Engineered Wood Adhesives Improve Production Efficiency

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With good chemistry great things happen.™

Ashland Specialty Ingredients: Industrial Specialties
Broad Technologies and Applications

innovation
the path for a better tomorrow

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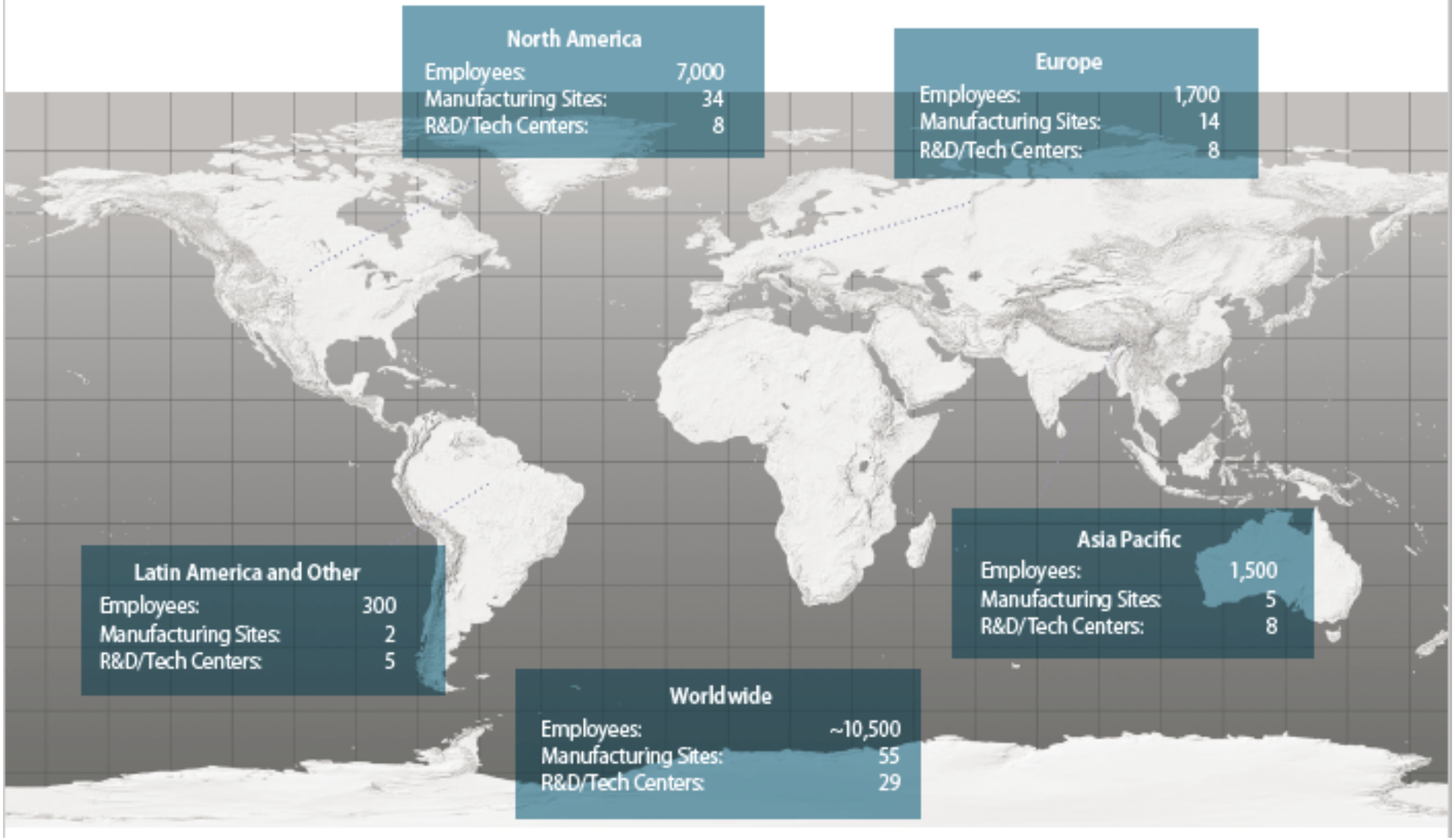
Ashland Global Presence



