

## RodPack: A New Form of Aligned Fiber Reinforcement for Wind Blade Spar Caps



2012 Wind Turbine Blade Workshop  
Sandia National Laboratories

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# RodPack prevents...

...wrinkles and waviness in wind blade spar caps



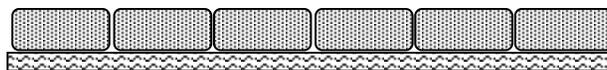
*RodPack is flexible enough to wind, but too stiff to wrinkle*

# Rod Pack is made up from...

- A layer of rectangular unidirectional fiber profiles, bonded to a carrier fabric
- The rods provide longitudinal properties
- The fabric provides an aligned, unitized material form, capable of being coiled or spooled. May provide additional cross-axis stiffness and strength if desired.
- Uniform width and thickness
- Roll or Spooled
- GL Certified

LFH/F 750

PET Nonwoven



} XC 12886

*Statement of Approval* 

Approval No. WP 1130018 104

The material described below complies with the applicable requirements as given in the Rules and Regulations of Germanischer Lloyd. On this basis the material is approved as **Glass Fibre Reinforcement** for the construction of components provided that the recommendations for use as specified by the producer are observed.

Type **NEPTCO RodPack 12886**

Description **Pre-cured glass fibre reinforced flat rods**

Producer **Neptco Inc.  
30 Hardsol St.  
Parsippany, NJ 07054  
United States of America**

Normative Reference **Rules for Classification and Construction,  
3 - Material and Welding Technology  
Part 2 Non-Metallic Materials**

Remarks **The rod pack is an aligned layer of flat rods with a rectangular cross-section of 1.5mm x 7.2mm. The rods are bonded to a non-woven fabric. Mechanical properties are listed on page two.**

This document consists of this page and a one-page annex which is integral part of the approval.

This Statement of Approval is valid until 2015-05-12.

Hamburg, 2011-05-13

**Germanischer Lloyd**

 Michael Kühnel

 Guido Michalek

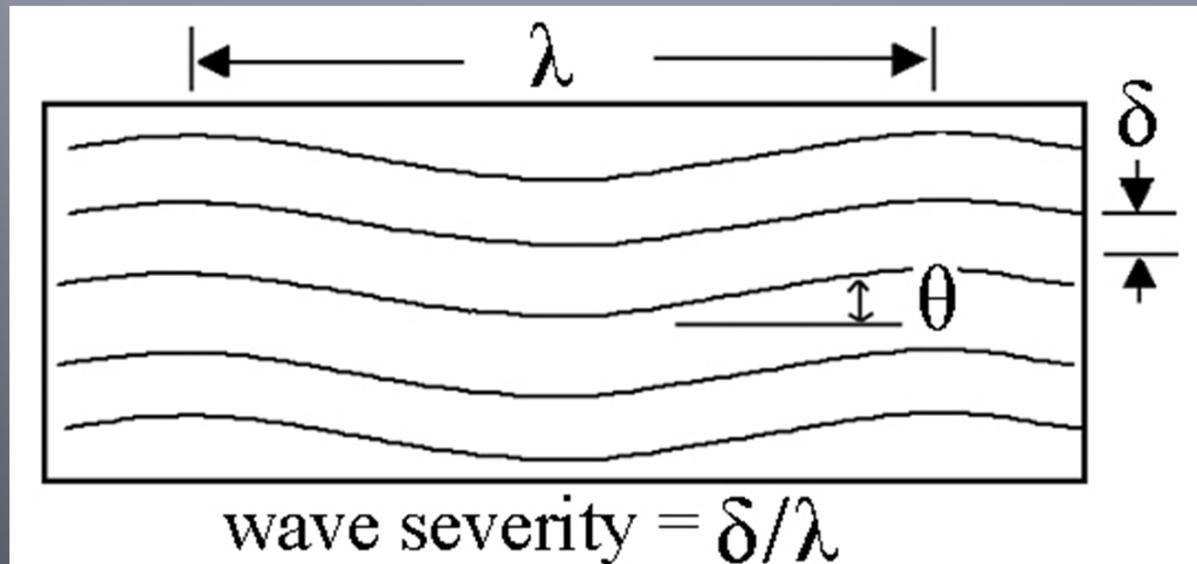
This document is the property of Germanischer Lloyd. It is not to be distributed outside the company. Germanischer Lloyd is not liable for any damage or loss of data.

