





## Temperature Measurement in Composite Production and Repair: Smart Thermocouples and Repair Thermal Management

Vlad Fedorchak – TEW&C

April 18, 2018

TE Wire & Cable CONFIDENTIAL

# Agenda




- **TE Wire & Cable Introduction**
- **Composites Overview**
- **Solutions to Measurement Problems:**
  - AccuClave®
  - Smart Thermocouples
  - AccuFlex™
  - Smart Temperature Sensor Systems
- **Questions**

# TE Wire Introduction



**TE Wire & Cable, LLC**  
107 North 5th Street  
Saddle Brook, NJ 07663  
201-845-9400  
[www.tewire.com](http://www.tewire.com)



- TE Wire & Cable LLC, a specialized Manufacturer of Thermocouple W&C for 77 years
- Headquarters and Manufacturing in suburbs of Saddle Brook, NJ
-  became sister company of TEW&C in 2015
- ISO 9001:2015 certified
- ISO 17025 certified temperature lab
- RoHS and REACH export compliant
- A member of the Marmon Group of companies a division of Berkshire Hathaway

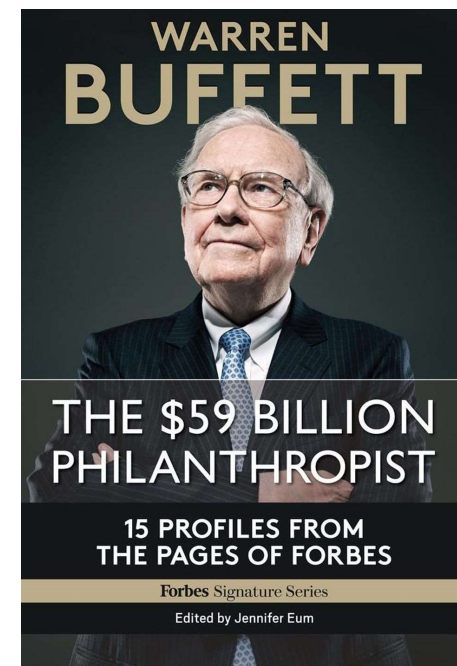
# TE Wire Introduction



- TE Wire & Cable is a member of The Marmon Group, A Berkshire Hathaway Company.
- Acquired by Berkshire Hathaway in 2008
- Berkshire Revenue exceeds \$241 Billion in 2017
- Berkshire Hathaway is ranked as the 3<sup>rd</sup> leading public company in the Global 2000 Forbes list with Market Cap of \$493.41 Billion as of April 2018



Marmon Wire & Cable LLC



# TE Wire Introduction – *Marmon EWC*



## Marmon Engineered Components Company – Engineered Wire & Cable Group

Power/Utility	Applied Sensor Solutions	Military/ Aerospace	Energy/ Industrial	Supply/Support

# TE Wire Introduction – *Primary Industries Served*



- Aerospace Composites
- Heat Treat / Metals
- Sensor Manufacturers
- Industrial
- Power Generation
- Plastics / Hot runner