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Broad Technology Platforms – Structural Adhesives

	100% Reactive	Water-based Polymers	Solvent-based Polymers
Transportation Adhesives	Urethanes Epoxy Acrylates (PLIOGRIP)		
Engineered Wood Adhesives	Urethanes (ISOSET & ISOGRIP))	Urethanes Latex (ISOSET)	
Specialty Resin & Adhesives		Phenol Formaldehyde (AROFENE)	Phenol Formaldehyde Rubber Modified (AROFENE)
Membrane Bonding Adhesives	Urethanes (PLIODECK)	Rubber Modified Acrylates (PLIOBOND)	Rubber Modified (PLIOBOND)

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Innovation Around World

Research and Development / Technical Service Centers

- Dublin, Ohio
- Kidderminster, United Kingdom
- Shanghai, China
- Mumbai, India

Manufacturing Facilities

- Calumet City, Illinois
- Columbus, Ohio
- Ashland, Ohio
- Kidderminster, United Kingdom

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Ashland Engineering Wood & Panel Adhesive Technology

Polyurethane Technology for EWP & Panel Applications

ISOSET® 2-K Adhesives

- Emulsion Polymer Isocyanate (EPI)
- Polyurethane Emulsion Polymer (PEP)

ISOSET® 1-K Adhesives

- Moisture-Cure Polyurethane (MCU), ISOSET SX10XX

ISOGRIP® 1-K Adhesives

- Moisture-Cure Polyurethane (MCU)

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Polyurethane Technology for EWP & Panel Applications

- Isoset products carry all building code approvals in US and Canada – I-Joist, Finger Joint, Glulam, etc EWP applications
- Isogrip and Isoset – tailored solutions for panel applications
  - Optimized adhesion to various of substrates
  - Optimized curing profile to customer's process

  Exterior Entry Doors, Patio Enclosure Panels, Structural Insulated Panels (SIPS), Architectural Panels, Garage Door Panels, and RV Panels, etc

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Adhesive Laminating Parameters in SIPs Process

- Spread Rate
- Mix Ratio or Water Mist Rate
- Open Assembly Time*
- Closed Assembly Time*
- Press Pressure and Time
- Strength Build/Handling Time

*** Temperature Dependent**

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SIPs Laminating Adhesive Comparison

Adhesives	Isoset (EPI)	Isogrip	Isogrip	Fast Cure Isogrip
Products	WD3-A322 & CX-47	3030D	5050D	4020D
Clean-Up	Water	DBE Solvent	DBE Solvent	DBE Solvent
Recommended Process Conditions	CAT* ≤ 30 min PT* ≥ 45 min	CAT* ≤ 30 min PT*≥60 min at 75-80F	CAT* ≤ 25 min PT*≥ 40 min at 75-80F	CAT* ≤ 3 min PT* ≥3 min at 75-80F
Code Reports**	NER 165	ESR-1140	ESR-1140	ESR-1140

