DO’s & DON’Ts of Epoxy Resins

by

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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 into 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 mfgrs.
  – 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

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>Mix Ratio</th>
<th>Mixed Visc</th>
<th>Pot Life @ 77°F (100 grams)</th>
<th>Tg °F RT / PC</th>
<th>Tensile (ksi) RT / PC</th>
<th>Price / lb. June ‘06</th>
</tr>
</thead>
<tbody>
<tr>
<td>EZ 10 / EZ 83 Slow</td>
<td>47 / 44</td>
<td>1300</td>
<td>2 hrs.</td>
<td>151 / 196</td>
<td>8.2 / 10</td>
<td>5.91</td>
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<tr>
<td>EZ 10 / EZ 84 Slow Low Visc.</td>
<td>47 / 44</td>
<td>800</td>
<td>2 hrs.</td>
<td>151 / 196</td>
<td>8.1 / 10</td>
<td>5.91</td>
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<tr>
<td>EZ 10 / EZ 87 Slowest</td>
<td>47 / 44</td>
<td>1500</td>
<td>5 hrs.</td>
<td>142 / 196</td>
<td>8.4 / 10</td>
<td>5.91</td>
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<tr>
<td>CPD 4426 / 9376 (RAEF) Fast</td>
<td>33 / 27</td>
<td></td>
<td>60 - 65 min</td>
<td></td>
<td></td>
<td>5.91</td>
</tr>
<tr>
<td>CPD 4426 / 9377 (RAES) Slow</td>
<td>33 / 27</td>
<td></td>
<td>120-140 min</td>
<td></td>
<td></td>
<td>5.91</td>
</tr>
<tr>
<td>JEFFCO 1307LV / 3102 Fast</td>
<td>25 / 22</td>
<td>900</td>
<td>10-15 min</td>
<td></td>
<td></td>
<td>7.45</td>
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<tr>
<td>JEFFCO 1307LV / 3176 Medium</td>
<td>25 / 22</td>
<td>500</td>
<td>20-25 min</td>
<td></td>
<td></td>
<td>7.13</td>
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<tr>
<td>JEFFCO 1307LV / 3176 Slow</td>
<td>25 / 22</td>
<td>1200</td>
<td>30-25 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MGS 285 / H235 Fast</td>
<td>50 / 40</td>
<td>~ 400</td>
<td>40 min.</td>
<td></td>
<td></td>
<td>9.26</td>
</tr>
<tr>
<td>MGS 285 / H286 Medium</td>
<td>50 / 40</td>
<td>~ 400</td>
<td>2 hrs.</td>
<td></td>
<td>na / 221-230</td>
<td></td>
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<tr>
<td>MGS 285 / H287 Slow</td>
<td>50 / 40</td>
<td>~ 400</td>
<td>4 hrs.</td>
<td></td>
<td>na / 10-11.5</td>
<td>9.56</td>
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<tr>
<td>MGS 335 / H335 Fast</td>
<td>45 / 38</td>
<td>~ 600</td>
<td>10-15 min</td>
<td></td>
<td>na / 167-176</td>
<td>7.86</td>
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<tr>
<td>MGS 335 / H340 Slow</td>
<td>45 / 38</td>
<td>~ 300</td>
<td>&gt; 4 hrs.</td>
<td></td>
<td></td>
<td>7.66</td>
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<tr>
<td>Aeropoxy PR2032 / PH3630 Fast</td>
<td>33 / 27</td>
<td>860</td>
<td>30 min.</td>
<td></td>
<td>na / 194</td>
<td>8.87</td>
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<tr>
<td>Aeropoxy PR2032 / PH3660 Med.</td>
<td>33 / 27</td>
<td>925</td>
<td>1 hr.</td>
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<td>na / 196</td>
<td>8.87</td>
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<tr>
<td>Aeropoxy PR2032 / PH3665 Slow</td>
<td>33 / 27</td>
<td>950</td>
<td>2 hrs.</td>
<td></td>
<td>na / 194</td>
<td>8.87</td>
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<td>Pro-Set 125 / 226 Hardener Fast</td>
<td>33 / 30</td>
<td>675</td>
<td>37 min</td>
<td>134 / 184</td>
<td>7.96 / 11.07</td>
<td>10.15</td>
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<tr>
<td>Pro-Set 125 / 229 Hardener Slow</td>
<td>33 / 30</td>
<td>400</td>
<td>77 min</td>
<td>133 / 161</td>
<td>7.55 / 9.97</td>
<td>10.15</td>
</tr>
<tr>
<td>West 105 / 205 Fast</td>
<td>20 / 18</td>
<td>975</td>
<td>9-12 min</td>
<td>129 / 142</td>
<td>7.8 / na</td>
<td>10.02</td>
</tr>
<tr>
<td>West 105 / 206 Slow</td>
<td>20 / 18</td>
<td>725</td>
<td>20-25 min</td>
<td>126 / 139</td>
<td>7.3 / na</td>
<td>10.02</td>
</tr>
<tr>
<td>West 105 / 207 Special Ctg Hdnr</td>
<td>33 / 28</td>
<td>775</td>
<td>22-27 min</td>
<td>118 / 123</td>
<td>7.5 / na</td>
<td>10.02</td>
</tr>
<tr>
<td>West 105 / 209 Extra Slow</td>
<td>33 / 28</td>
<td>725</td>
<td>40-50 min</td>
<td>121 / 134</td>
<td>7.3 / na</td>
<td>9.65</td>
</tr>
<tr>
<td>Poly-Fiber - Poly Poxy</td>
<td>40 / 33</td>
<td></td>
<td>105 min</td>
<td>143 / 160</td>
<td>8.8 / 9.6</td>
<td>7.95</td>
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<tr>
<td>Poly-Fiber - Alpha Poxy</td>
<td>55 / 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.61</td>
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<tr>
<td>DOW DER 330 / 749</td>
<td>17.5 / 15</td>
<td>~1500</td>
<td>45 min.</td>
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<td>3.48</td>
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<tr>
<td>EPON 862 / EPI-CURE 3234</td>
<td>18 / 15</td>
<td>775</td>
<td>35 min.</td>
<td></td>
<td></td>
<td>2.93</td>
</tr>
</tbody>
</table>

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 crystalize 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

- **EPON 828 / EPIKURE 3223 (12 ± 1 phr)**
- **MGS 285 (40 ± 2 phr)**
- **MGS 335 (38 ± 2 phr)**
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

Viscosity Centipoise

Temperature (°F)

Gel Time - minutes
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
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
Laminating resin L 285 - Hardener 287

Heat treatment 50°C (120°F) Traitement thermique 50°C
Heat treatment 60°C (140°F) Traitement thermique 60°C
Heat treatment 80°C (175°F) Traitement thermique 80°C

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

Heat treatment 50°C (120°F) Traitement thermique 50°C
Heat treatment 60°C (140°F) Traitement thermique 60°C
Heat treatment 80°C (175°F) Traitement thermique 80°F

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](http://www.gougeon.com) - 517-654-7286

- The Epoxy Book – System Three Resins
  - [www.systemthree.com](http://www.systemthree.com) - 206-782-7976
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Questions and Answers