# NEPTCO Incorporated

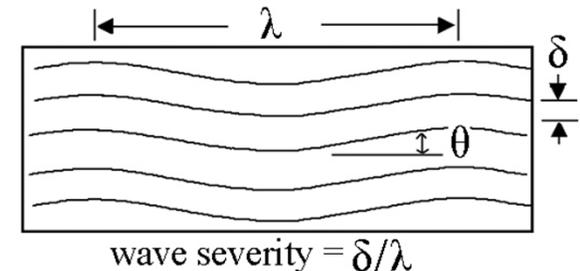
- Global leader in radiation cured composite materials
- 1,000,000 km/yr. profile capacity
- Core competencies in unidirectional composites and roll to roll web processing
- Headquartered in Rhode Island with (2) factories in North Carolina and Suzhou, China
- 400 employees worldwide
- JV Partner with OCV in Telecom



# How does RodPack eliminate fiber wrinkle and waves?



# Sources of Fiber Waviness in classic UD Composites



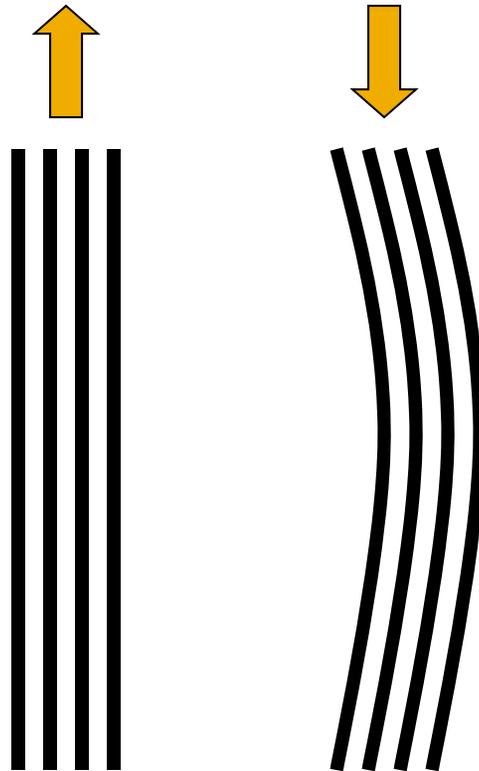
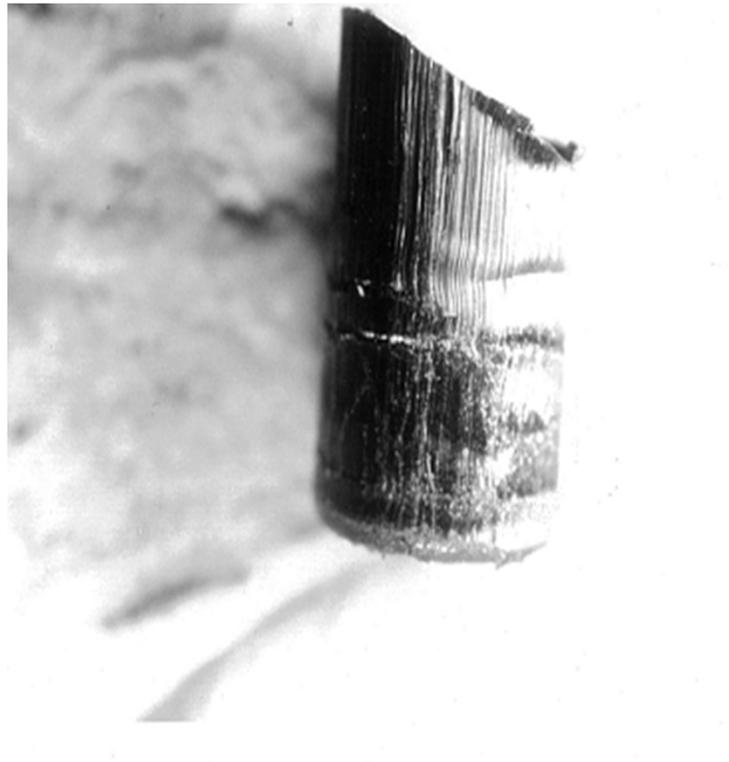
- Macro or "Waves"
  - Non-uniform cure shrinkage of infusion resin
- Midi
  - Mapping a flat 2-D material into a mold with compound curvature.
- Micro
  - Crimp from weaving, stitching and cross ply roving gaps
  - Winding or spooling an uncured fiber based web