* CAT = Close Assembly Time
* PT = Press Time
** Meeting AC05 Testing Standard

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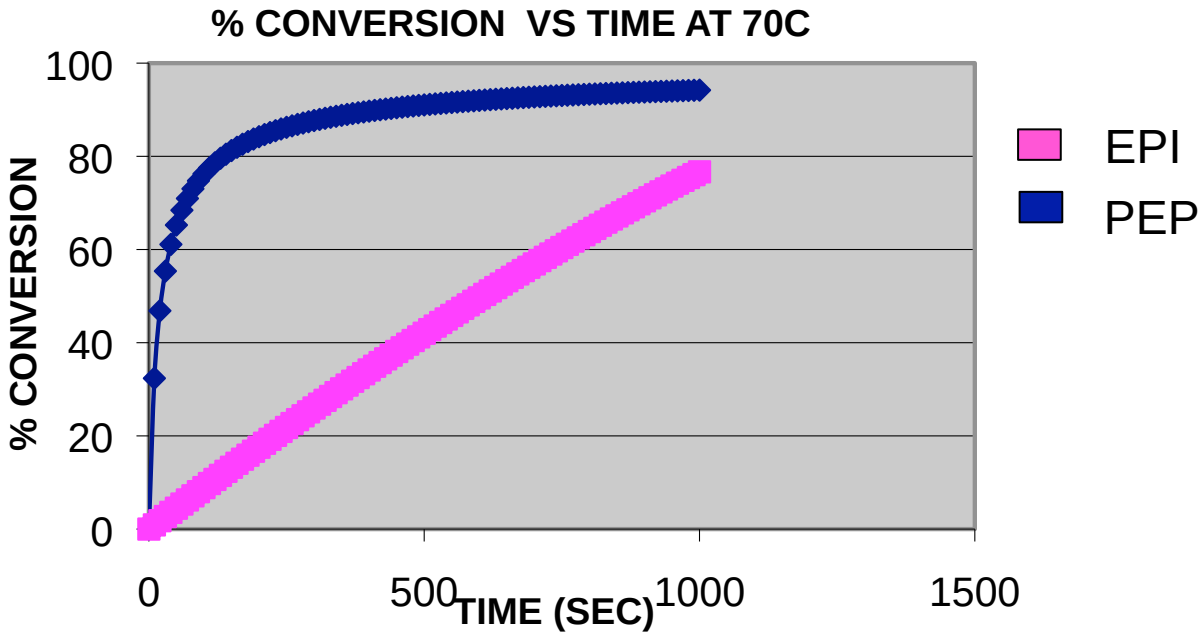
Isoset to Improve Engineering Wood Production Efficiency

Isoset Adhesives – Tailored Curing Profile

- Emulsion Polymer Isocyanate (EPI): A322/CX-47
- Polyurethane Emulsion Polymer (PEP): A322/UX100



High Performance In Exterior (Wet Use) Structural Applications

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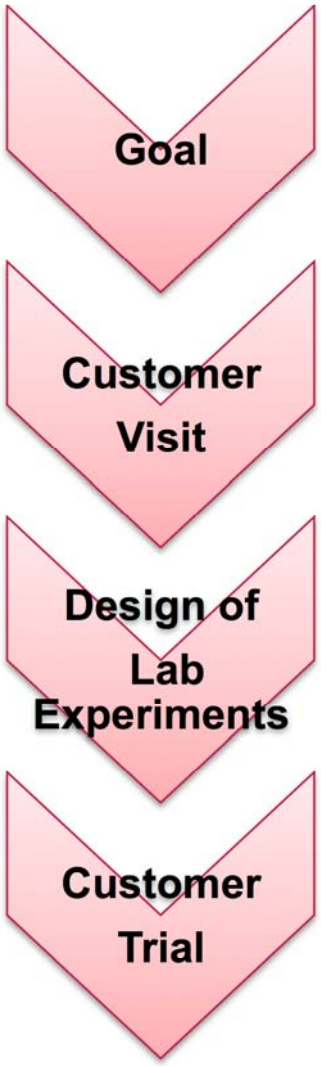
Production Efficiency Optimization



- Improve Production Efficiency

- Understand Customer's Current Production Line Details

- Conduct DOE Studies

- Conclusions/Solutions

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Example: Adhesive Curing Model for EWP Applications

1. **In EWP plant, environmental temperature, wood temperature vary with seasons, which impacts the product performance due to changes in adhesive curing curve.**
2. **Ashland provides systematic curing curve based on customer's production conditions, which enable customers to tune up production parameters so as to optimum product performance and efficiency.**
3. **The goal is to create curing model under customer process conditions:**

- Wood Temperature: 5^{o}C, 10^{o}C, and 20^{o}C
- Oven Temperature: 25^{o}C and 35^{o}C
- Time in Oven: 20, 30, 40, 60min and 24hrs

