INNOVATIONS FOR LIVING™

COMPOSITE SOLUTIONS

2008 Wind Turbine Blade Workshop
Materials & Codes

Durable Composite Materials for Wind Turbine Blades

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OCV™ Reinforcements | OCV™ Technical Fabrics | OCV™ Non-Woven Technologies

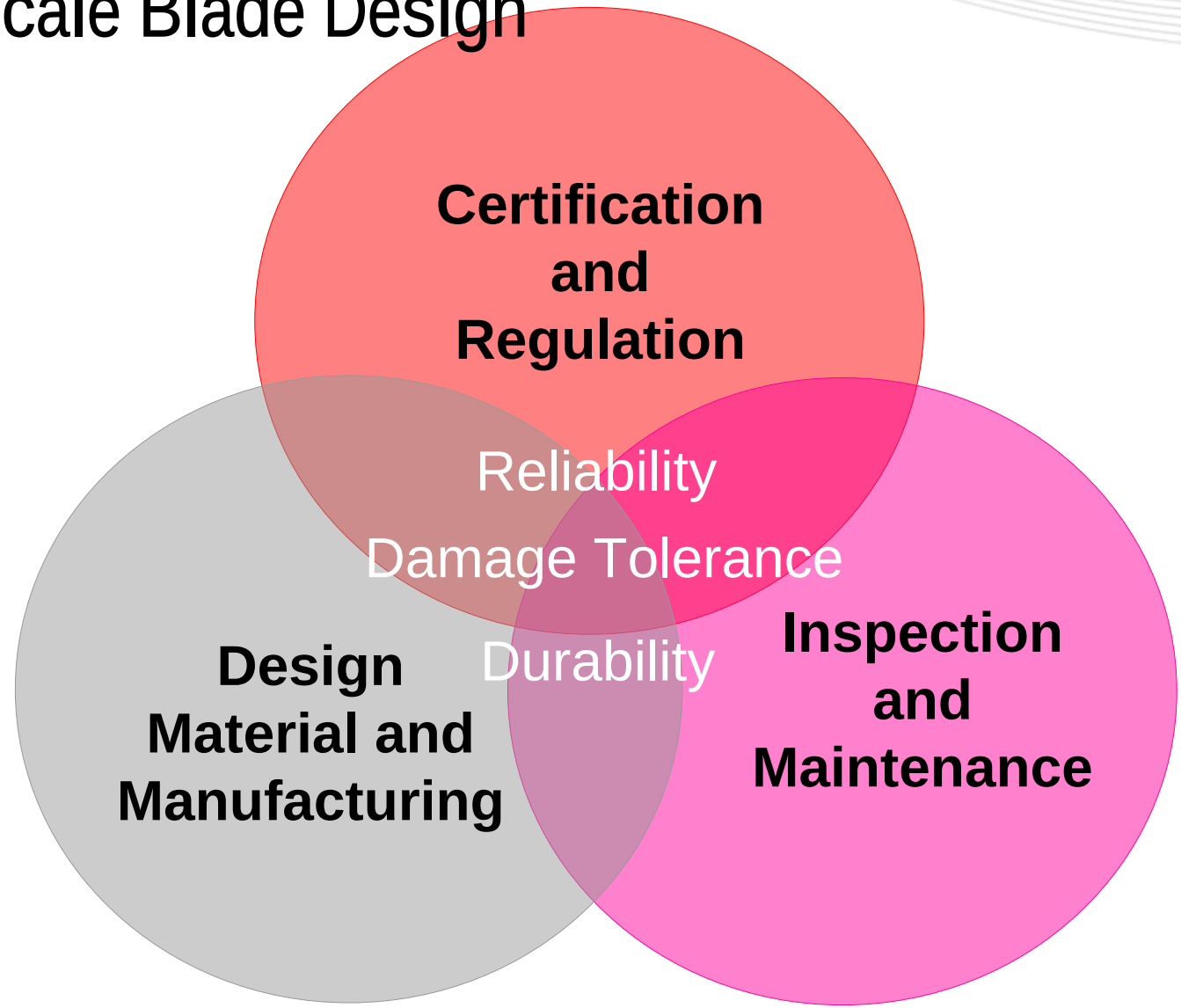
Key Market Drivers

- **Cost of energy (need for lower cost per kwh)**
  - **For Wind energy to compete with traditional energy sources, cost is very critical and largely depends turbine capital costs**
  - **Blades are estimated to be 15 to 20% of installed wind turbine cost and 10% of total lifetime cost**
    - **Blade design and material properties are very critical**
- **Rapid growth**
  - **Lack of competitive high performance materials to support growth**