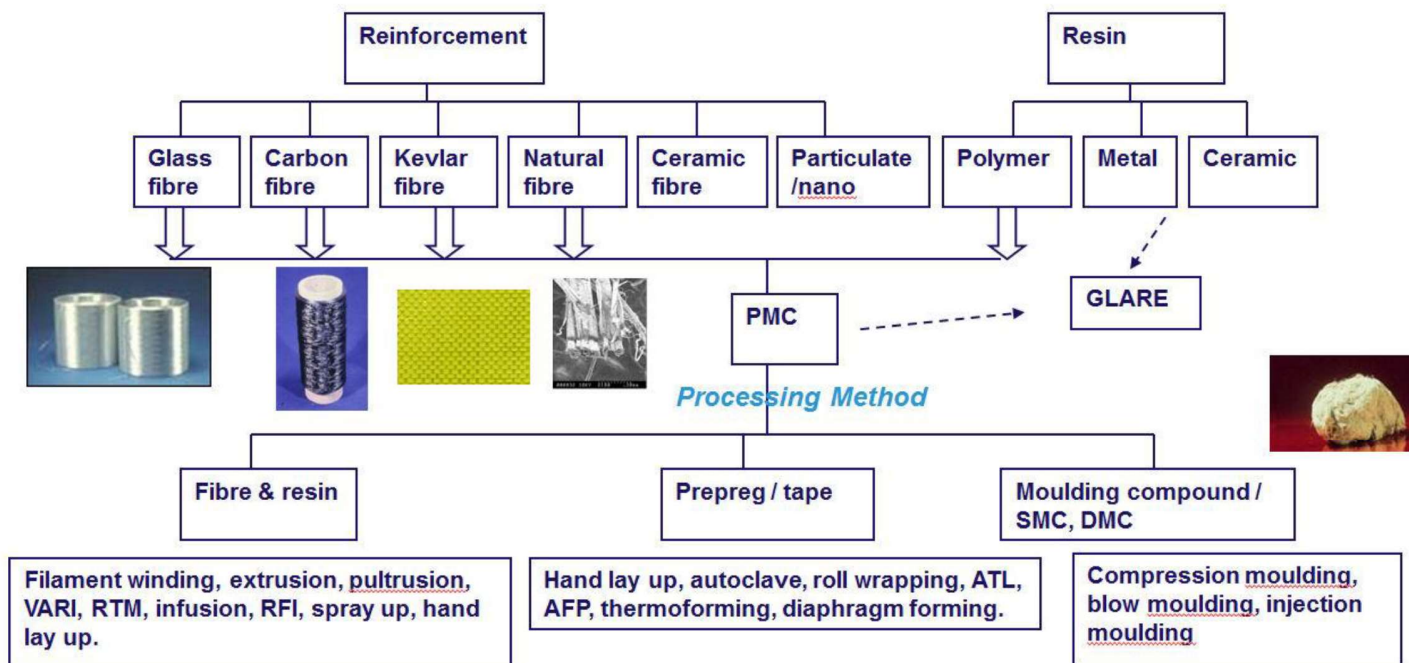




# Composites Overview

## ■ What are composites?

- A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components.





# Composites Overview



- **Why composites?**
  - **Composites have excellent strength and stiffness**
  - **Lightweight**
  - **High Strength to Weight ratio**
  - **Corrosion resistant**
  - **Ultimate designer material – complex one piece parts possible**
  
- **All of this doesn't come without challenges!**
  - **High Cost of development and production**
    - Expensive Capital Equipment often bottleneck in ramp up of production
    - High temperature (up to 370C) and pressure (up to 200psi)
  - **Lack of understanding on damage tolerance and fatigue resistance outside of prime manufacturers**
  - **NDT requirements**
  - **Know-how in production and repair techniques**

# Solutions to Measurement Problems



When Failure is Not an Option ...

Exclusive **TRAC** online traceability!

