Novel Monomer Free Vinyl Hybrid Resin for Composite Radomes and Aerospace Applications

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Background

- Advanced Material Market
- Styrenated Systems are Unacceptable
  - Governmental Regulations
  - Control Technologies Needed
  - Minimize Capital Investment
- Development Need for Reactive Diluent Free Thermoset Resin Systems
  - Cost Effective
  - Improved Dry/ Wet Tg
  - Improved Water Absorption
  - Improved Production Rates- approach 3 minute cycle

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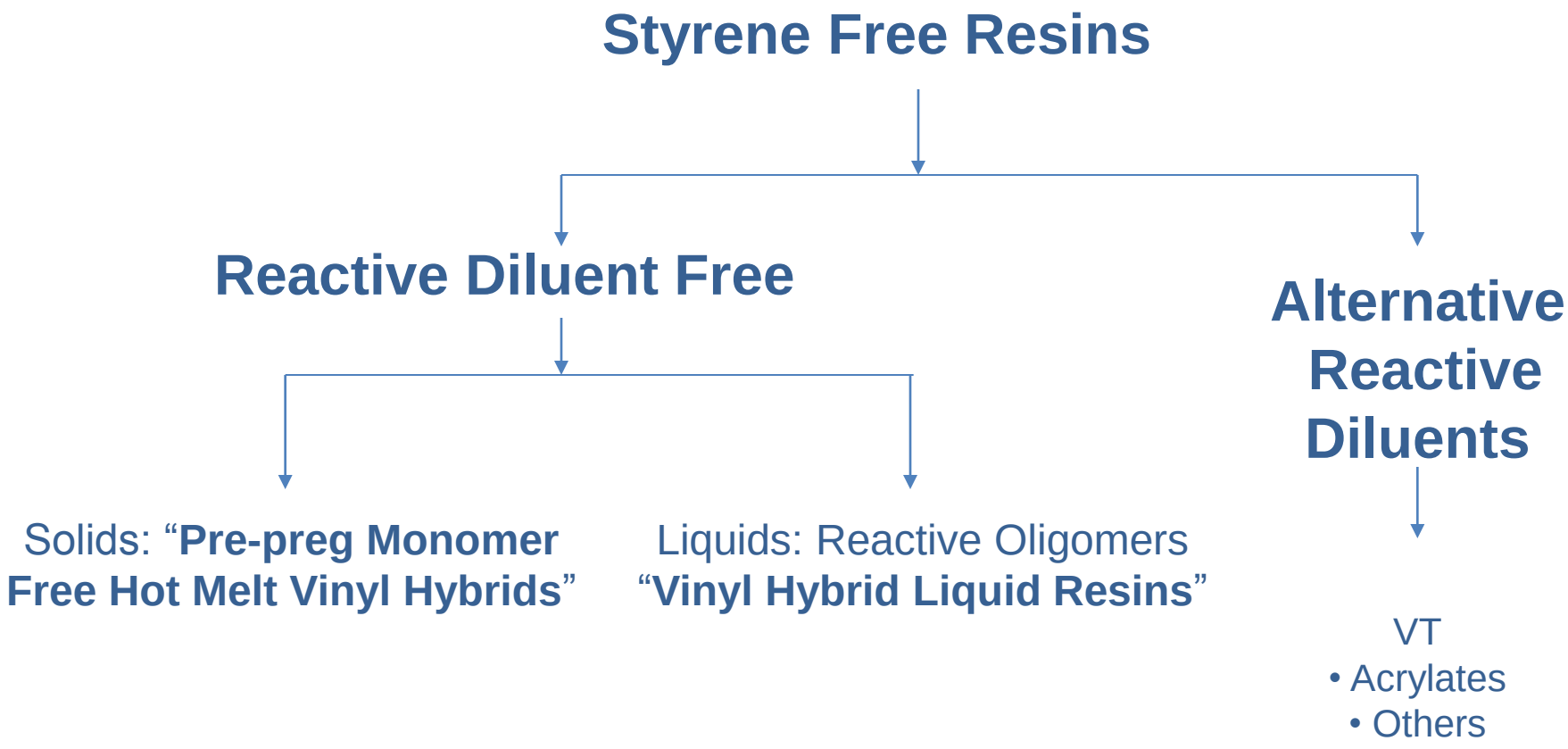
Nomenclature



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Chemistry Description: Vinyl Hybrids

- ADVALITE™ – Monomer Free Hot Melts
- ADVALITE™ – Vinyl Hybrid Liquid Resins

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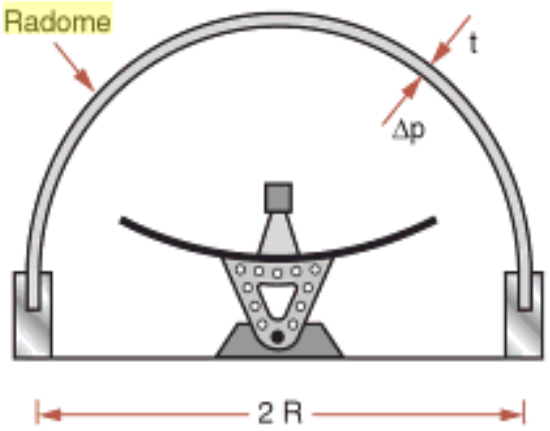
Radomes

Functions

- Shield microwave antenna from adverse environmental effects
- Minimal effect on electrical performance
- Withstand Structural Loads from pressure differential



Material Property Considerations

- Water Absorption: Water absorbs transmission energy and increases loss tangent
  - Low water absorption is necessary for radomes
- Dielectric Constant: Determine the ability of insulator to store electrical energy
  - Low dielectric constant is necessary for radomes
- Loss Tangent: Ratio of input/output power through material
  - Low loss tangent is necessary for radomes