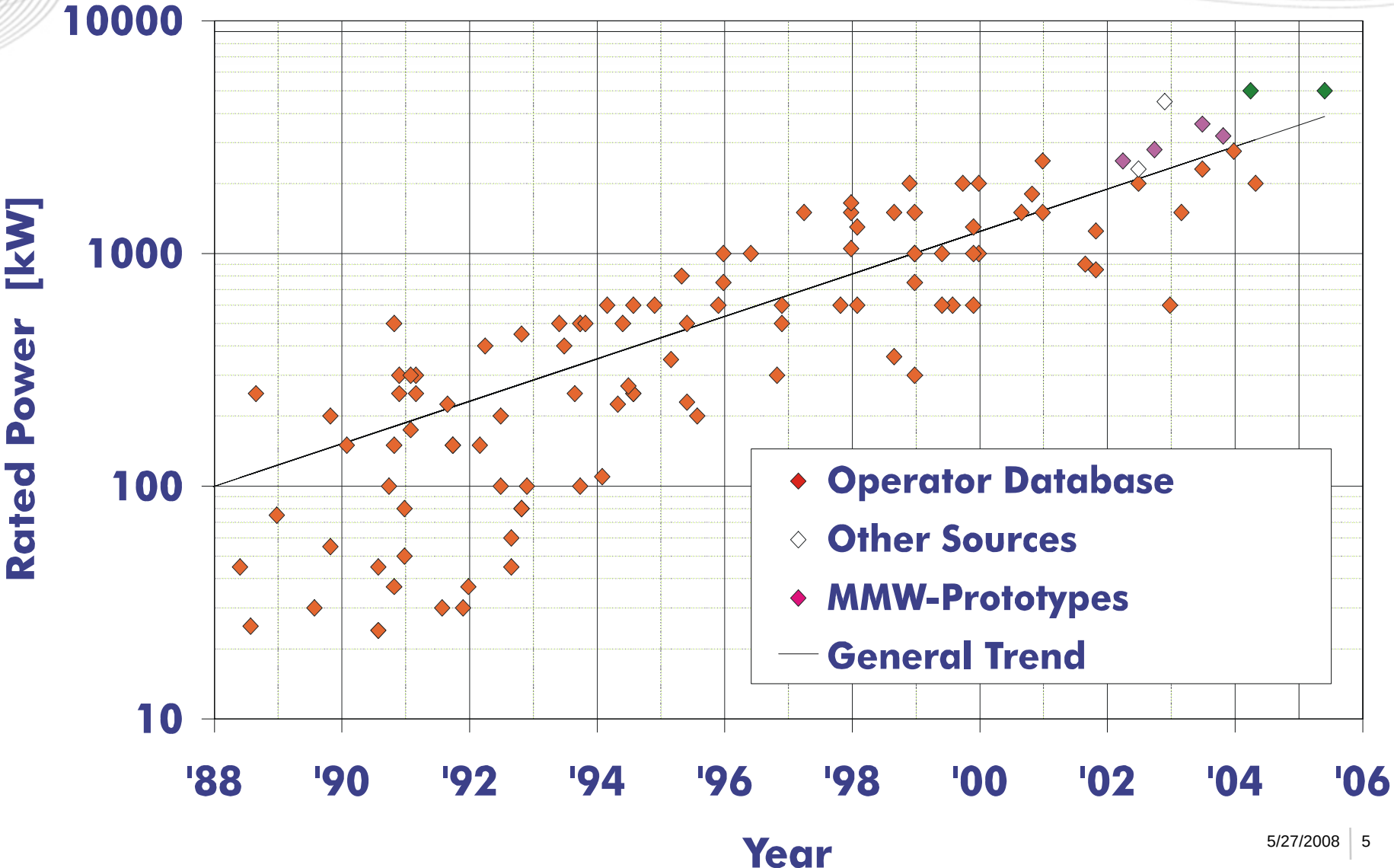
Key Performance Drivers

- **New Materials with improved properties to achieve weight reduction and durability**
  - **Higher modulus for stiffness**
  - **Improved strength with lower variation**
  - **Improved fatigue strength**
- **New Materials with processing flexibility**
  - **Faster processing time**

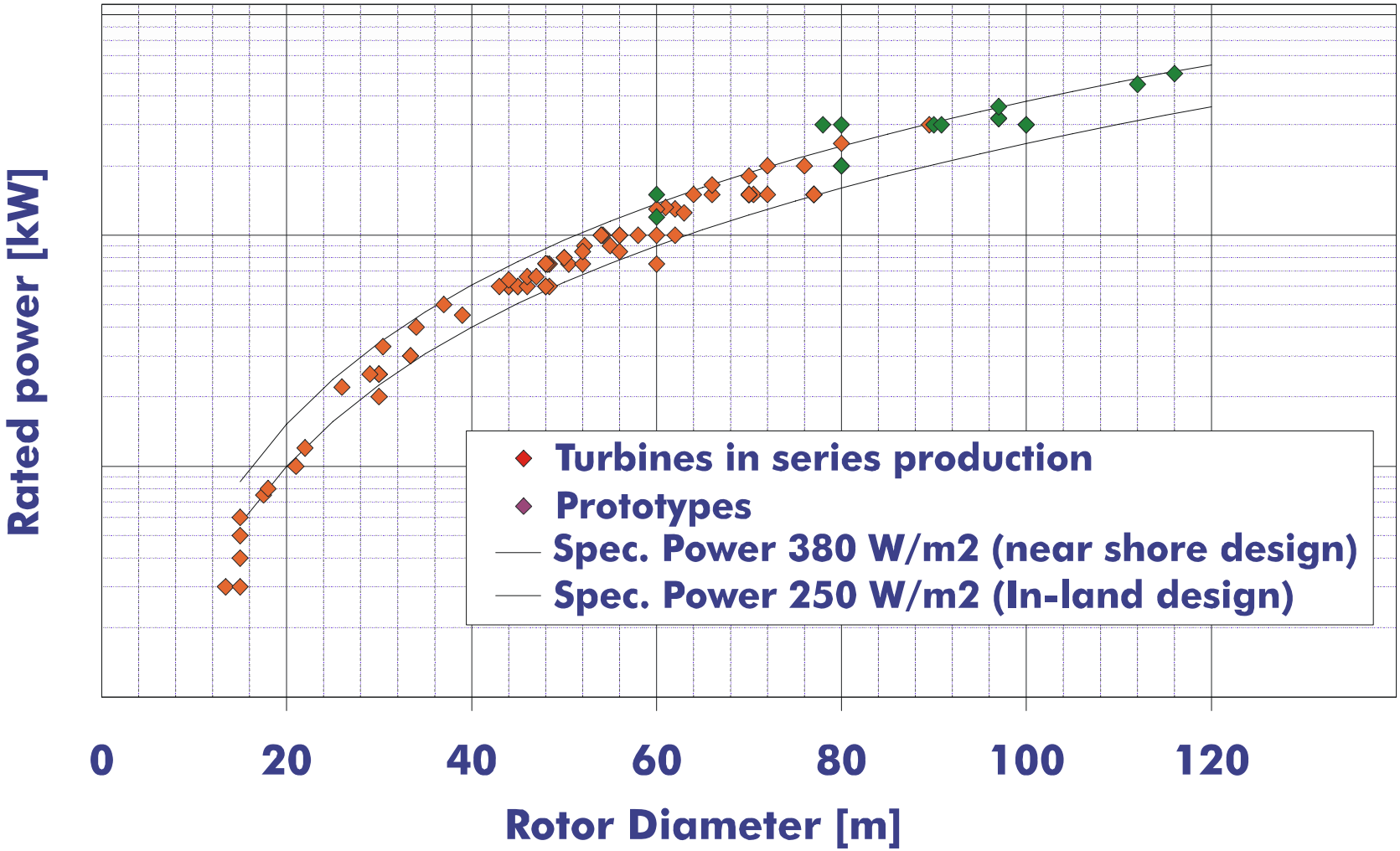
Utility Scale Blade Design



Rated Power from Wind Turbines is Increasing

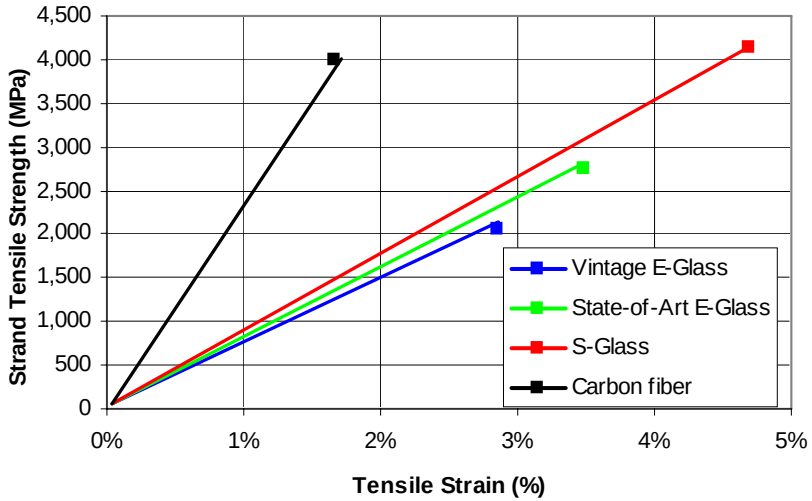


Higher Rated Power → Large Rotor Diameter → Longer Blades
High Performance Composites: The way to go!