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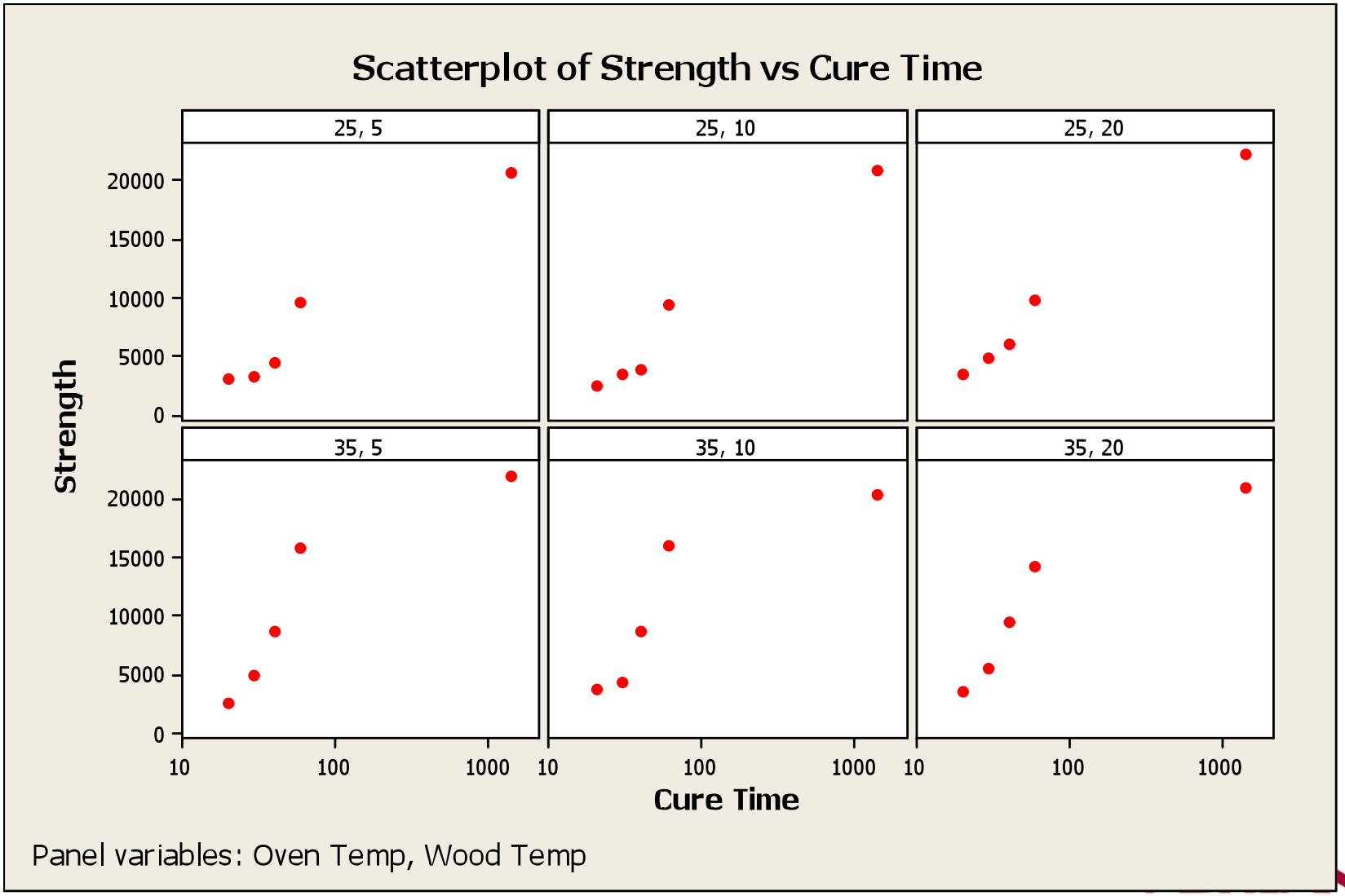
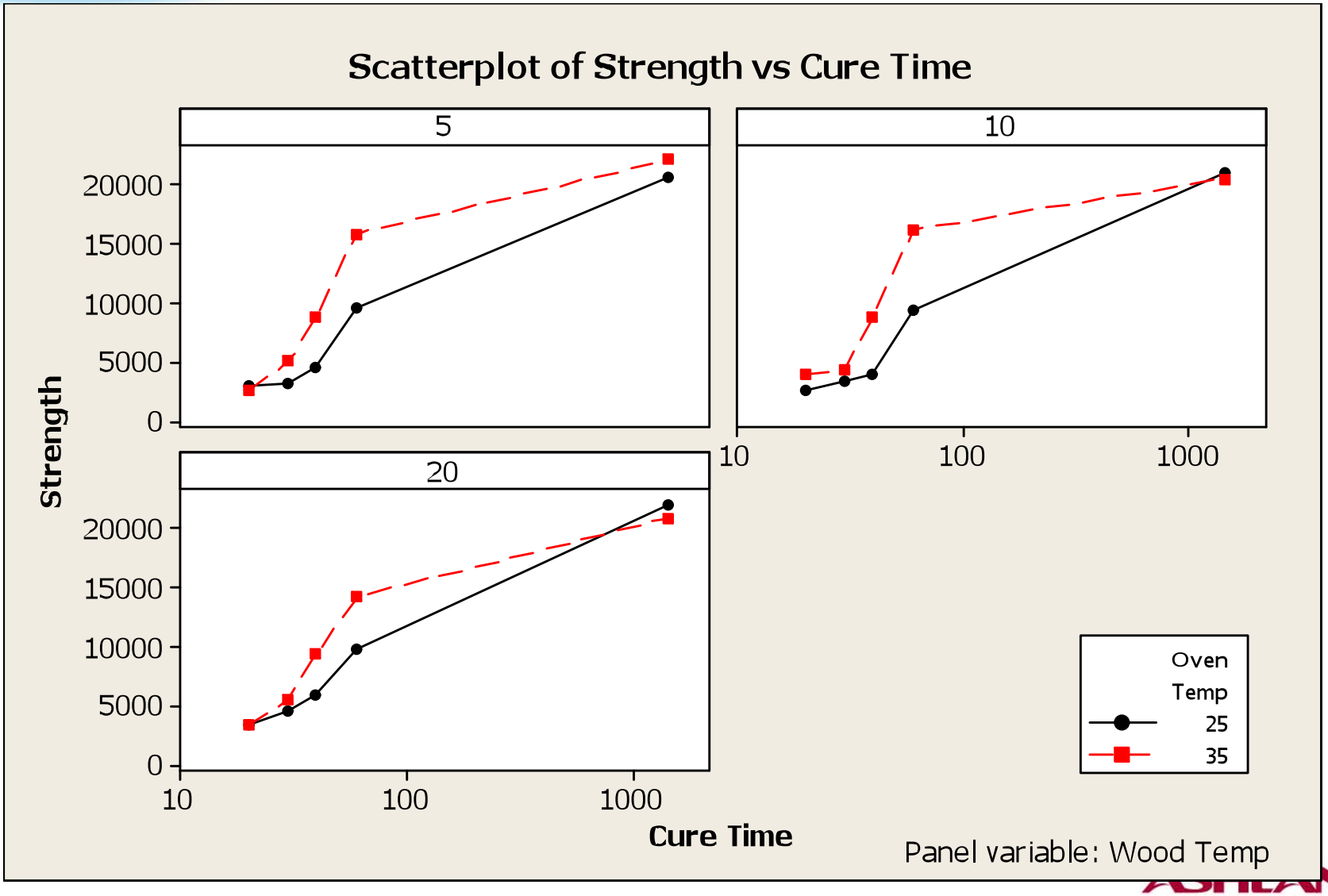