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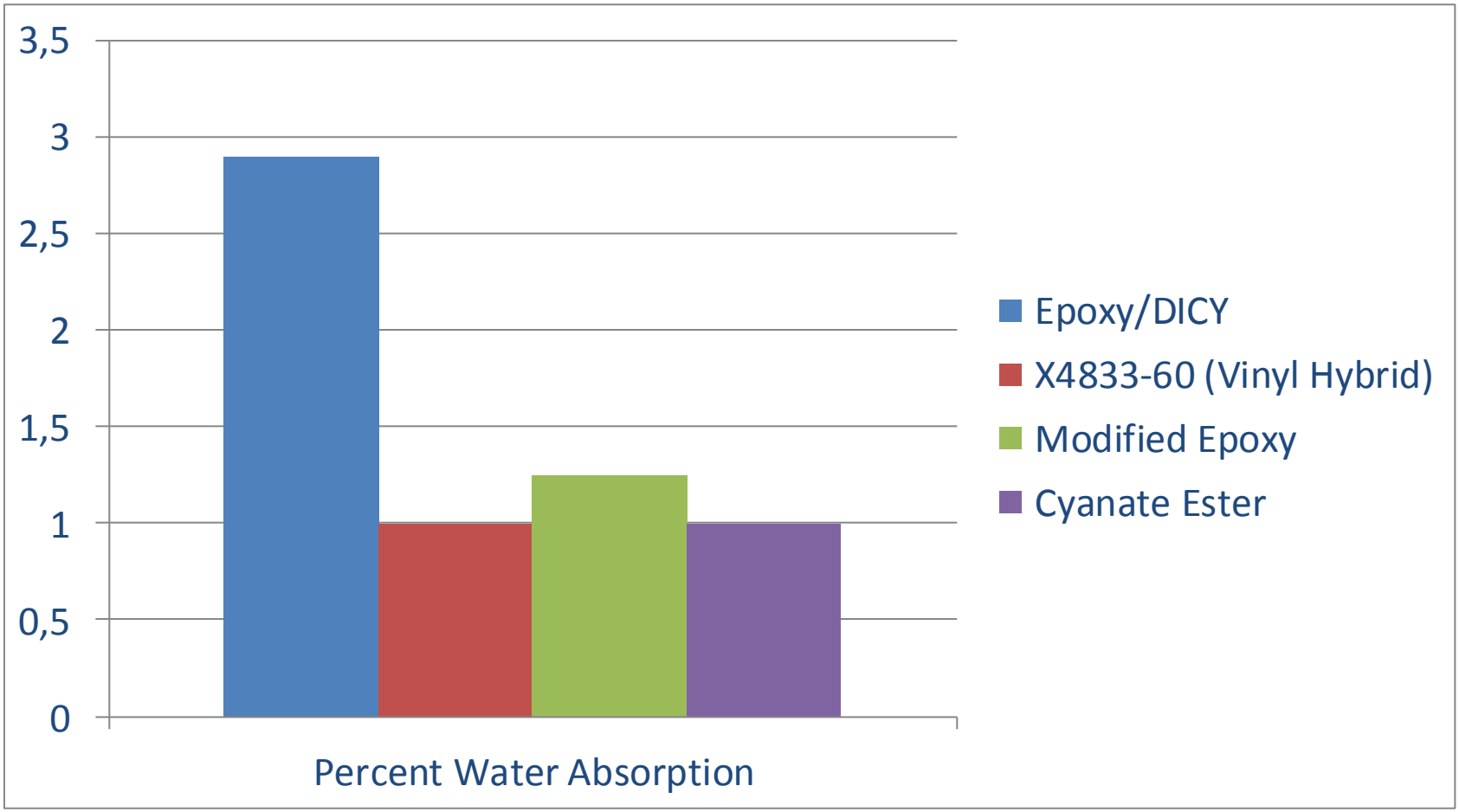
Radome Resin Candidates

- Cyanate Esters
- Modified Epoxies (BisA Cyanate/Epoxy)
- Epoxy (Accelerated Dicyanamide, 120° C cure)
- ADVALITE™ Vinyl Hybrid

% Water Absorption Comparisons (64 Hour Boil)