Improvement in Material Performance

- **Increased Resin Matrix Fracture Toughness**
- **Increased Glass Fiber Strength and Fatigue Performance**
  - Glass Composition and Homogeneity
  - Fiber/Strand Alignment
  - Fiber/Matrix Adhesion



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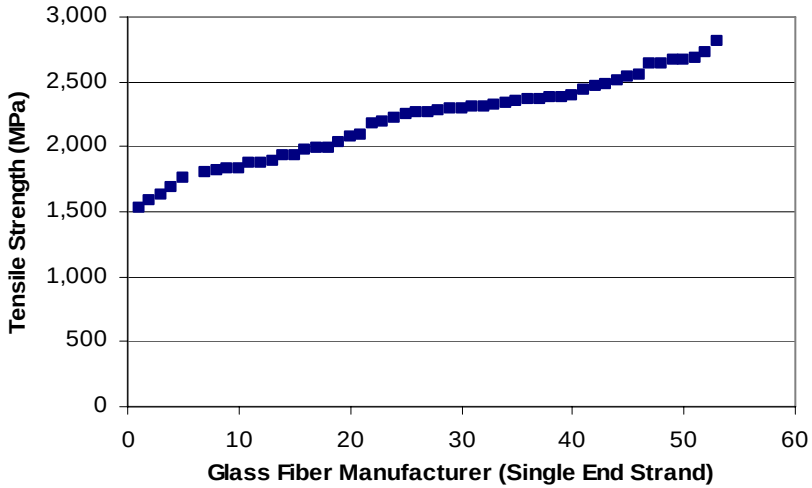
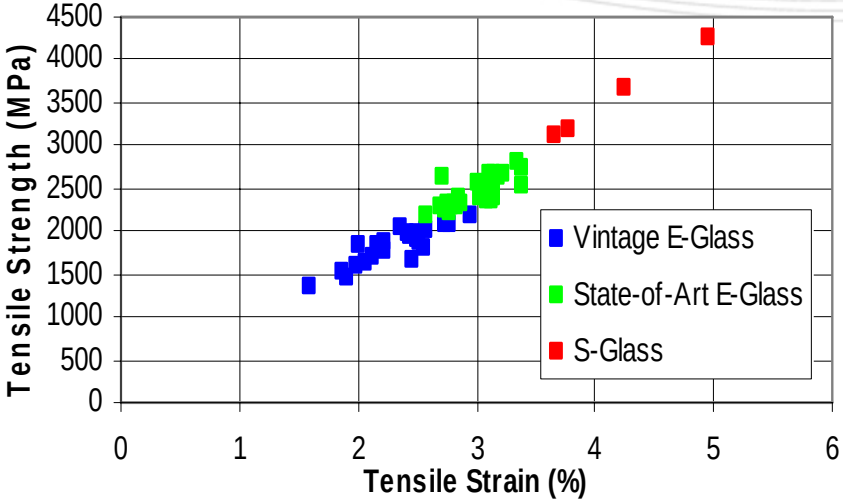
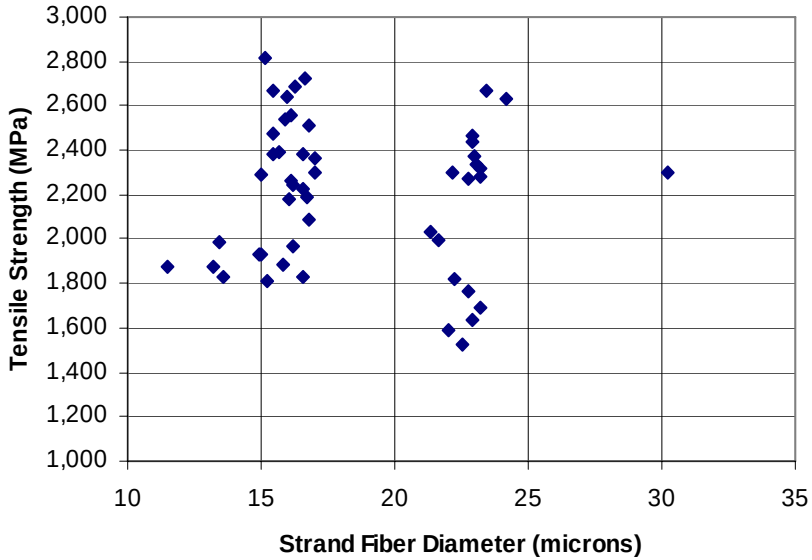
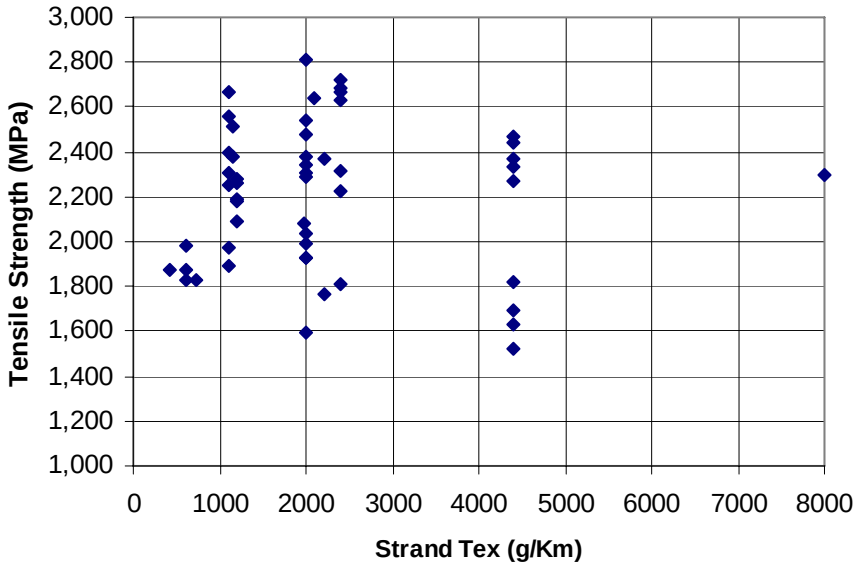
Evolution of Higher Strength Glass Fibers