## AccuClave® Thermocouple Systems for Composite Cures

<p><b>Problem:</b> Lost parts due to bad thermocouples (TC)</p> <p><b>Solution:</b> <b>AccuClave® Pre-made Assemblies</b></p> <ul style="list-style-type: none"> <li>• 0% failures</li> </ul>	<p><b>Problem:</b> Erratic temperature readings caused by refurbished extensions</p> <p><b>Solution:</b> <b>AccuClave-X® Reusable Thermocouple Extensions</b></p> <ul style="list-style-type: none"> <li>• Optimized thermocouple system savings</li> </ul>	<p><b>Problem:</b> Lost time connecting thermocouples to jack panels</p> <p><b>Solution:</b> <b>AccuConnect™ Multi-circuit Extension Harnesses</b></p> <ul style="list-style-type: none"> <li>• Reduces clave loading time by up to 90%!</li> </ul>	<p><b>Problem:</b> Deep mark-off indentations in composite surfaces</p> <p><b>Solution:</b> <b>AccuFlex™ Low-profile, Flat TC Assemblies</b></p> <ul style="list-style-type: none"> <li>• Used for MRO composite repairs</li> </ul>
<p><b>Zero Failure</b></p> <ul style="list-style-type: none"> <li>• Lead/lag thermocouples</li> <li>• Tool/part thermocouples</li> <li>• Leak proof</li> <li>• Reusable</li> <li>• Molded plug</li> </ul>	<p><b>Cost Savings</b></p> <ul style="list-style-type: none"> <li>• Reusable interconnect</li> <li>• Rugged</li> <li>• Faster clave loading</li> <li>• 200+ cure design life</li> </ul>	<p><b>Reduced Setup Time</b></p> <ul style="list-style-type: none"> <li>• Multi-circuit harness</li> <li>• Load/unload faster</li> <li>• Reusable</li> <li>• 200+ cure design life</li> <li>• Saves autoclave idle time</li> </ul>	<p><b>Minimal Mark-Off</b></p> <ul style="list-style-type: none"> <li>• Composite repair thermocouples</li> <li>• Flat (less than 0.012")</li> <li>• Leak proof</li> <li>• Easy bag seal</li> <li>• Low profile</li> </ul>



**TEW&C** TE Wire & Cable LLC 107 North Fifth Street, Saddle Brook, NJ, USA

Selecting autoclave thermocouples just got easier!

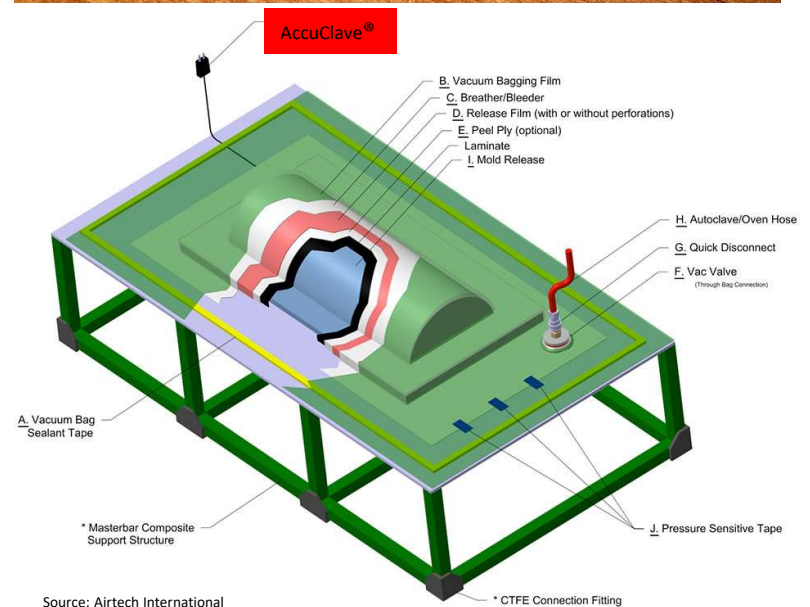
Get your **FREE** interactive line cards!



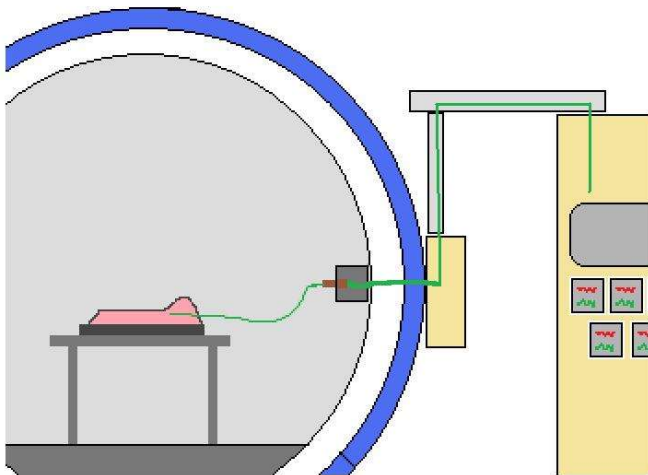
# Solutions to Measurement Problems – *AccuClave*®