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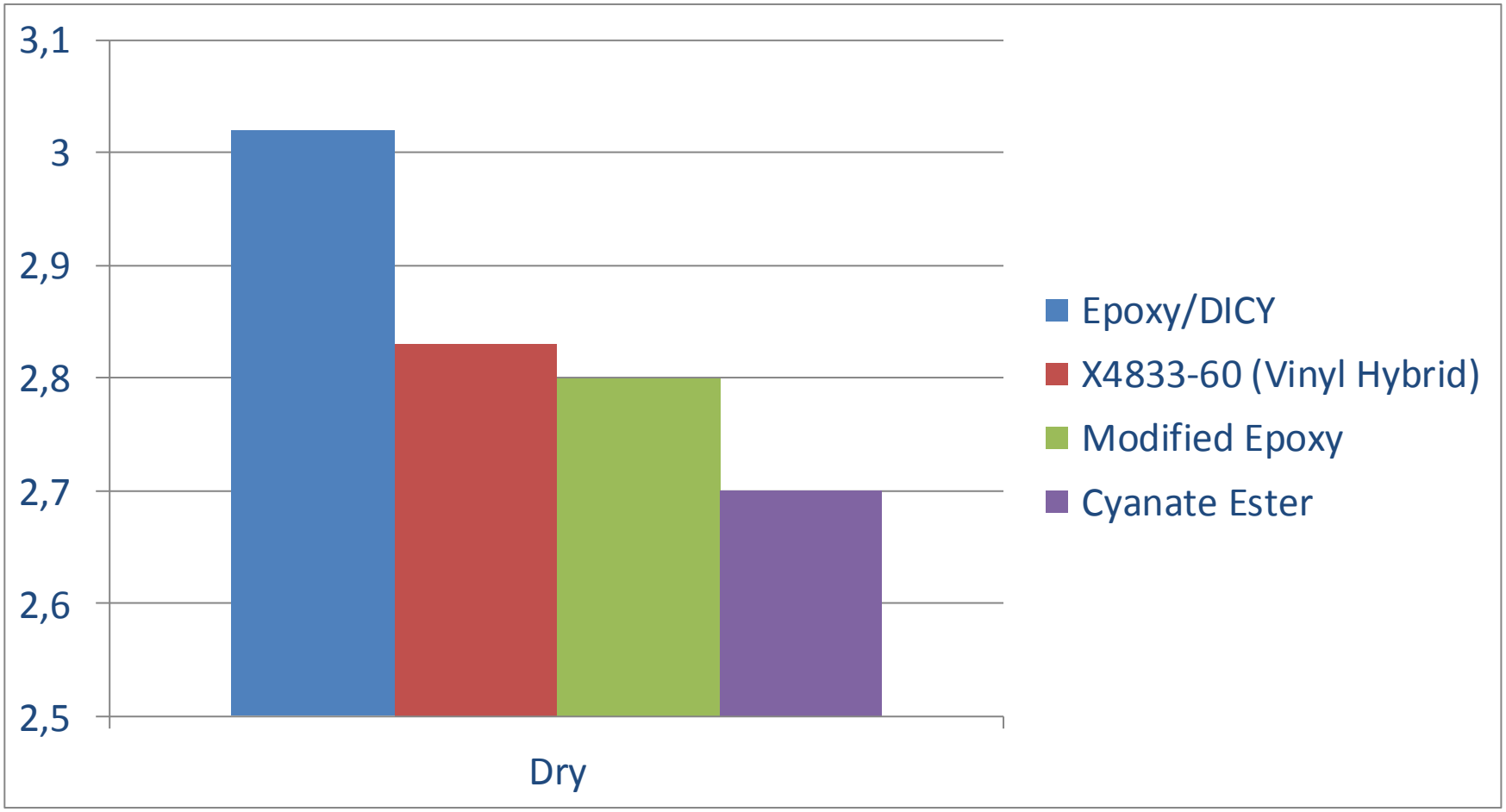
Dielectric Constant Comparison



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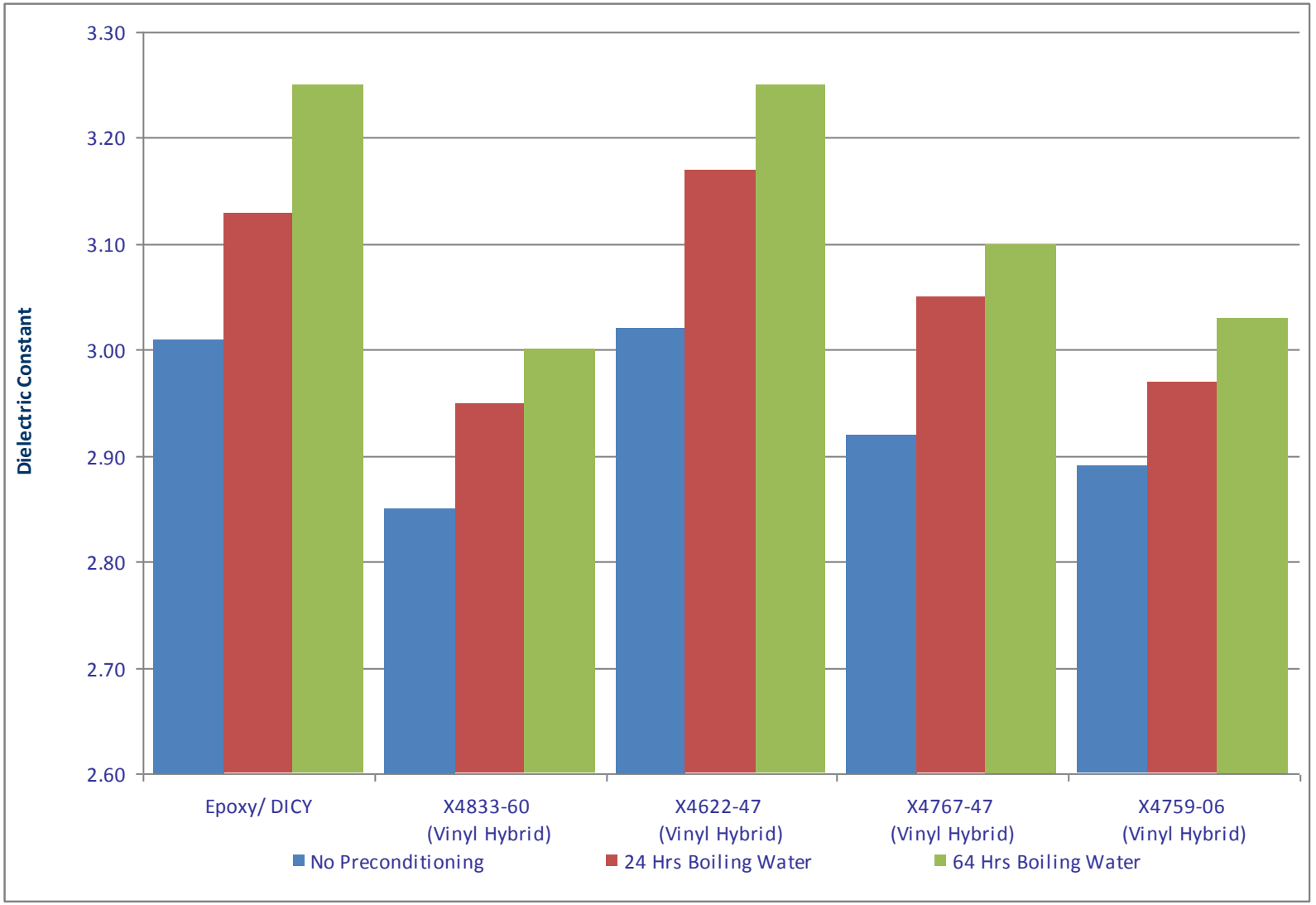
Dielectric Constant Comparisons Dry vs. Wet