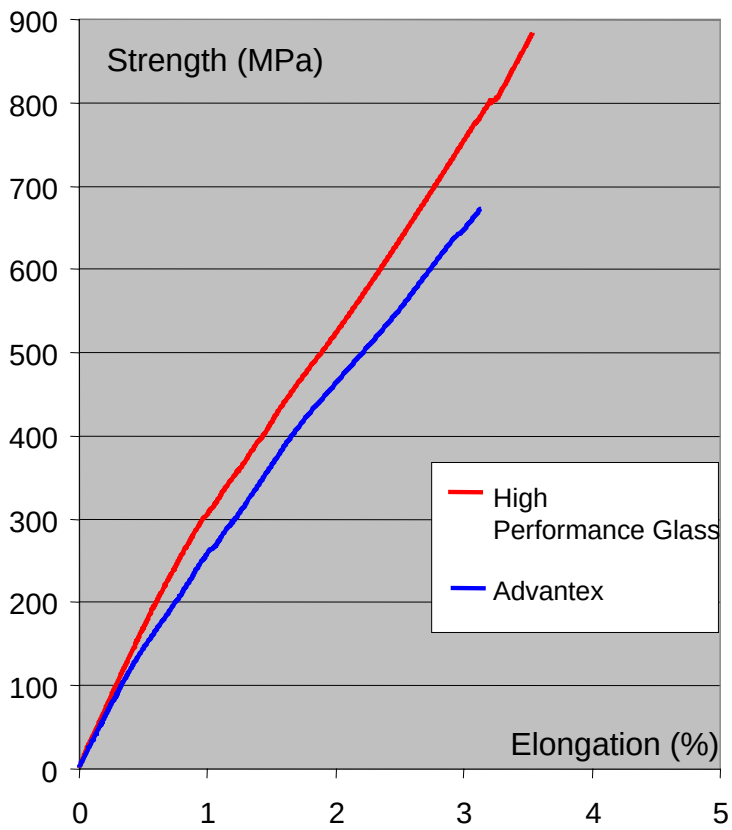




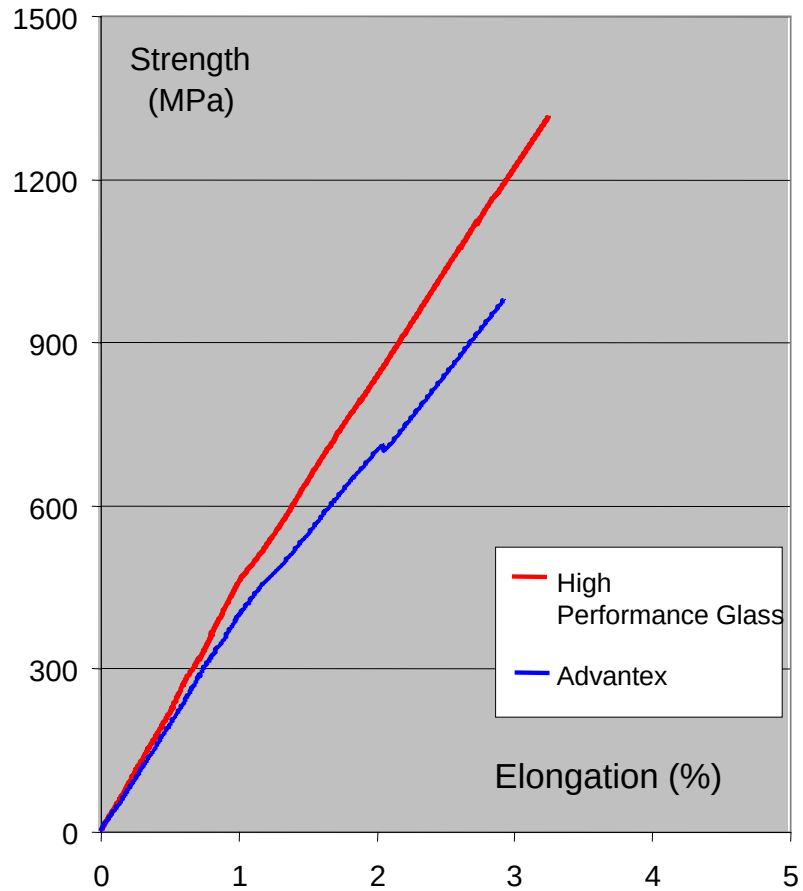


Improved Tensile Strength in High Performance UD Epoxy laminates

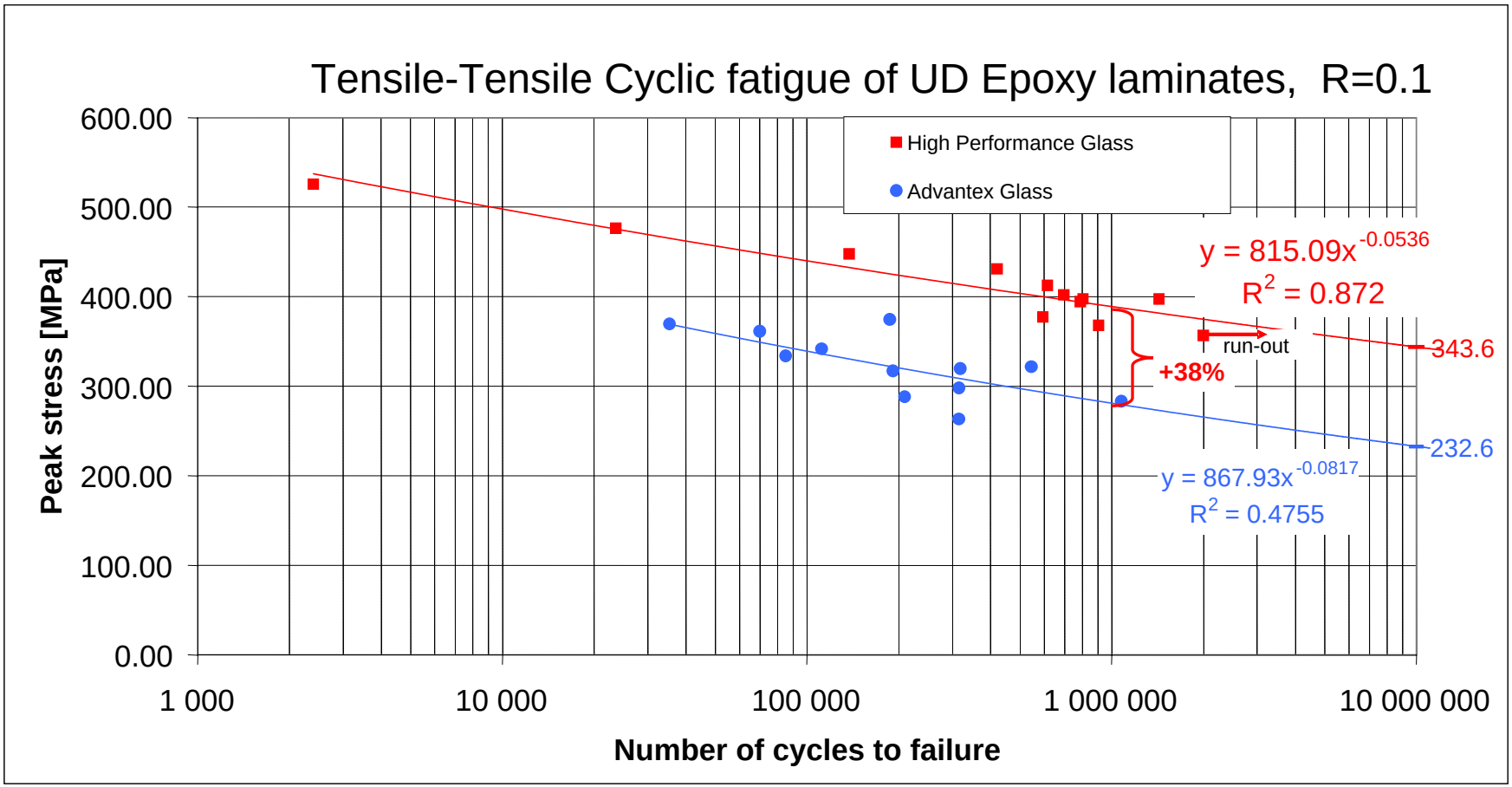
Infusion of dry wound rovings



Infusion of UD fabric

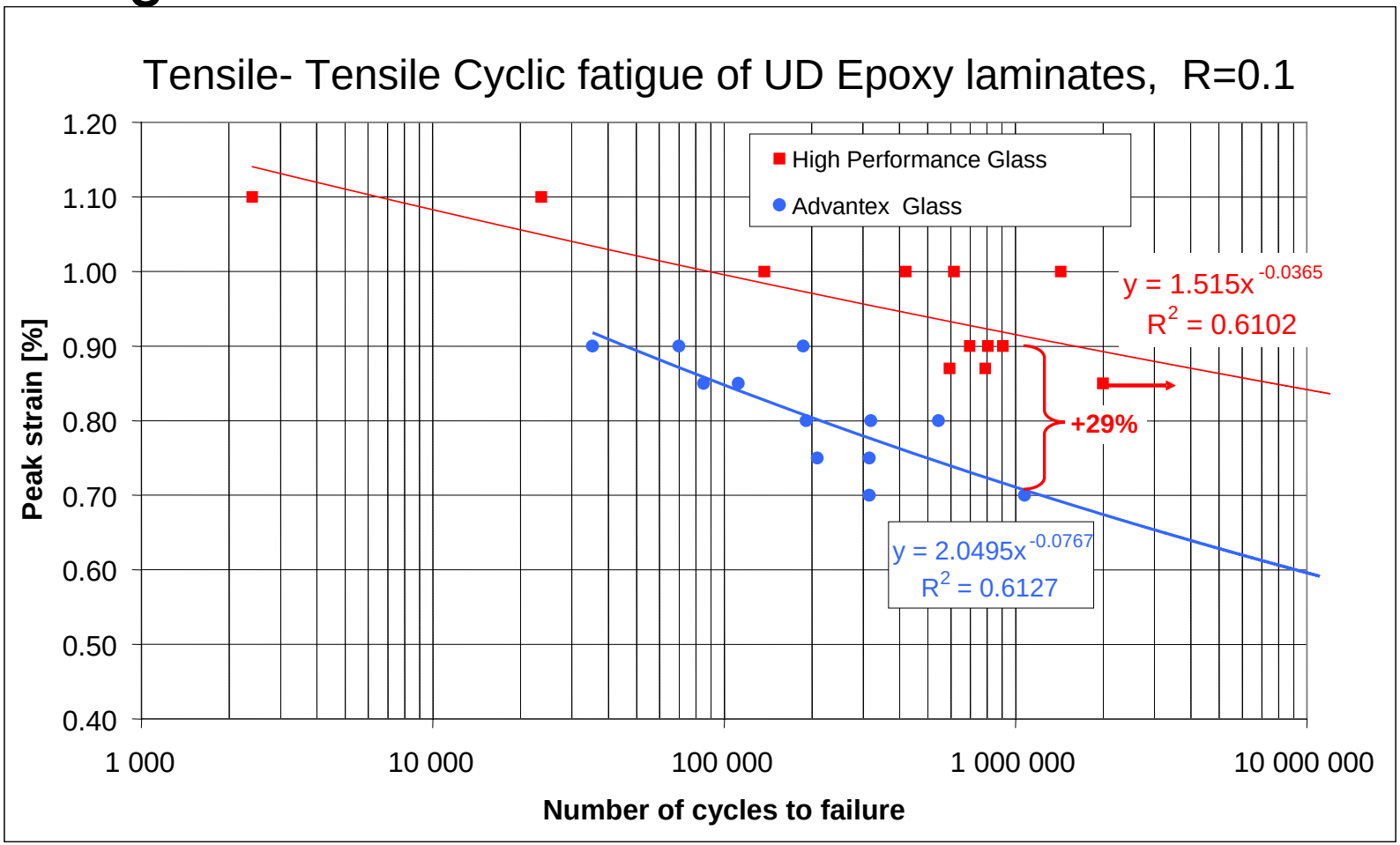


Fatigue Strength



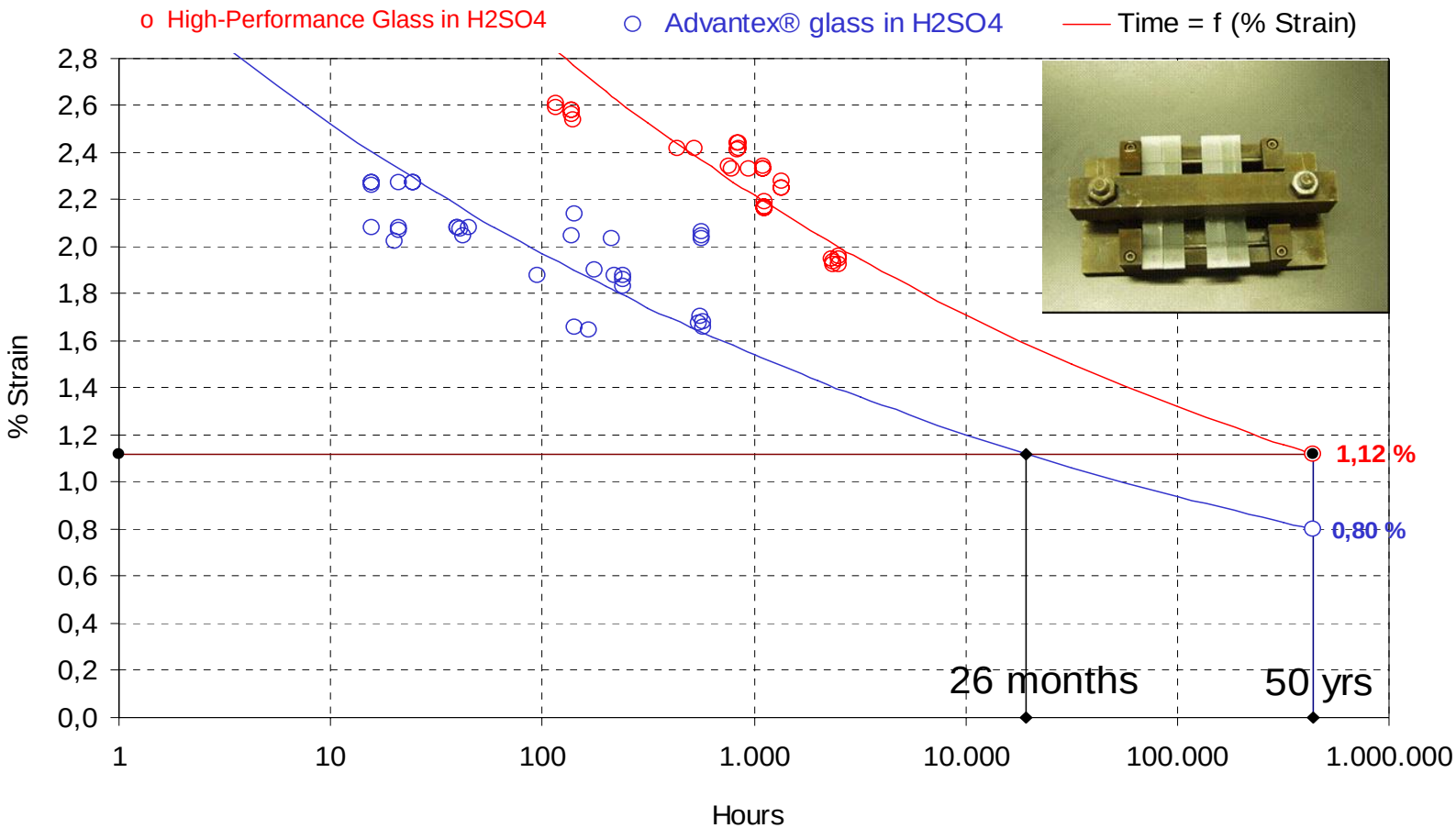
Time to failure is increased by more than a decade for High Performance Glass compared to Advantex Glass at a given stress level

Fatigue Strain



Time to failure is increased by more than a decade for High Performance Glass compared to Advantex Glass at a given strain level

Improved Strain-Corrosion of High Performance Glass



50 year Strain to failure for High Performance flat glass laminates in 5% H_2SO_4 is 40% higher than Advantex glass

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Stress-Corrosion Set-up

Tensile loading frames (cantilever)

