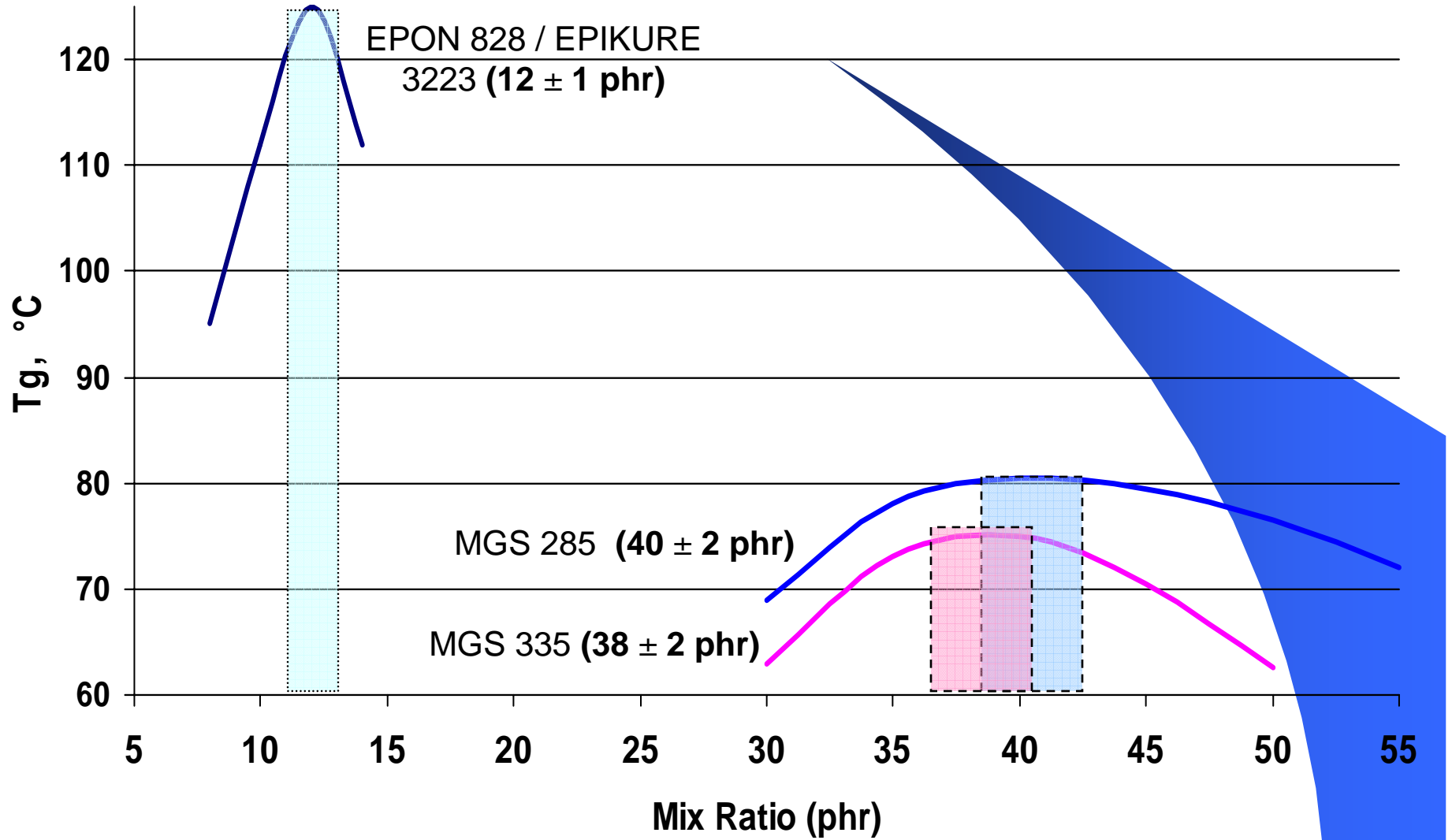
- Mix 1-2 minutes while scraping sides and corners
- Excessively vigorous mixing entrains air
- Large batches can justify motorized mixers
- Use propellor style mixer blade – not Jiffymixers.

Dispensing and Mixing

- MIX RATIO

- Effects resin performance properties
 - Heat and Chemical Resistance
 - Physical Properties
- Do not attempt to adjust pot life with mix ratio
- Change the hardener or,
- Blend Fast a Slow hardeners as needed
 - Thoroughly blend before dispensing.