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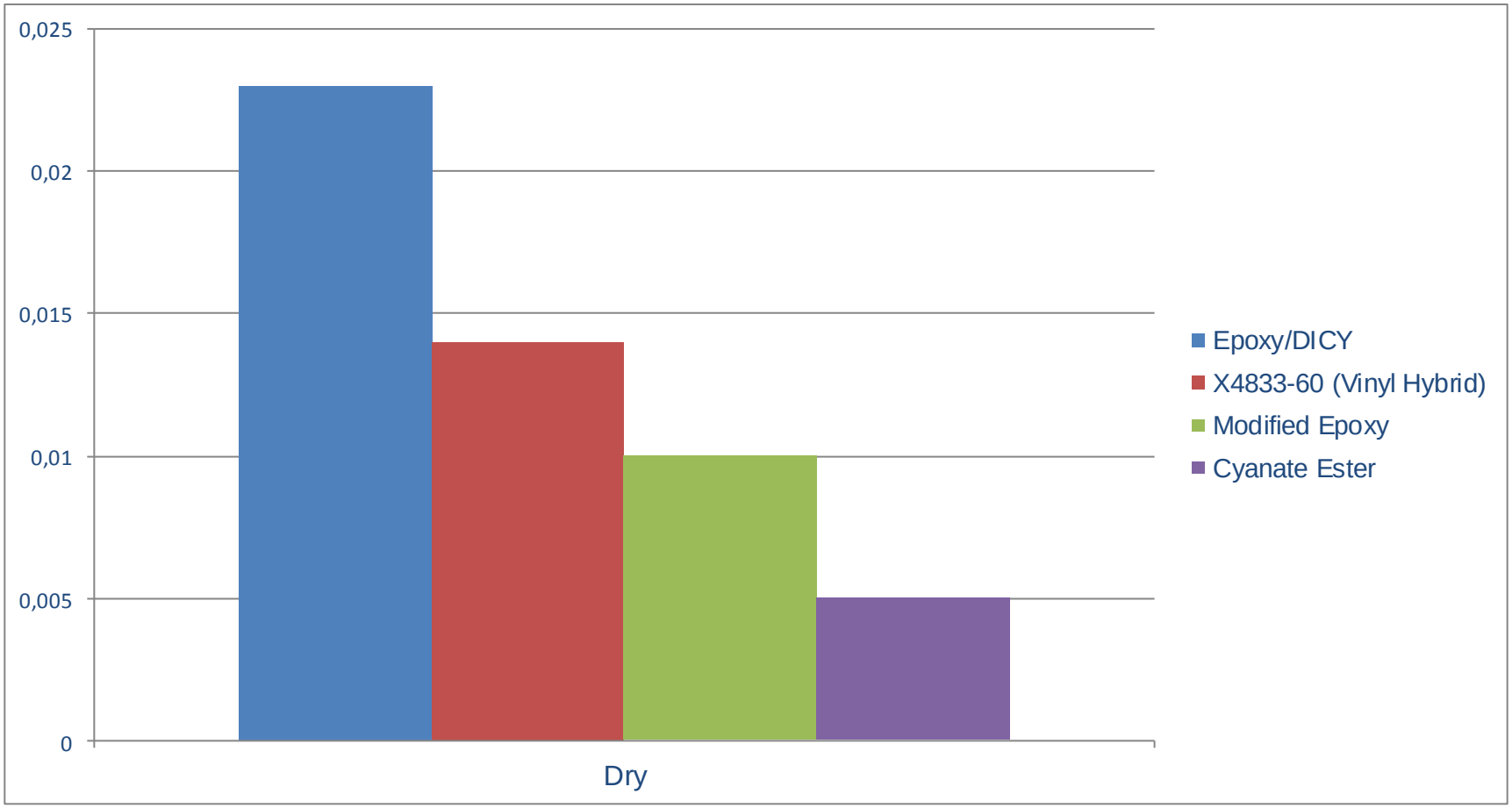
Dissipation Factor/Loss Tangent Comparison