Rod in tension-corrosion

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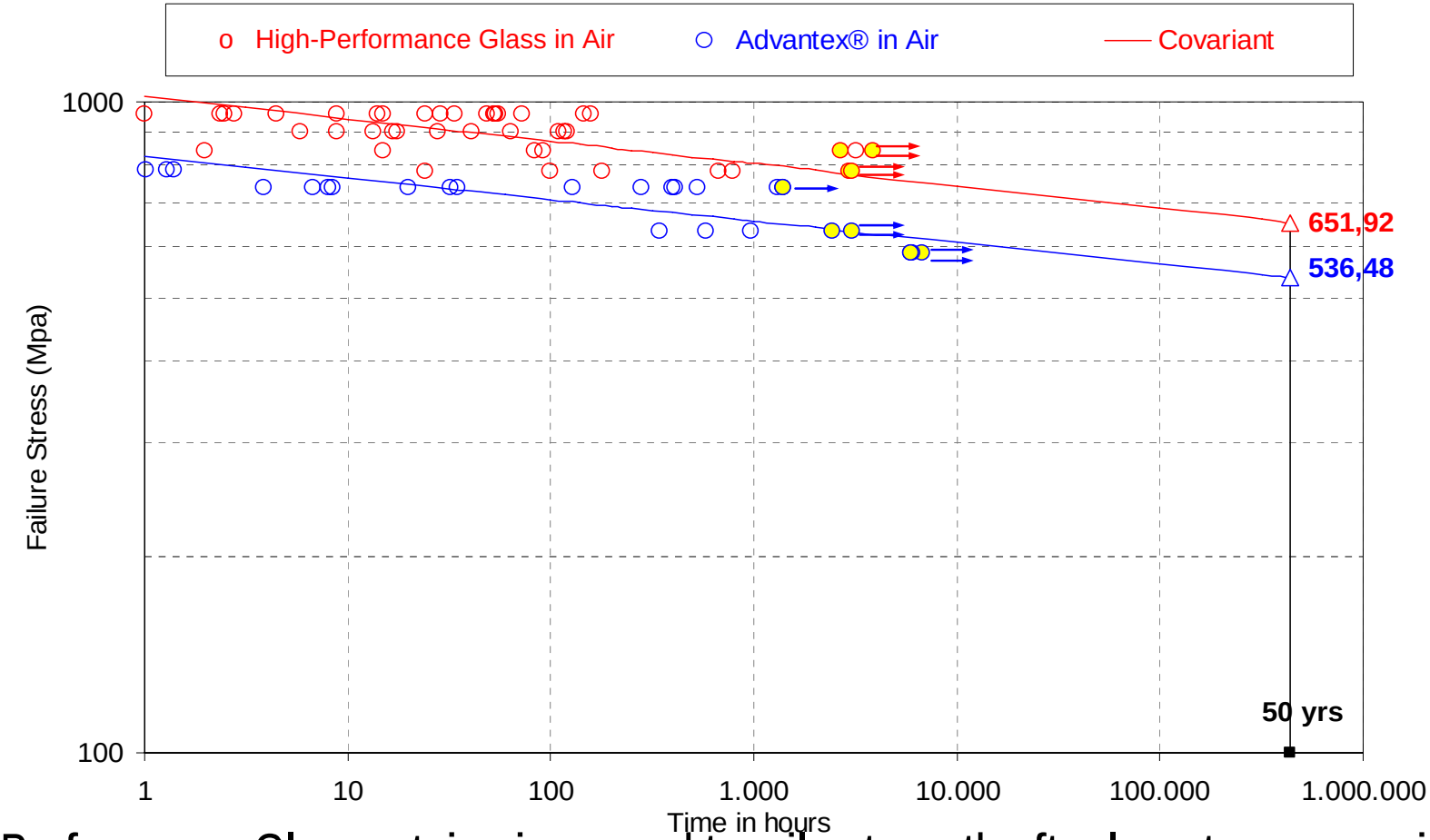
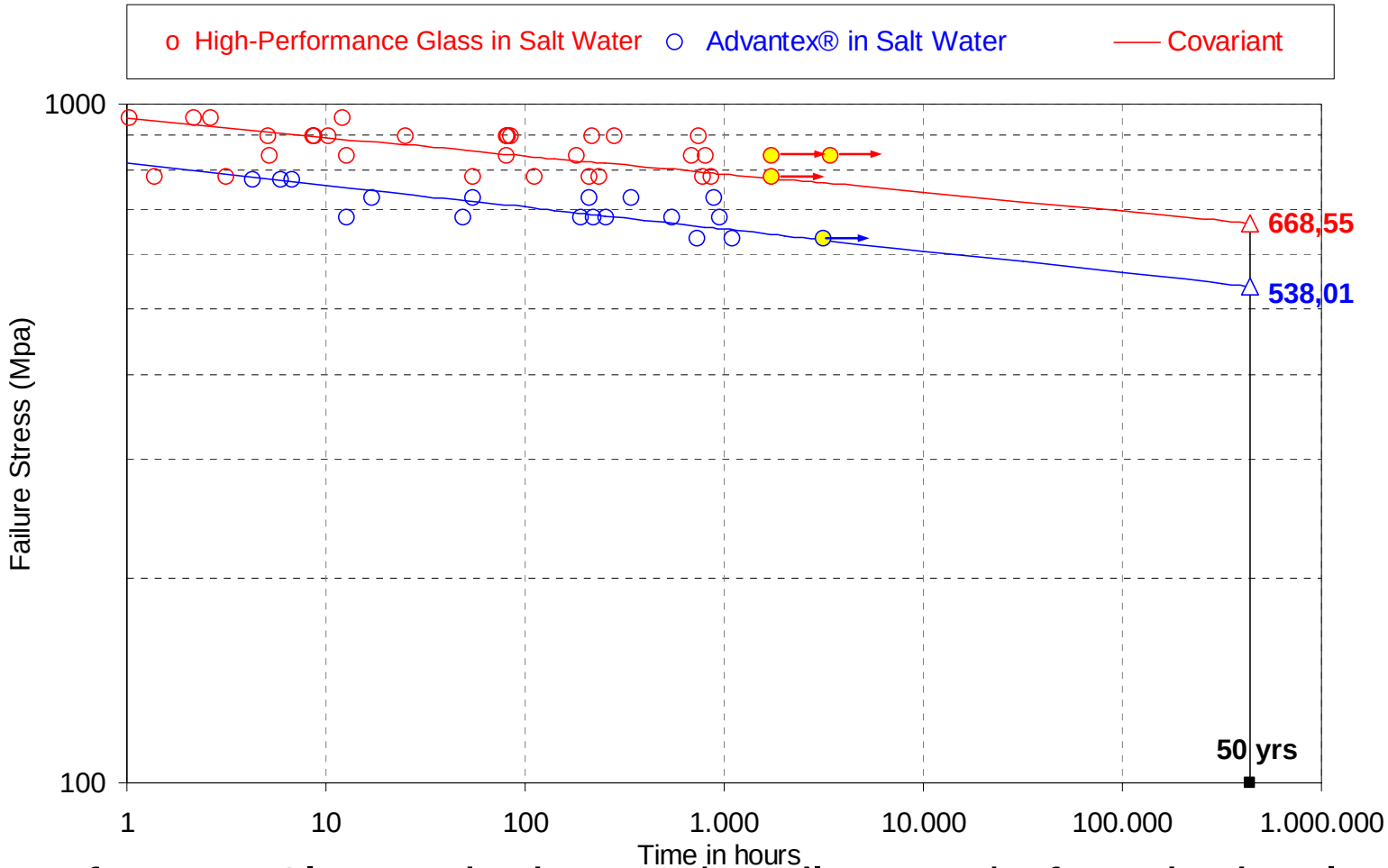
Long Term Creep