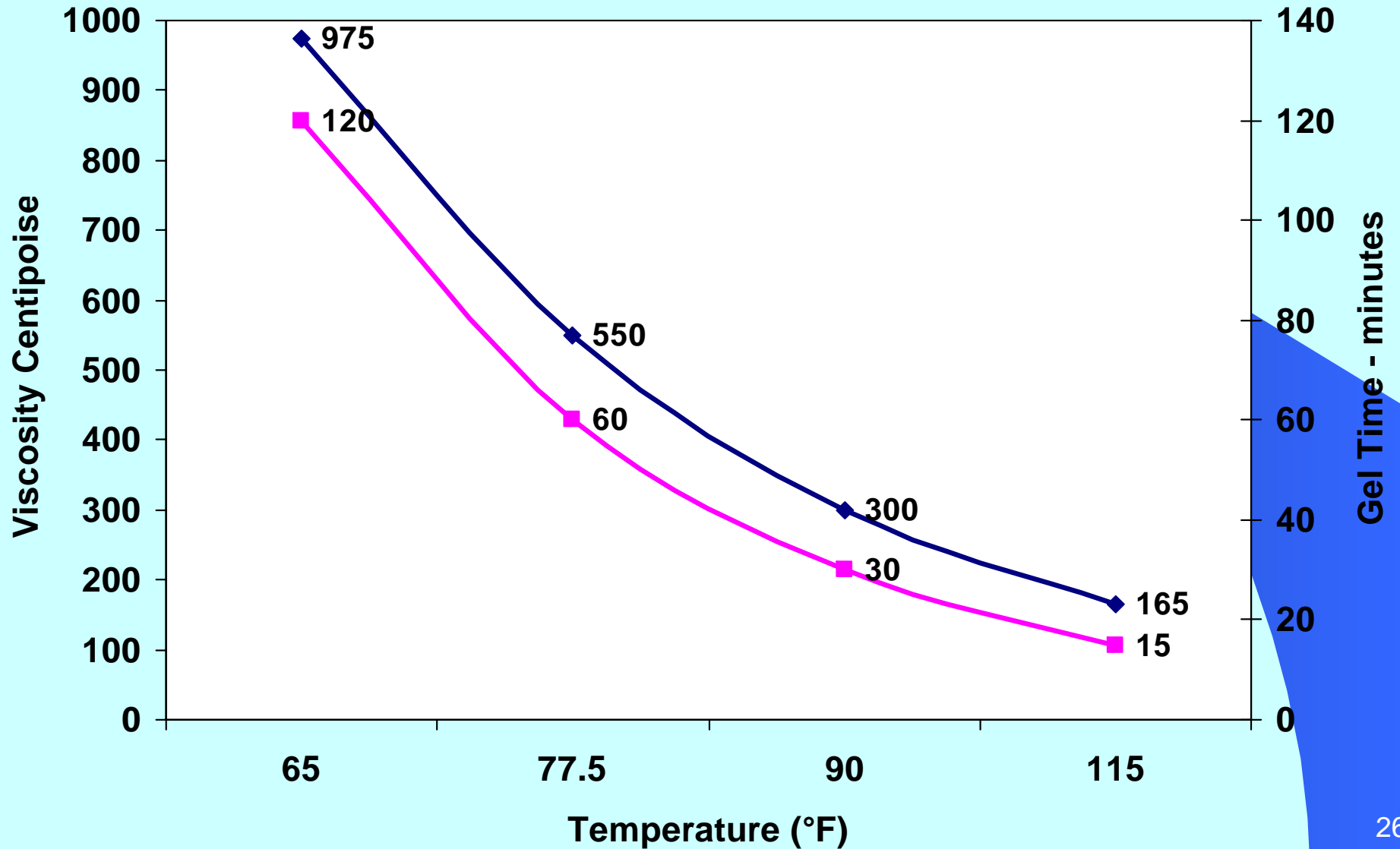
Curing Agent Mix Ratio vs. Glass Transition Temperature



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 – which effects
 - All of the above

Temperature vs. Viscosity & Reactivity



Temperature Control

- Ideal working temperature 70-80°F
 - Absolutely nothing below 65°F
- Don't start if the temps can fall below 65°F in 12 hrs.
- Humidity
 - Avoid foggy or rainy days, dewy mornings and evenings particularly in an open air shop
- Invest in an AC / Heating unit
 - You will finish the project a lot sooner