# The original issue...

- Maximize the dynamic flexural properties) of the V-22 Osprey Wing Section.
- Loads are alternating and environment is severe.
- Weight premium is high



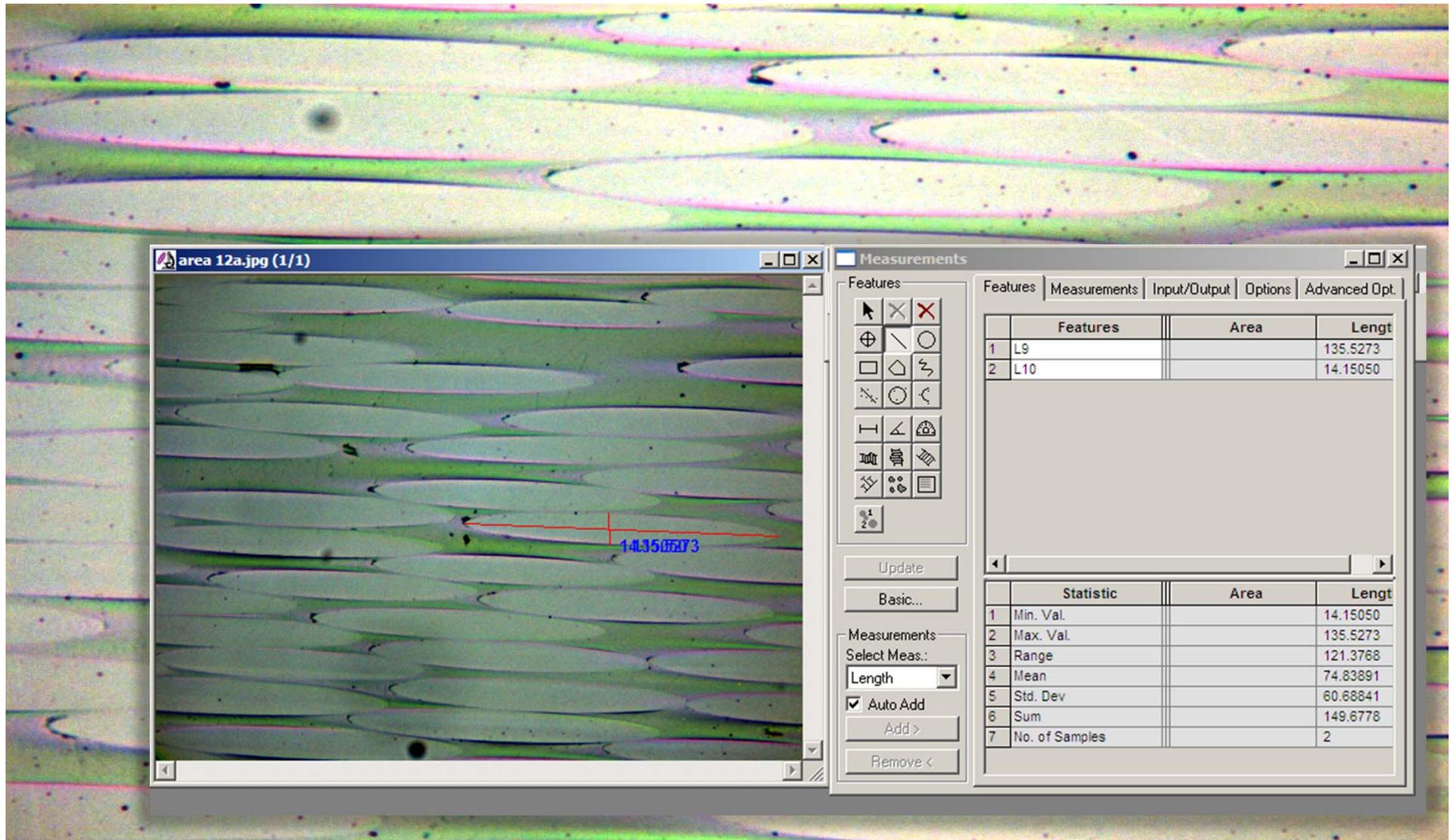
# High Compression Strength Composite Rods