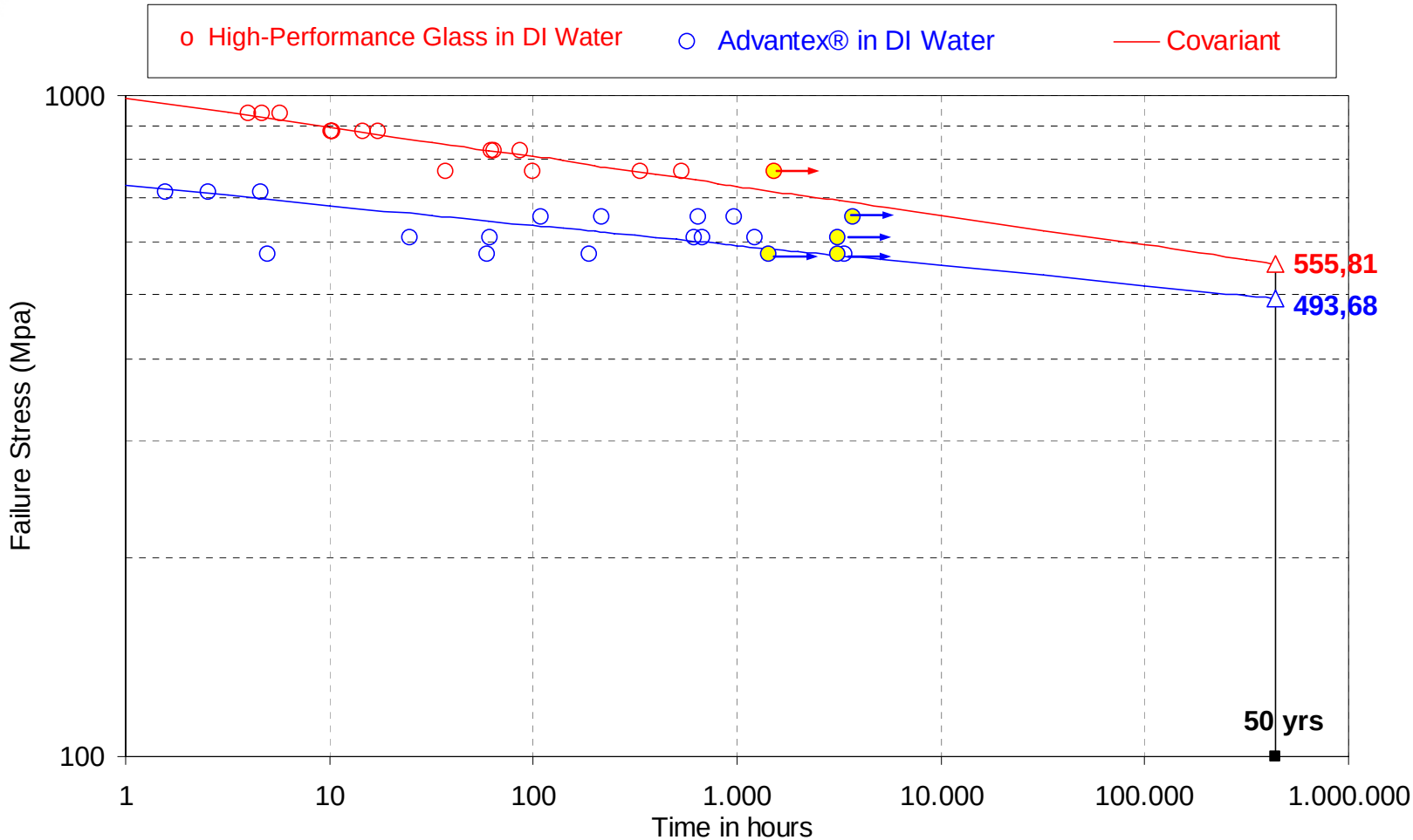
High Performance Glass retains improved tensile strength after long term creep in air

Stress-Corrosion in Salt Water



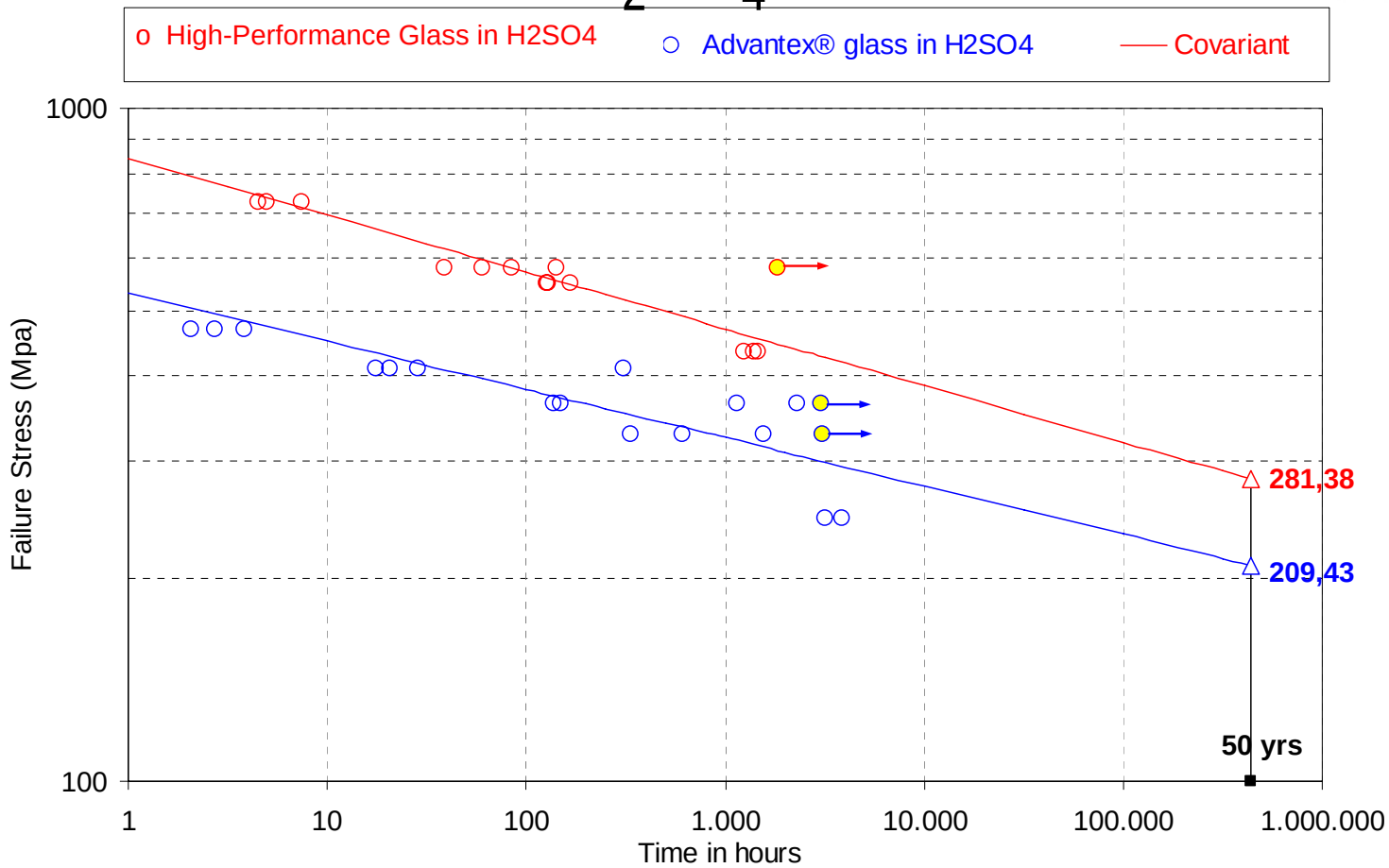
High Performance Glass retains improved tensile strength after aging in salt water