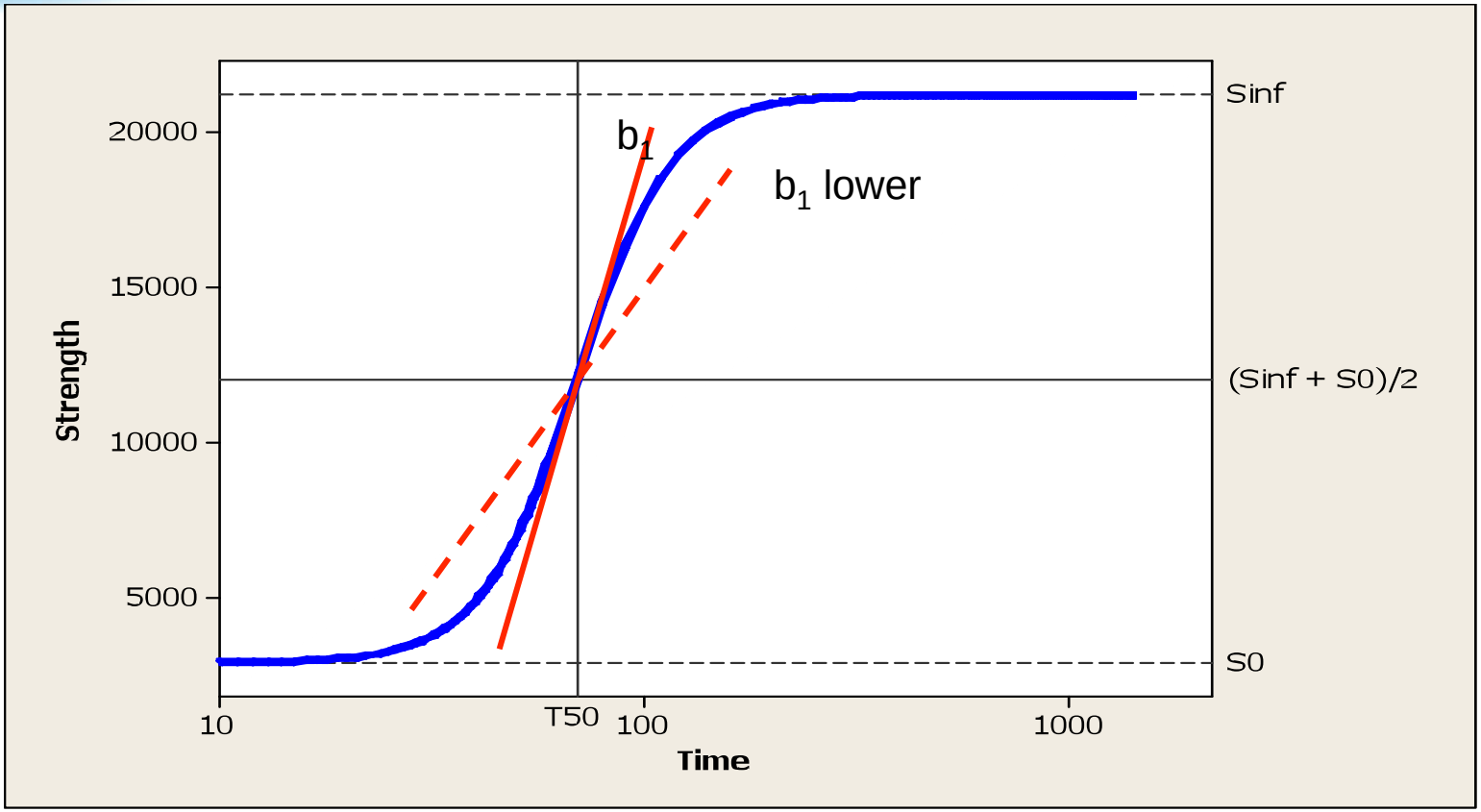
Data: Individual Curves