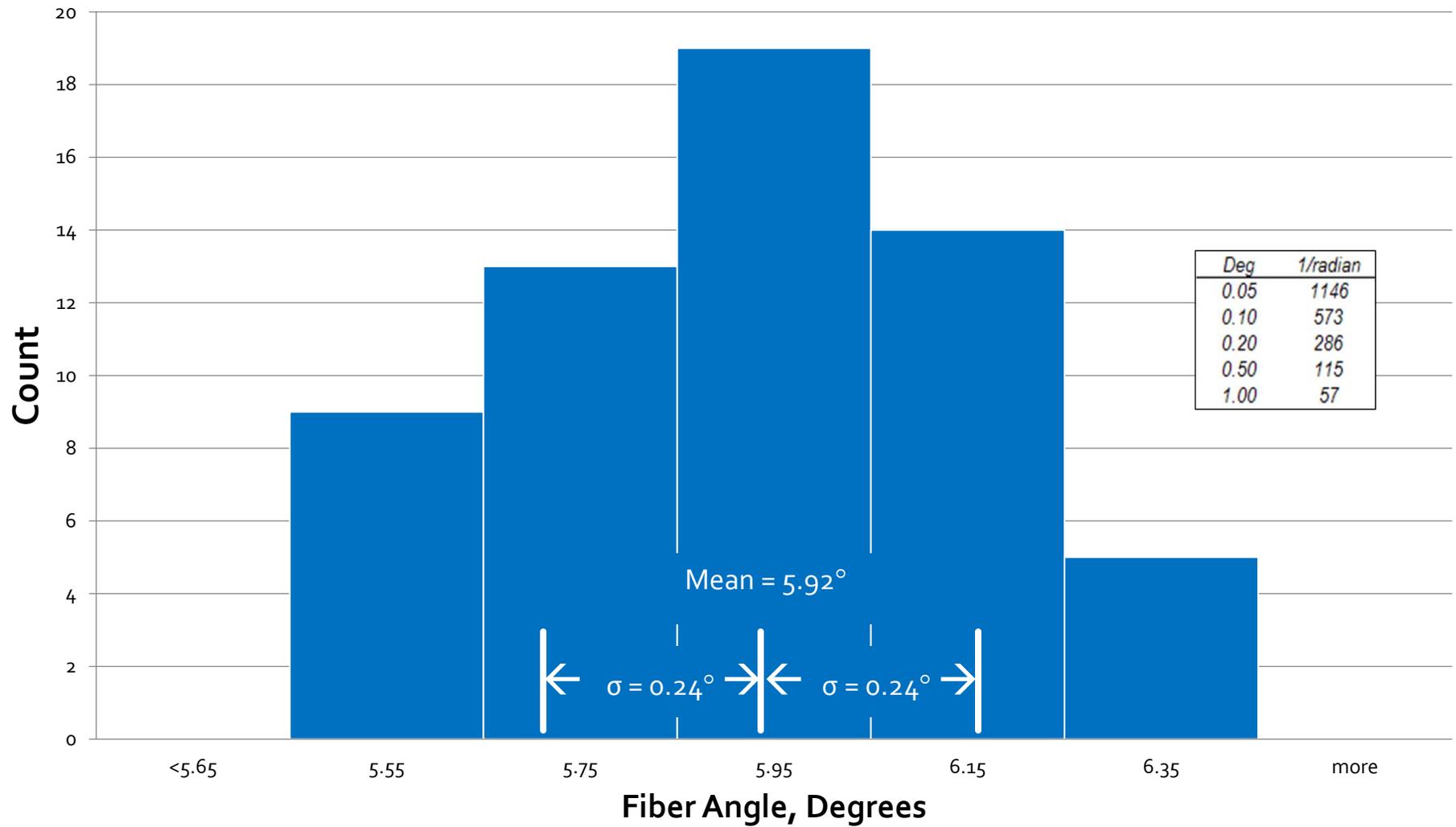
# Measuring Fiber Collimation

Polished 6° off axis

Image Analysis of Elliptic Ratio



# Fiber Collimation... 250:1



# Fiber Collimation

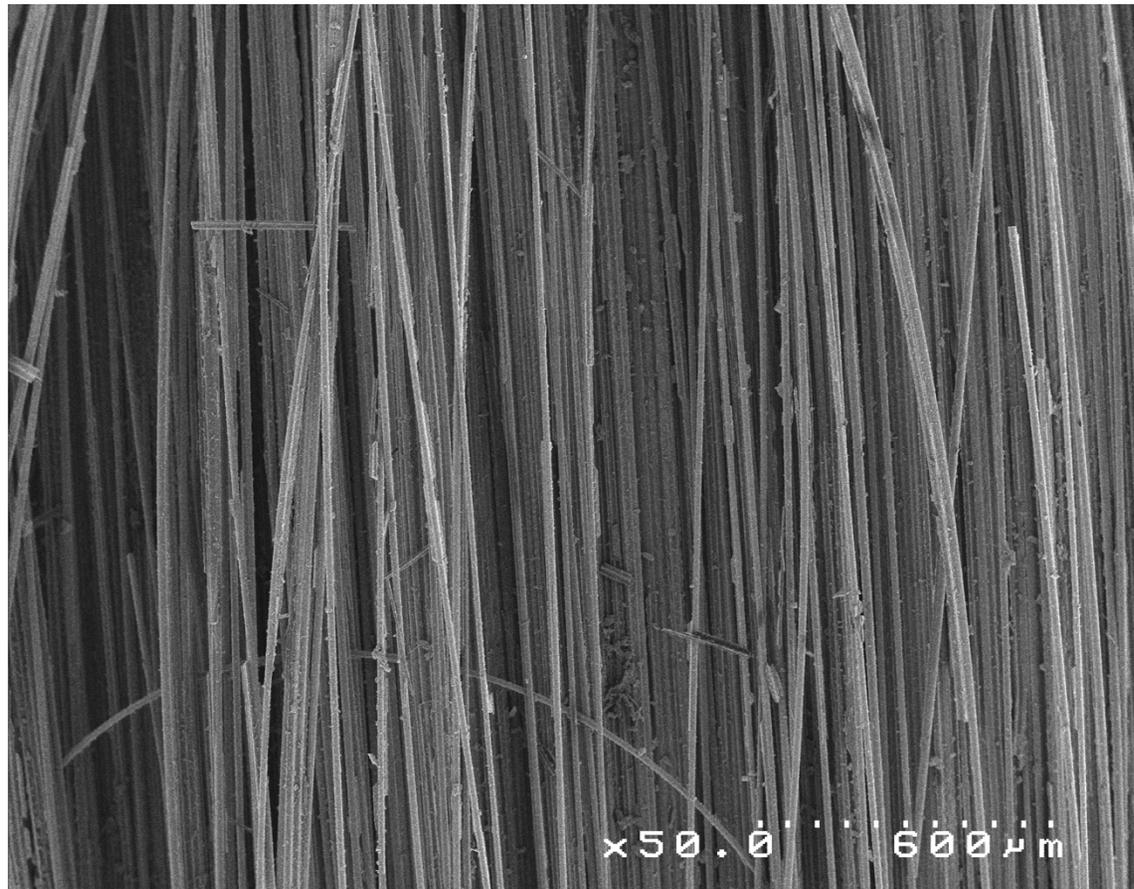
- RodPack Profiles >250:1
- Pultruded Rods 50-100:1
- Shrink Waves 10:1??

# Creating high fiber alignment

- Controlled roving placement within the profile
- Controlled effects of package twist
  - Carbon
  - Glass
- Removal of roving texture and glints
- “A broken fiber is a preventable defect”
- Lock in alignment with a fully cured matrix

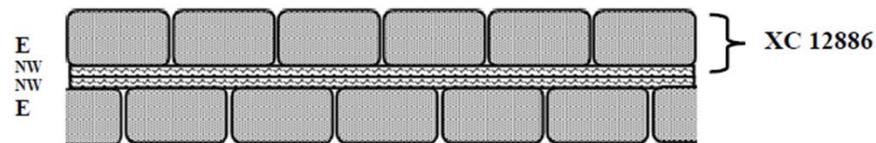
# Tough, High Modulus Matrix

Matrix resin is well adhered to the glass filaments



# Results

Schematic of XC 12886 based laminate



PROPERTIES OF LFH / WE 750 FLAT RODS				
Composite Property	Test Method	Fiber Volume Fraction	Unit	LFH/WE 750
Longitudinal Tensile Modulus	ASTM D 3916	69%	MPa	51,500
Longitudinal Tensile Strength	ASTM D 3916	69%	MPa	1420
Longitudinal Tensile Strain	ASTM D 3916	69%	%	2.9