Stress-Corrosion in De-Ionized Water



High Performance Glass losses some of the improved tensile strength after aging in De-Ionized Water, however still retains a significant (~13%) higher strength

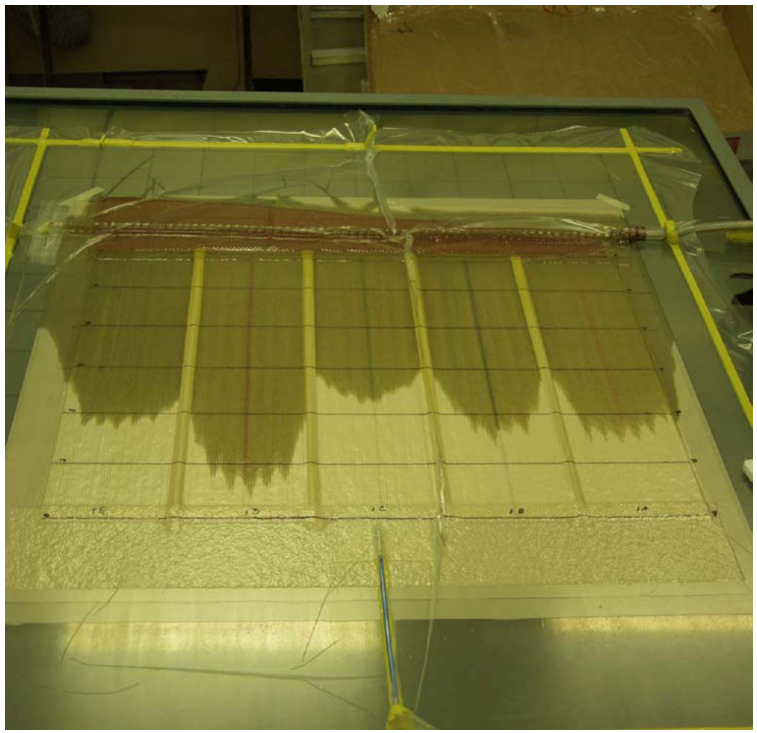
Stress-Corrosion in H_2SO_4



High Performance Glass exhibits further improvement in tensile strength after aging in H_2SO_4, indicating greater corrosion resistance in acidic environment

Improvement in Material Process Flexibility

- **Reduced Fabric Misalignment with Good Conformability**
- **Faster and More Consistent Resin Infusion**



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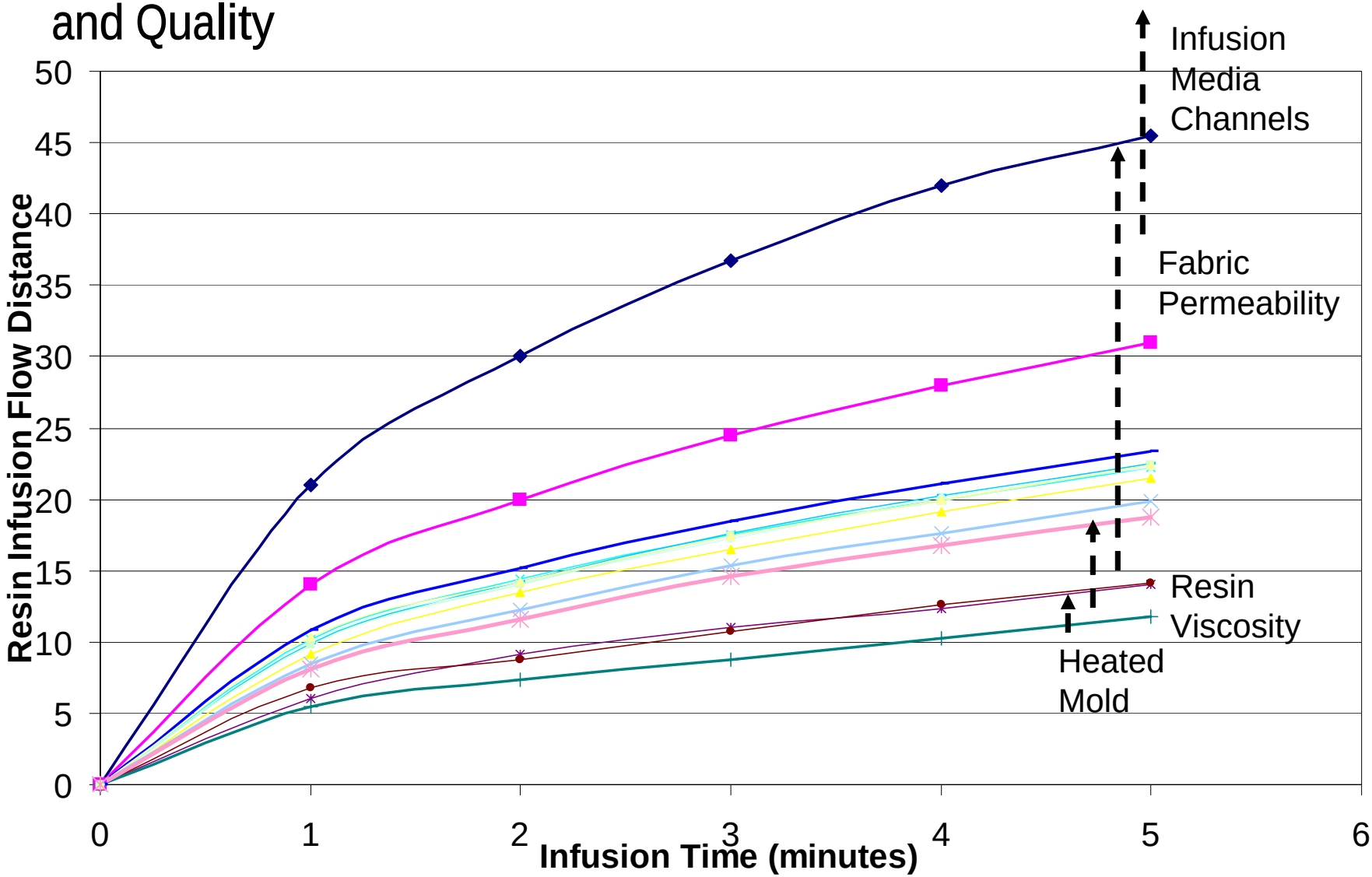
Improvements in Fabric Design on Resin Infusion Flow Rate and Quality



Summary

- Rapid market growth demands use of high performance materials, cost effective processing and efficient design
- High Performance Glass has demonstrated high strength, improved fatigue and long term durability
- High Performance Glass provides opportunity to reduce blade weight or increase the blade length without increasing blade weight
- Lower cost per kWh is possible!