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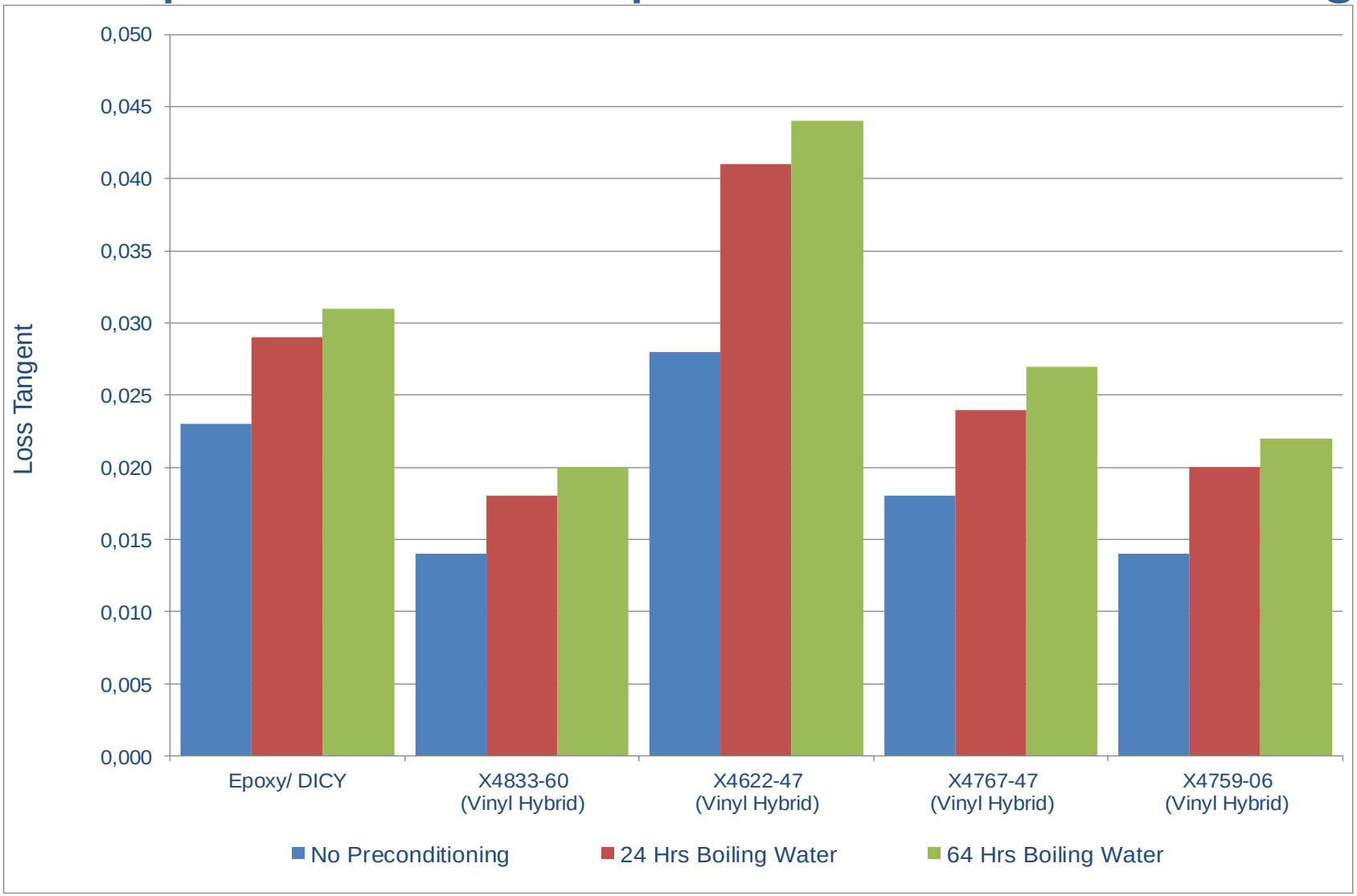
Comparison of Dissipation Factor/Loss Tangent



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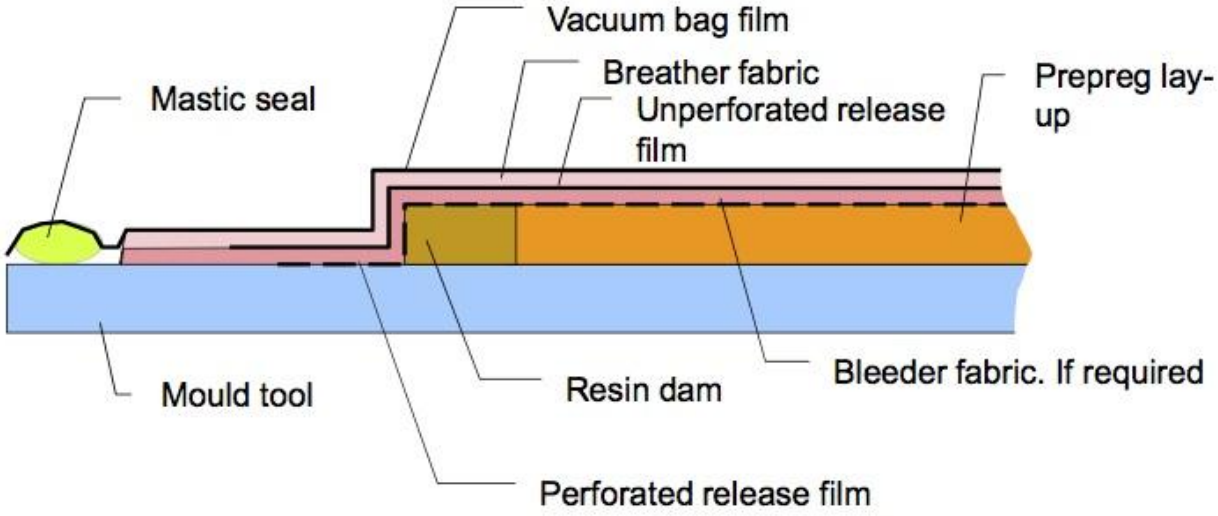
ADVALITE™ X4833-60 Radome Resin

Clear Cast Mechanical Properties

Property	Units	ADVALITE™ X4833-60
Flexural Strength	M Pa	78,7
Flexural Modulus	G Pa	4,14
Tensile Strength	M Pa	35,3
Tensile Modulus	G Pa	3,54
HDT	°C	>200
Dry Tg	°C	193
Wet Tg	°C	172

Hand Lay-up (Prepreg)



Properties for Optimum Prepreg

- Optimum tack and drape
- Low volatile content
- Low temperature cure
- Long shelf-life
- Low heat of reaction
- Controlled flow

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Hand Lay-up

- Heat of reaction of ADVALITE™ Vinyl Hybrids System is roughly half of a standard 120 °C cure, accelerated Dicyanamid Bis-A epoxy, so parts with large cross-sections can be cured with less risk of exotherm and cracking

- ADVALITE™ Vinyl Hybrid Systems offer cure times under 5 minute for rapid part production