Jerry Schneider' Shop 2.jpg



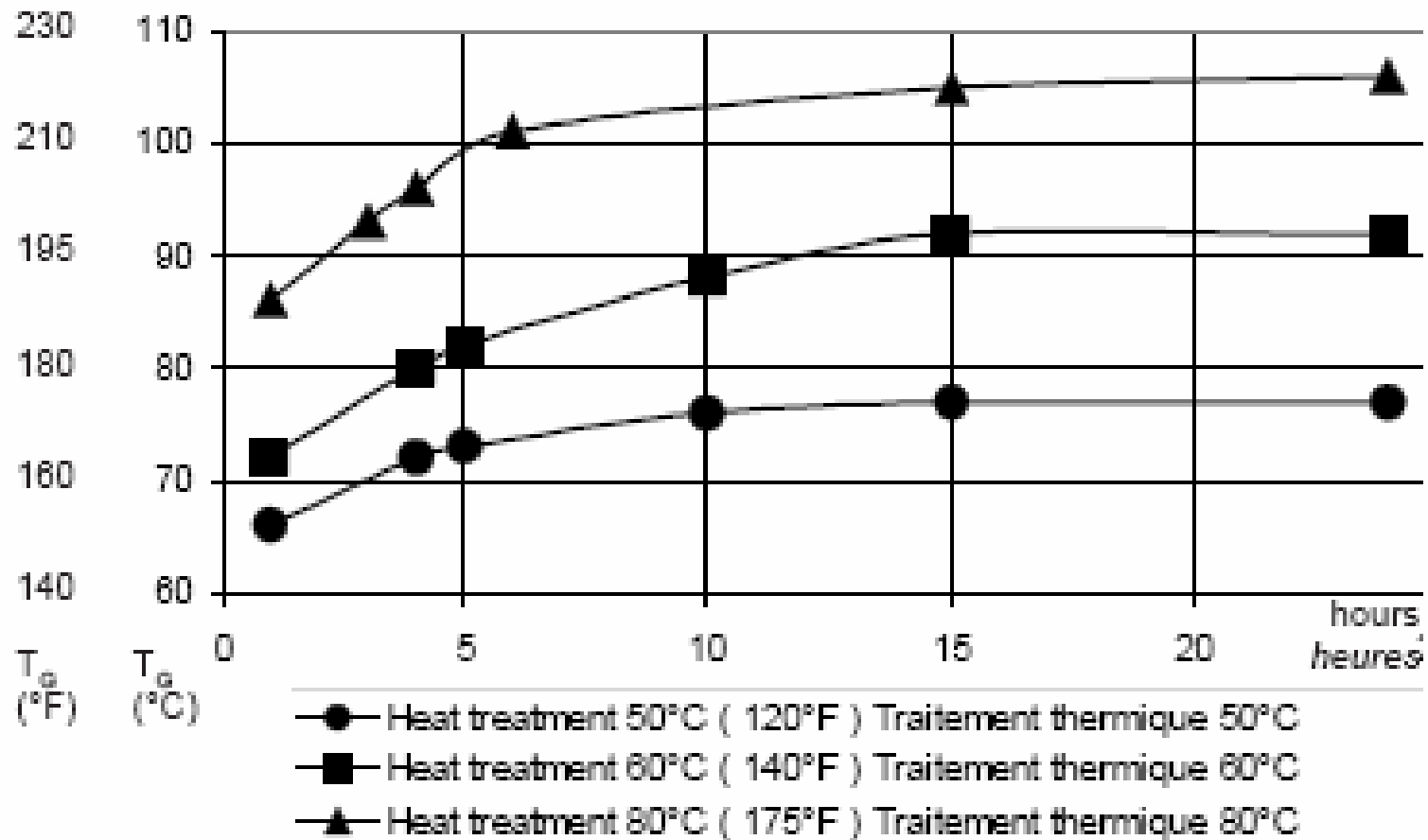


Curing

- The curing of epoxies is a chemical reaction controlled by:
 - Temperature, Mass, Pressure
- Typically, the reaction plateaus after 7-10 days
- Most systems obtain adequate performance with ambient temperature cures
- But, it will not cure completely at room temperature
- Optimum performance is obtained through a “Post Cure”.

Curing

- Post Curing
 - Heating the resin to drive the cure to higher state.
- 4-8 hrs. @ 140° is generally sufficient
 - About 1 day in a typical attic in the south
- For some systems it is not necessary
 - Others – it is a must
- Follow the formulators recommendations