Data: Strength vs. Time (by Oven & Wood Temp)



Fitting Non-linear Model with Oven & Wood Temp



$$Strength = \frac{S_{\inf} - S_0}{1 + \exp\left(\left[\left[T_{50} + T'_{50} * \left(\frac{OvenT - 25}{10}\right)\right] - Ln(Time)\right) * \left[b_1 + b'_1 * \left(\frac{WoodT - 5}{15}\right)\right]\right)} + S_0$$

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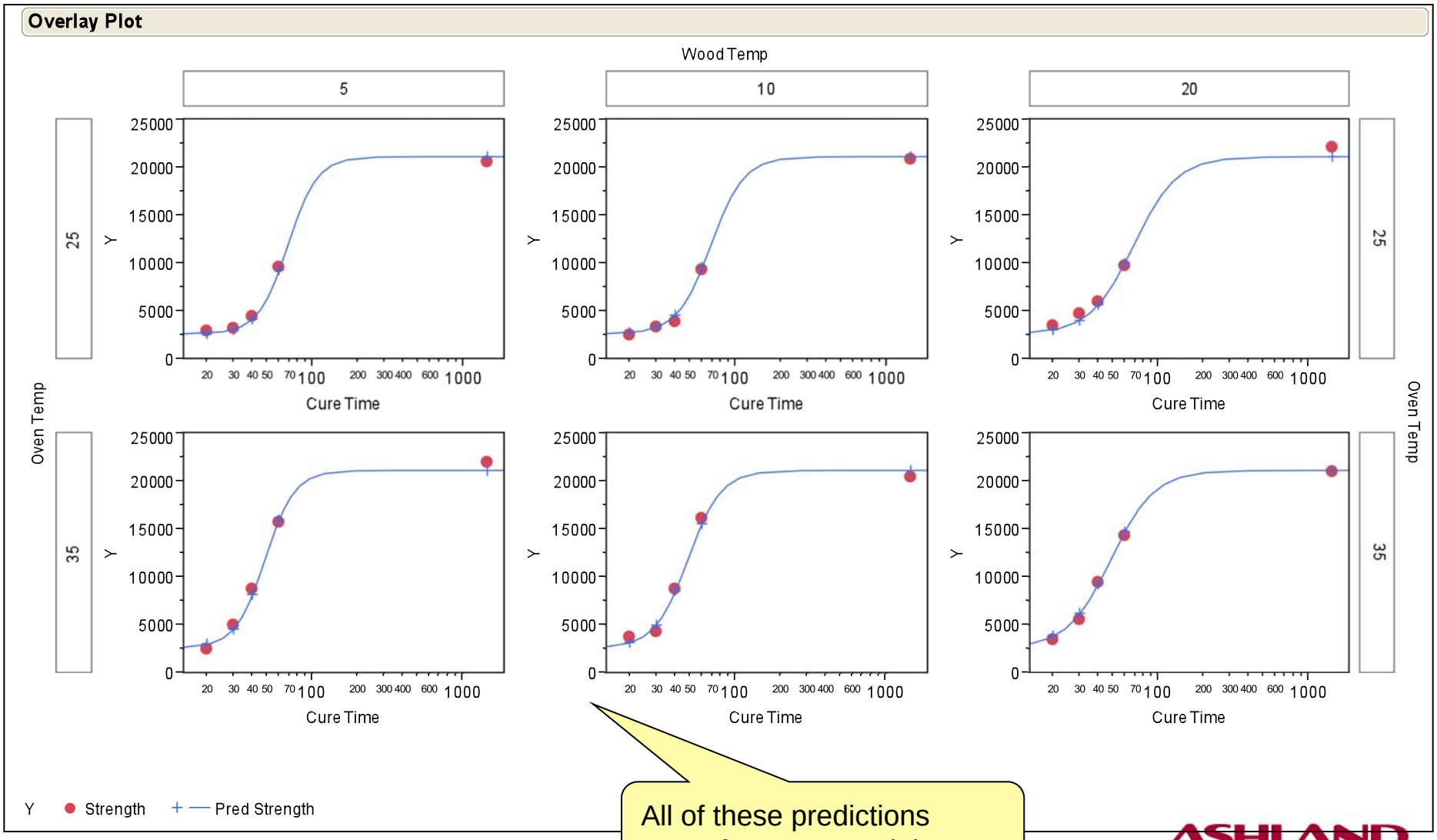
Final Model Results



All of these predictions come from one model.