- ADVALITE™ Vinyl Hybrid Systems are a peroxide-cure, lending itself well to inline mixing for rapid prepreg production

- Prepreg produced using ADVALITE™ VINYL HYBRIDS systems does not need to be frozen or refrigerated, lowering the cost of shipping and handling, and minimizing scrap due to expired shelf-life

Typical shelf-life @ 21°C for:

Cyanate ester	14 days
Cyanate/Epoxy	14 days
120 °C cure epoxy	4 to 8 weeks
ADVALITE™ Vinyl Hybrid>	1 year

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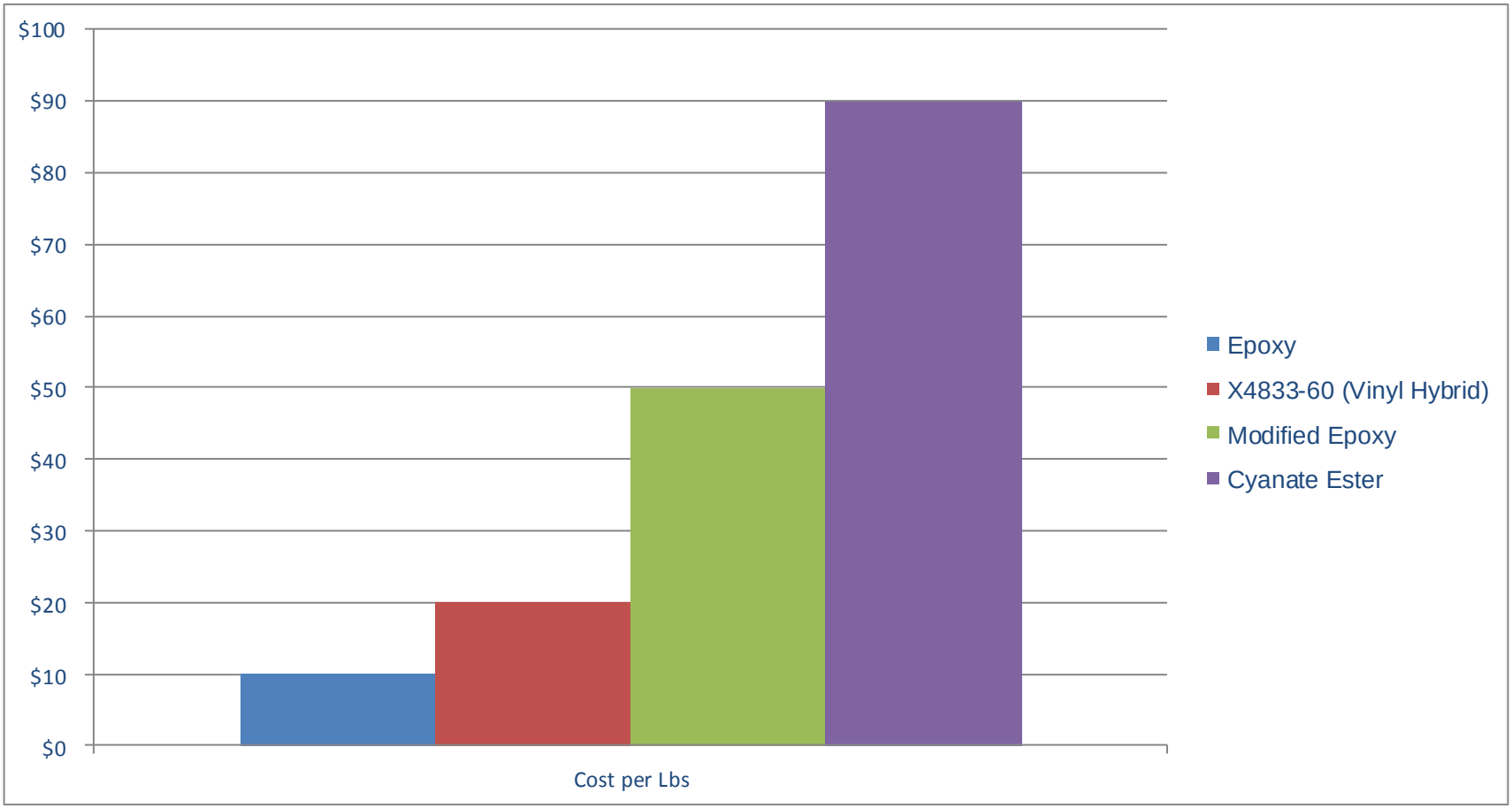
Radome Resin
Typical Cost/Lb (Formulated)



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ADVALITE™ 35000-00 Vinyl Hybrid FR Grade Hot Melt Prepreg Resin

Prepreg Thermo-Mechanical Properties

Property	Units	ADVALITE™ 35000-00 RT	ADVALITE™ 35000-00 RT, Wet	ADVALITE™ 35000-00 120° C
Tensile Strength	M Pa	73	69	51
Tensile Strength Retention	%		94%	70%
Tensile Modulus	G Pa	4,6	4,7	4,3
Tensile Modulus Retention	%		102%	93%
Compression Strength	M Pa	64	58	
Compression Modulus	G Pa	4,8	4,6	
Flexural Strength	M Pa	113	100.0	54.0
Flexural Strength Retention	%		89%	48%