- **Applications:** Aerospace composites, autoclaves
- **Available:** J type or K type thermocouple calibration, custom lengths
- Reduce/Eliminate vacuum leaks
- No stripping insulation at vacuum seal
- No loose connections with pins
- No reversed polarity
- No connector covers/screws popping off (**FOD risk**)
- Reduced non-conformity reporting and QC red tags
- Accepted during NADCAP audits
- **TRAC** – Easiest traceability in the industry!
- **All AccuClave products come from a 3000FT max certified spool @ 0, 121, 260°C per BAC5621**
- **100% tested for quality**



# AccuClave in Production - *Horizontal Stabilizer*



Simple view of an autoclave and part

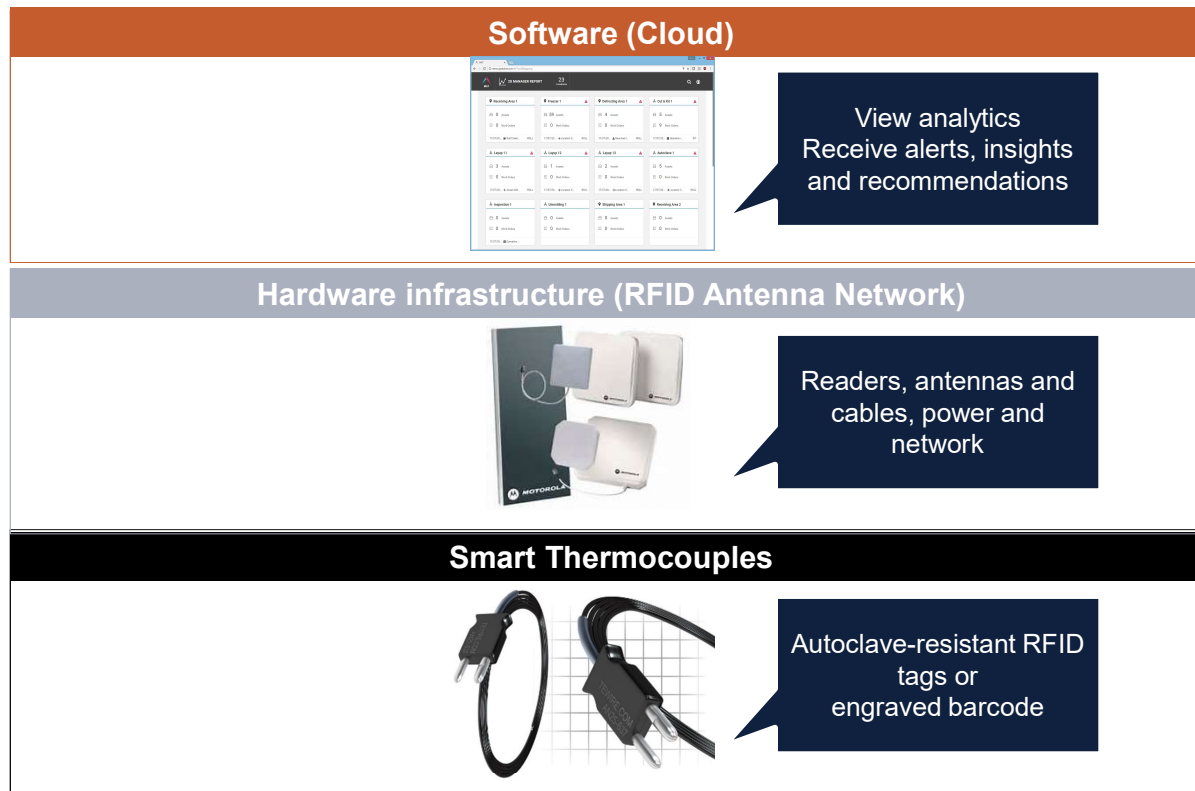


## Solutions to Measurement Problems - *Smart Thermocouples*



- **Material and Asset Tracking (RFID) – high temperature**
  - Currently customers manually track the date of first use or the number of uses for:
    - Thermocouples
    - Tools
    - Frames/carts
  