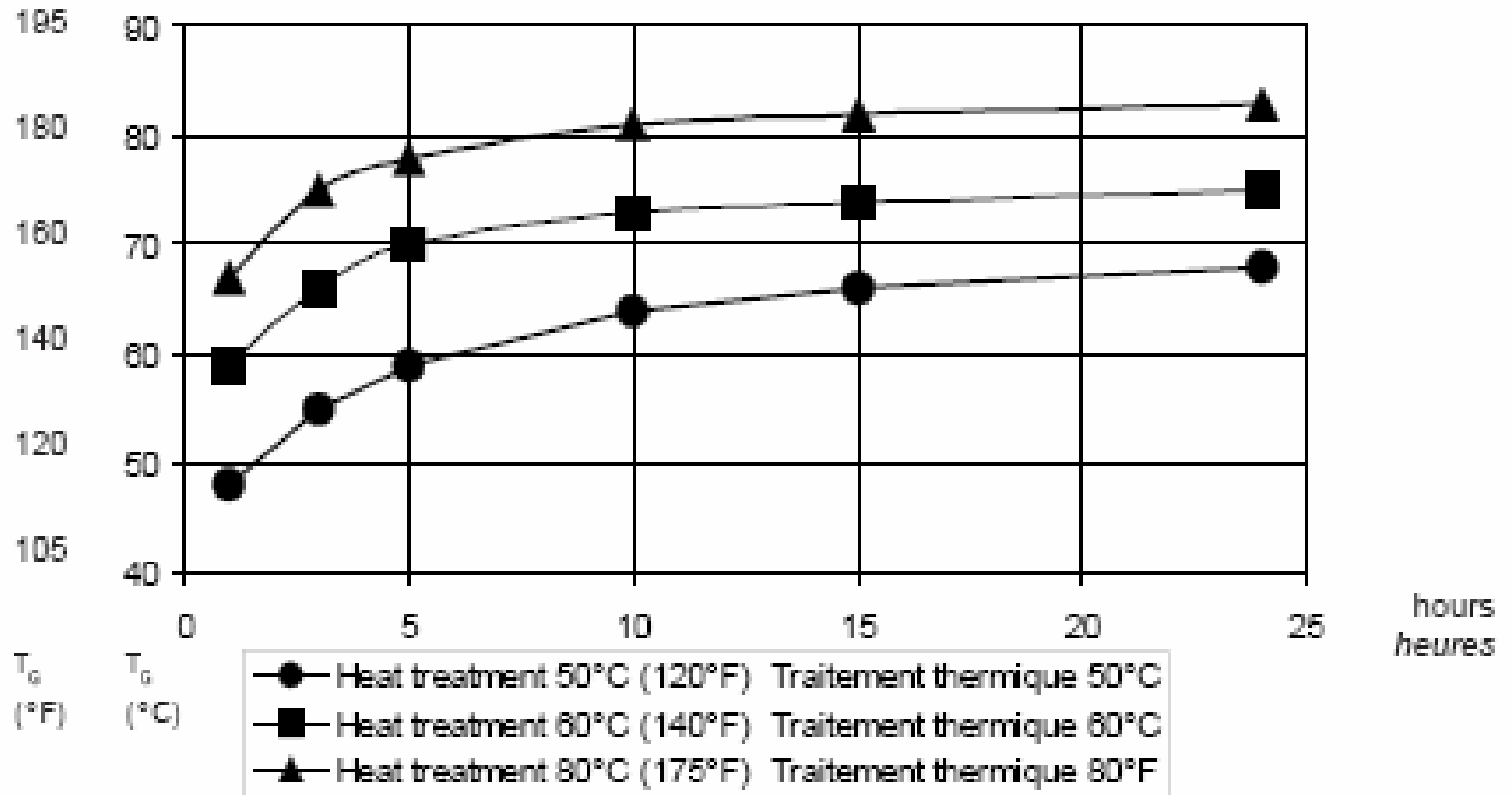


Initial curing before heat treatment 24 h
at room temperature

Durcissement initial 24 h à température ambiante
avant traitement thermique

Laminating resin L 335 - Hardener 340

Résine L 335 - Durcisseur 340



Initial curing before heat treatment 24 h
at room temperature

*Durcissement initial 24 h à température ambiante
avant traitement thermique*

Curing

- All Epoxies benefit from a post cure
 - Increases
 - Tg / HDT
 - Fuel Resistance
 - Physical Properties
 - Compensates for
 - Mixing errors
 - Shop Conditions
 - Bad Batches
 - Quirky formulations

Curing

- Post Curing Tips

- Consider hiring a body shop paint oven
- Heat the article slowly and evenly
- Stand wings up on the leading edge
- Place a circulating fan inside “black tent ovens”
- Do not bake articles directly in the sunlight
- Do not exceed foam core temperature capabilities

Getting Help

- Aircraft designers provide technical support via newsletters, workshops and websites
- Some suppliers can provide technical support training – Sport Air Work Shops
- Join a local EAA Chapter
 - Technical Counselor
- Join an aircraft builders web forum such as:
 - Canard-aviators@yahoo.com
 - Cozy_builders@mailman.qth.net

Recommended Reading

- Handling Guide – Gougeon Laminating Systems
 - www.gougeon.com - 517-654-7286
- The Epoxy Book – System Three Resins
 - www.systemthree.com - 206-782-7976

Thank you for attending my forum

I can be reached at:

gluegaru@earthlink.net

281-277-7767

Questions and Answers