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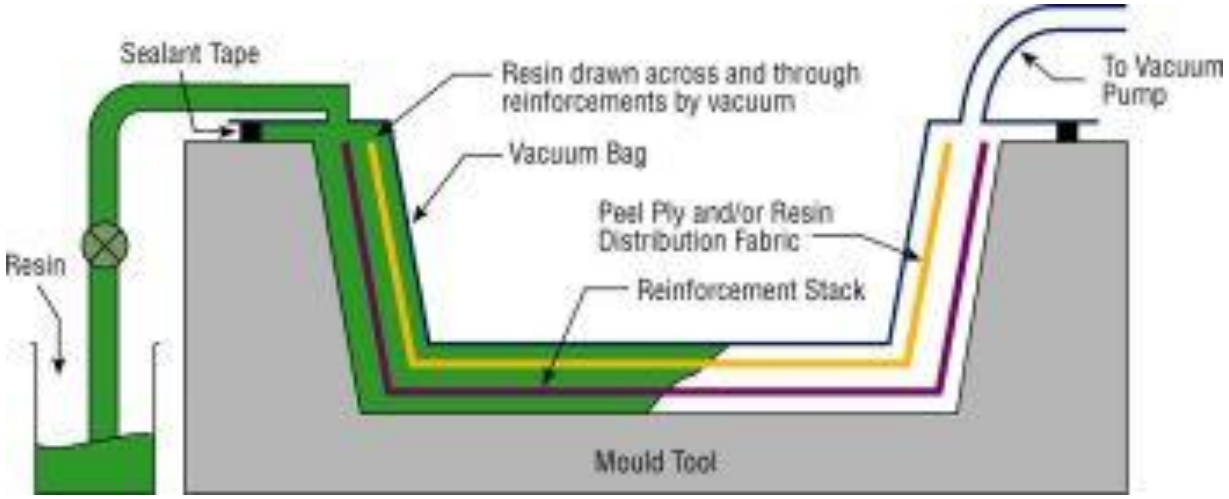
ADVALITE™ Vinyl Hybrid Liquid Resins Vacuum Infusion Process (VIP)



Critical to Filling Complex Geometries and Moldability:

- Processing Conditions- resin factors to consider:
  - Polymer structure
  - Viscosity
  - Degree of cure-part thickness
- Optimize resin for low viscosity and good fiber wetting while retaining good physical properties

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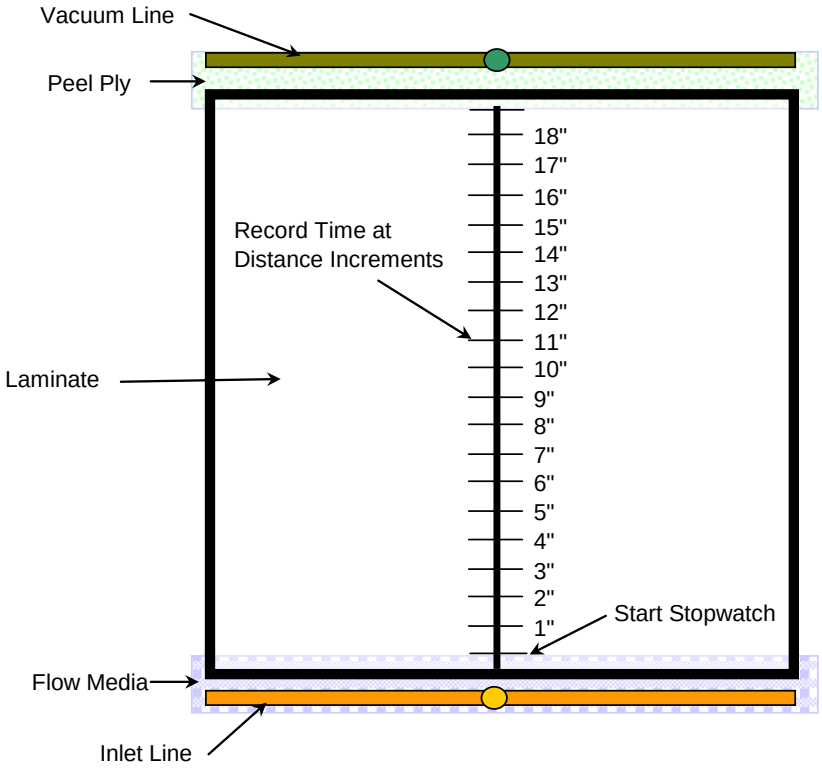
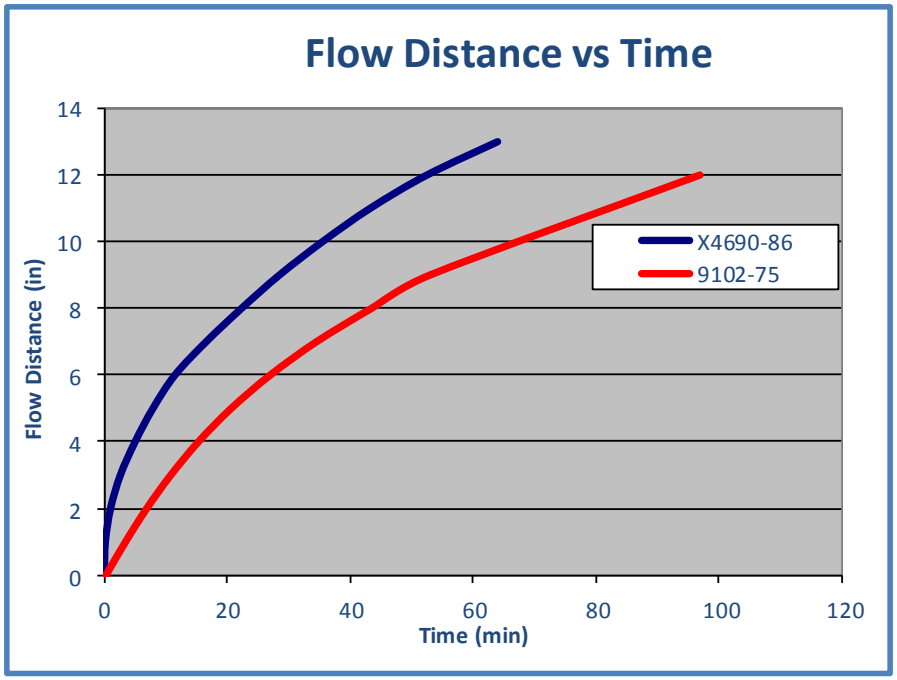
Vacuum Infusion Process
Infusion Flow Rates