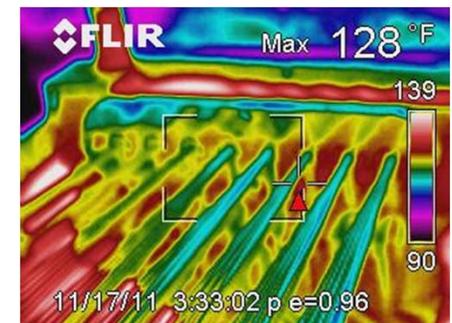
# Is RodPack a PULTRUSION?

## TYPICAL PULTRUSION

- Process Speeds of m/min
- Mold release package
- Fillers
- Thermal Cure
- Short lengths

## NEPTCO GRP ROD PROCESS

- Process at KMs / hr
- No Additives
- No Fillers
- UV Cure (GRP)
- Lengths to 100+ km



# RodPack Product Form

- Assembly of profiles and carrier fabric
  - Rod - GRP or CFRP, 68% Vf
  - 4-5gsm Adhesive
  - 17 gsm PET Non-woven
- Widths and lengths per mutual agreement
  - Fixed number of rods
  - 1% Inter-rod gap
  - Lengths per ply drop schedule
- Supplied on 500mm ID banded coil or spooled

# RodPack Product Form

Widths to 800mm



Banded coils or spools

# Tapering Letoff



## Letoff

- Lengths to 300m
- Controlled tension
- Accommodates either Coils or spools

## Abrasive Tapering

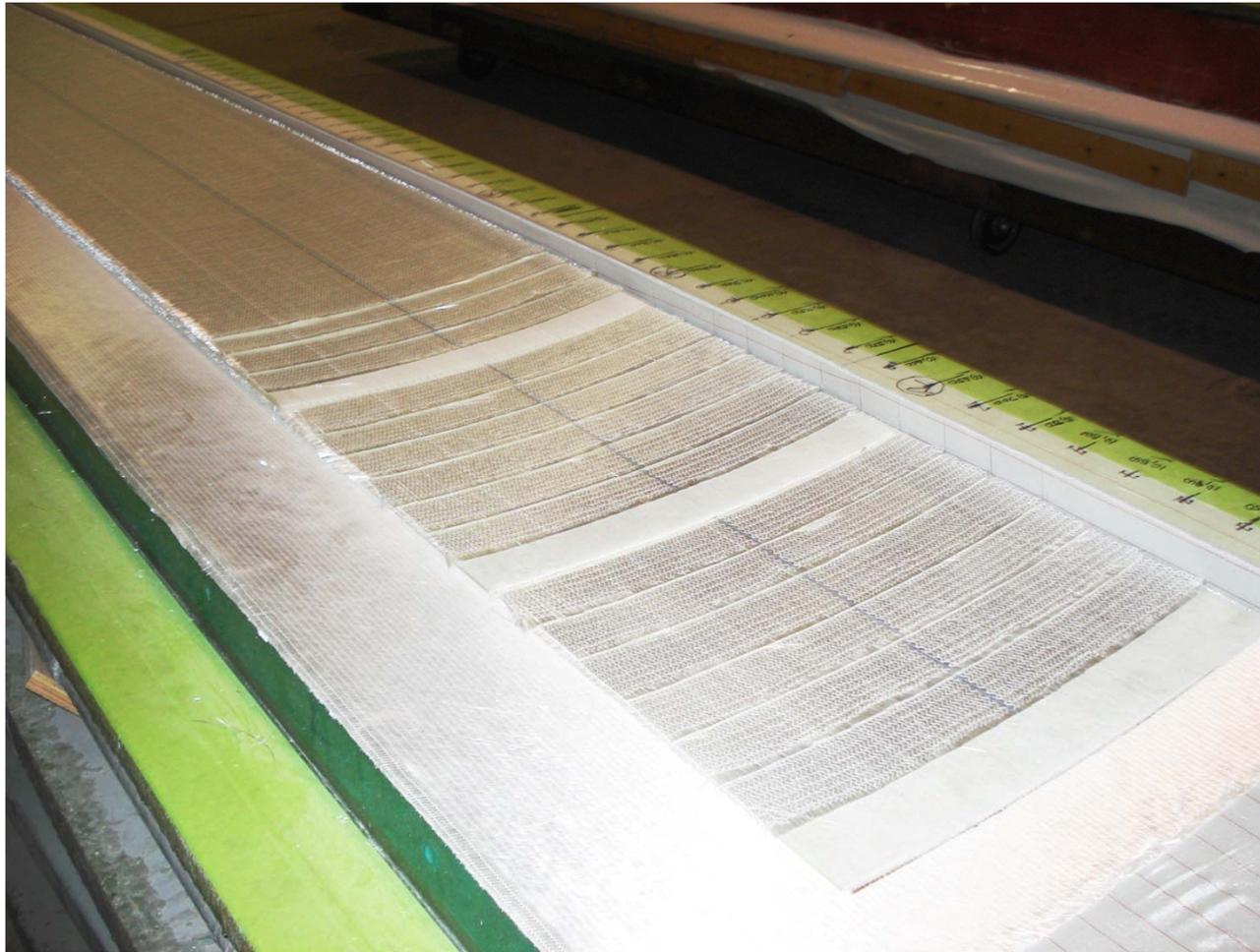
- 75:1 double taper, leading and trailing
- Cut to length, digital length readout