Conclusions

- *Prediction models were developed that incorporated the impact of both Oven and Wood Temperatures.*
  - *Increased Oven Temperatures significantly shifted the curves to the left and resulted in strength builds earlier in time.*
  - *Increased Wood Temperature slightly broadened the curves over time.*
  - *Neither Oven nor Wood Temperatures significantly affected the initial or final properties.*

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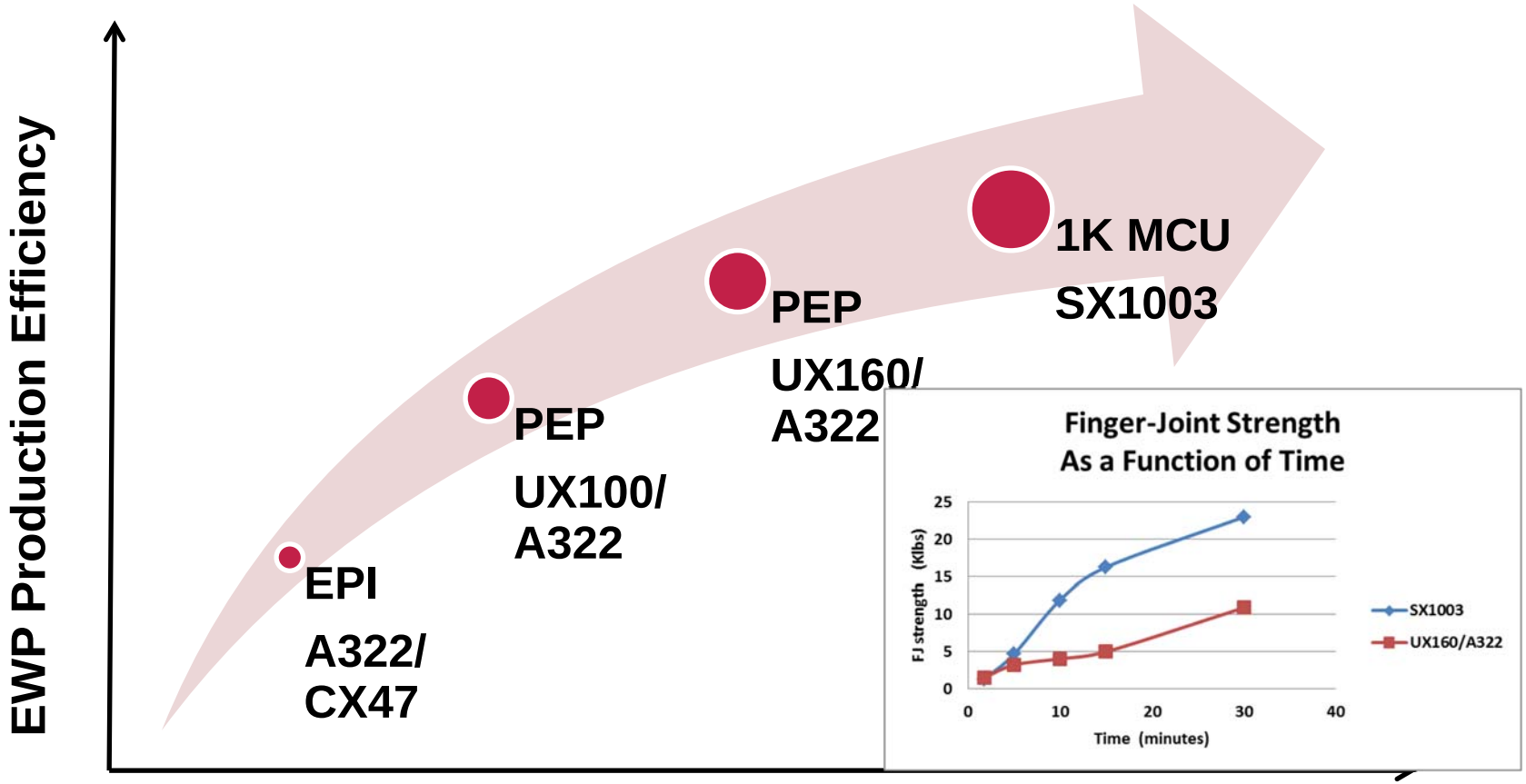
Three Generations of ISOSET For Enhancing EWP Production Efficiency



Summary

- Tailored product development and product offers to meet customer application needs
- Excellent technical support to provide customer optimized process conditions
- New product innovation to drive higher production efficiency

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