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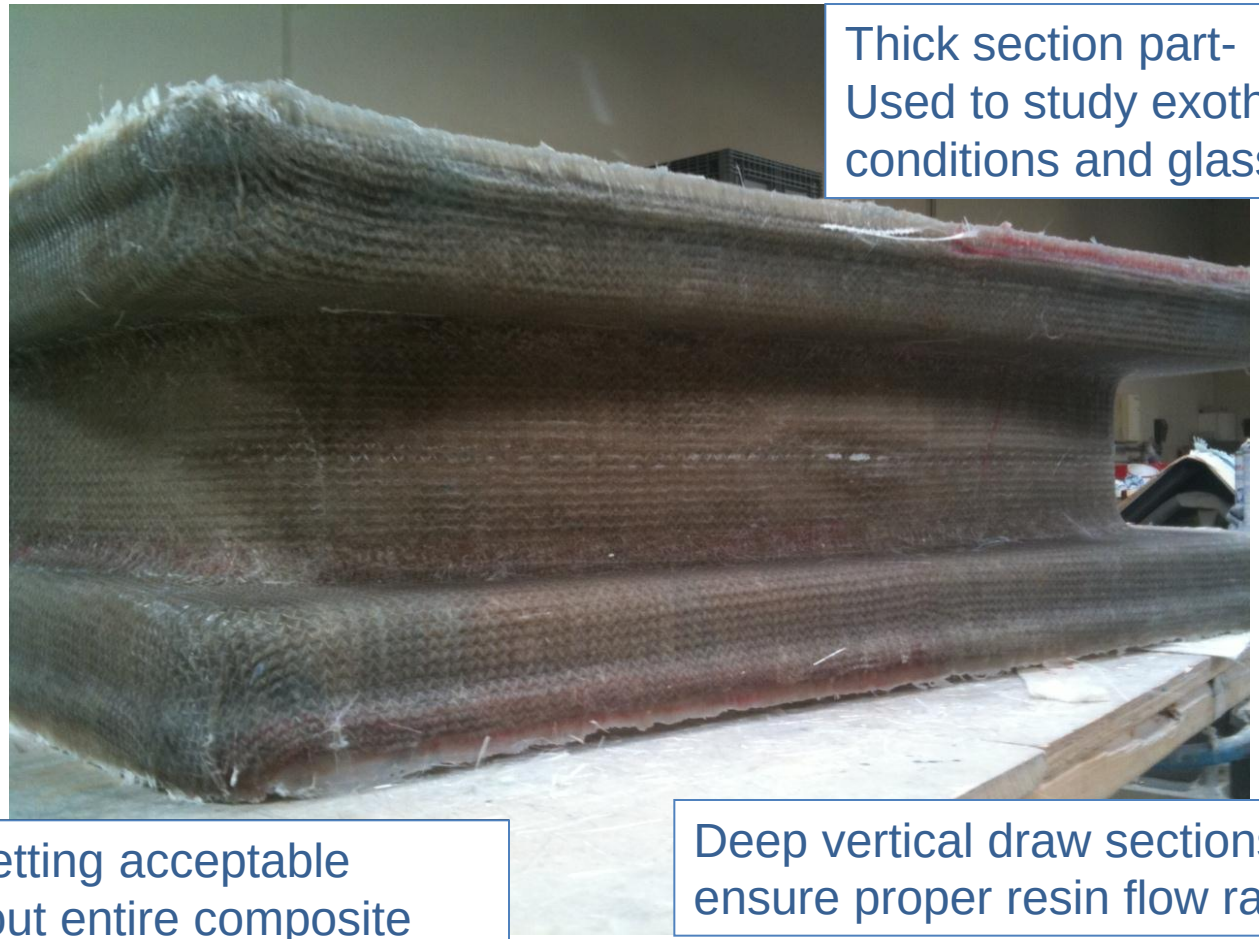
Vinyl Hybrid Infusion Trial



Thick section part- 12 mm
Used to study exotherm conditions and glass wetting

Glass wetting acceptable throughout entire composite part

Deep vertical draw sections to ensure proper resin flow rates

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Mechanical Properties Comparison

Neat Resin Clear Cast Results

Property	Units	ADVALITE™ 35065-00	ADVALITE™ 35060-00	ADVALITE™ X4830-27	ADVALITE™ X4759-06
Flexural Strength	M Pa	159,3	116,9	74,6	117,3
Flexural Modulus	G Pa	4,37	3,61	3,52	4,24
Tensile Strength	M Pa	80,3	45,6	16,0	31,8
Tensile Modulus	G Pa	3,83	3,77	3,63	4,14
Elongation	%	2,8%	1,5%	0,5%	0,9%
HDT	C	72	155	>200	>200
Dry Tg	C	81	170	149	175
Wet Tg	C		166		
Water Absorption	%		0,83%	0,57%	0,16%
Viscosity	cps	625	1,200	400	1350

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Conclusions

ADVALITE™ Vinyl Hybrid Systems offer resins capable to produce both prepreg and vacuum infusion molding systems for the Aerospace market which offer the following:

- Excellent retention of properties after exposure to water at elevated temperature
- Superior performance to epoxy regarding; Water Absorption, Dielectric Constant and Dissipation Factor
- Lower heat of reaction than epoxy for rapid cures of thick cross-section parts
- No need for refrigeration of prepreg
- Lower total cost for the manufacture of cost effective commercial radomes

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Questions?

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THANK YOU FOR YOUR ATTENTION!