# Hybrid Lamination

- Interleaving RodPack and fabrics, i.e. unidirectional stitched glass
- Considered for:
  - Economics of the BOM
  - Means to combat large waves
  - Ease of introducing a new material
  - Tailoring properties, esp. transverse
  - Use existing fixed shear web tooling

# Hybrid RodPack-Fabric Lamination 1:6 Ply Ratio



# Three Opportunities for Cycle Time Reduction

- Mold Filling
- Infusion
- Cure

Economic Relativity Principle: Time = \$\$

# RodPack offers faster mold filling

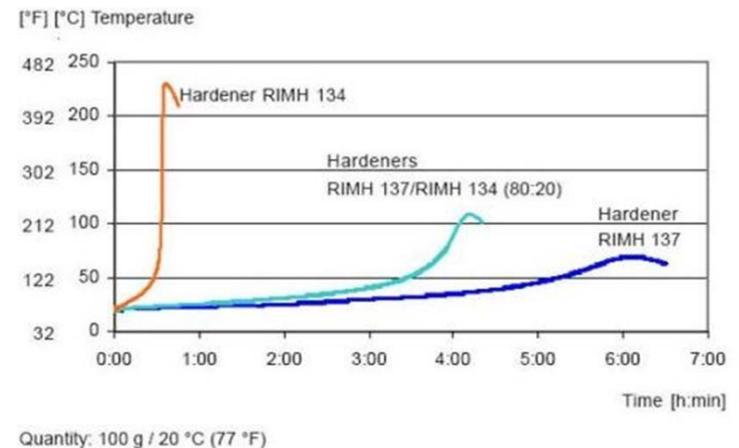
- **Fewer layers**
  - One RodPack layer can replace more than 2 previous layers
- **Less handling, automation friendly**
  - RodPack does not misalign when positioned into the mold, presents a firm edge to the mold
  - No need for tensioning, brushing, post tensioning, etc.
- **Our Challenge:**
  - Build an automated tapering letoff for 1 min/ply fills.

# RodPack Speeds Resin Infusion

- Engineered rod-rod gaps of 50-100  $\mu\text{m}$  offer increased z-axis permeability, shorter infusion times
- Shorter infusion time allows increased process latitude
- Shorter infusion time may allow a further infusion temperature increase

# RodPack reduces resin cure time

- Negligible exotherm with 100% RodPack
- Low and predictable exotherm with hybrid spar
  - lower curing energy
  - greater thermal mass
- Rods resist cure shrinkage
- Higher cure temperatures possible



# RodPack

- Is used alone, or in a hybrid layup with other reinforcement
- Improves spar cap properties
  - Eliminates waves in spar cap infusions
  - Offers superior translation of fiber properties to make a lighter blade
- Reduces cycle time 3 ways
  - Fill Mold
  - Infusion
  - Cure

**Thank You**

