INNOVATION: A NEVER ENDING JOURNEY
CHALLENGE EVERYTHING!

- How did I get here and who are we?
- Had to reinvent myself and what it means to be the leader of our company
- Surround yourself with people that share your values and vision
- Hold everyone accountable to goals
- Core values are critical
- Still learning and growing, never stop
What is a composite?

So many varieties

The future of building materials

Testing and design is key to best technology

Internal capability speeds innovation
INNOVATION RESOURCES

- Full state of the art composite weaving machinery
- Resin design and characterization laboratory for Epoxy and Polyurethanes
- Testing cyclical capability to determine long term performance and strain characterization (lifespan)
- NRI University to educate and push application ease
- A commitment to never settling and always pushing technology and questioning what is possible
- Manufacturing equipment designed and manufactured on Aerospace prepreg lines
- PEOPLE, Goals and Accountability
Multi axis weaving for fiber optimization quality control and consistency from lot to lot.

By controlling our fiber we control and understand the importance of sizing, binders and the value of different performance carbon and glass fibers.
- World Class Prepregging machines
- Manufacturing quality standards taken from the aerospace industry
- Repeatable performance in the field
- Core technology proven
- Efficiency of fiber improved
- Innovate where it make sense and take technology and improve upon it
CONFIDENCE IS KEY TO COMPOSITE ADOPTION AND FUTURE APPLICATIONS

- **Innovate**
  - R&D Lab
  - Test, test, test

- **Educate**
  - Engineers
  - Applicators

- **Support**
  - Training
  - Design
  - Delivery
THE ROAD TO OPTIMIZATION OF OUR APEX LINE

- Select a specific application and examine needs
- Select a fiber type
- Design a range of fiber orientations and layup designs
- Lab scale to screen for winners
- Take three options to large scale and determine optimized solution
- Full scale testing of winner
- Long term cyclic testing
- Review the results and present value
Tensile Testing
➢ Elongation to failure tended to increase with addition of chopped fiber (*preferable for long-term cyclic testing*)

Flexural Testing
➢ Failure mode of the 0 and 12 oz/yd² samples was primarily fiber breakage
➢ Failure mode of the 4 and 8 oz/yd² samples was primarily delamination (*preferred method of failure*)

ILSS Testing
➢ Not a significant difference with different percentages of reinforcement
FULL-SCALE PRESSURE TEST

Based on results and discoveries in coupon testing:

- Test group #1 (70:30) was eliminated entirely
- Test group #s 2.2, 2.3, 3.2, and 3.3 chosen to continue (80:20 and 90:10 with 4 and 8oz/yd² of CSM)
- Test group #3.1 (90:10 with no CSM) was also chosen but only to serve as a baseline comparison for the other test groups

Full-scale pressure test conducted on each sample and biaxial strain data collected

Pipe sample and defect created according to drawing using a 12.75-inch x 0.375-in, Grade X52 pipe

Strain gauges applied at marked areas
FULL-SCALE TEST RESULTS

- Comparing to identical test on a product by GTI in the 1990’s:
  - In burst testing, reduced strain in the defect region by 50% at pressures up to 2000 psi and as pressure increased this reduced strain by over 70%.
  - Also, when the pressure was returned to zero the strain went back to zero showing no permeant yielding in the defect zone.
  - In cyclic testing, reduced max strain in defect region by 50%.
    - Relatively constant strain range over long-term usage
Optimized system at the same thickness show substantial reduction in strain under repair vs. CS published data. NO residual strain damage to the underlying Steel as all strains return to zero.
INNOVATION: THE JOURNEY CONTINUES

- Pushing limits of resins
- Fillers and optimizers composite resins
- Optimizing carbon fiber utilization
- Robotic application
- Simplification of installation
- Growing people and making leaders