- **TE Wire and Software partner are working on an innovative Smart Thermocouples Solution enabling manufacturers to extract additional value from their thermocouples and enter the era of Industry 4.0**
  - Track location and duty cycles
  - Run analytics and get insights
  - Improve efficiency and quality
  - Optimize thermocouples refurbishment & retirement

# Solution Architecture





# Use Case 1: Location Tracking

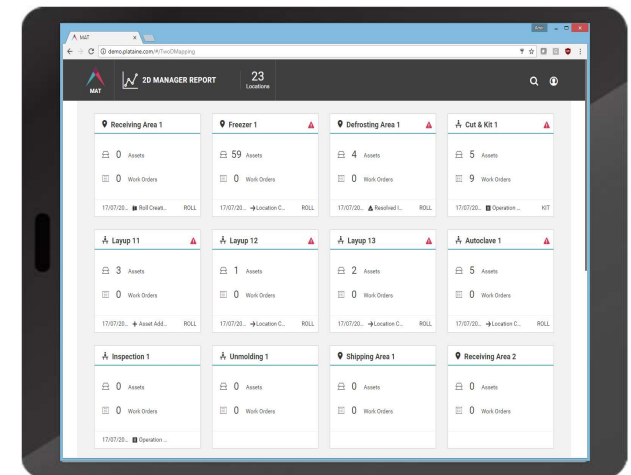


## ■ Key features

- Track thermocouple movement as it moves from station to station
- View thermocouples on site map using a web browser

## ■ Benefits

- Save time spend on inventory management
- Avoid production delays due to missing thermocouples
- Automate replenishment of thermocouples
- Reduce thermocouples loss/misplacement
- Improved site(s) visibility



*View thermocouples on site map using a web browser*



## Use Case 2: Thermocouples Utilization

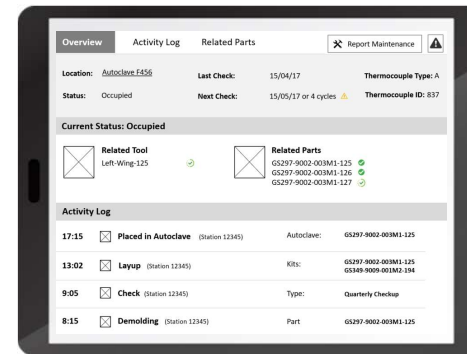


### ■ Key features

- Monitor thermocouples' autoclave duty-cycles
- Present thermocouple history
- Trigger (visual/audio) alerts for thermocouple refurbishment, calibration or 'end of life' based on prior runs/failures
- Access to calibration history for NADCAP

### ■ Benefits

- Improved quality compliance
- Digital traceability and audit readiness
- Reduce risk of overusing thermocouples or reusing failed thermocouple
- Extend thermocouples usage and utilization (within permitted spec)



*View thermocouple utilization page and plan ahead*



*Alert for thermocouple refurbishment, calibration or 'end of life'*

## Use Case 3: Scale Up, Tracking Additional Assets Throughout the Supply Chain



### ■ Key features

- Track raw material, WIP, and finished parts
- Manage sensitive materials' shelf life and get related alerts
- Maintain the Digital Thread, inheriting properties from raw materials to parts, as well as pairing of thermocouples to molds and parts
- Monitor mold autoclave duty-cycles
- Audit-ready data of all activities and assets

### ■ Benefits

- Improved quality compliance
- Digital traceability and audit readiness
- Reduce risk of using expired material or overused molds

# Composites Repair



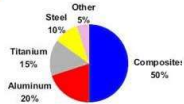
- Increased use of composites implies composite repair is needed

- Prominent Damage areas:

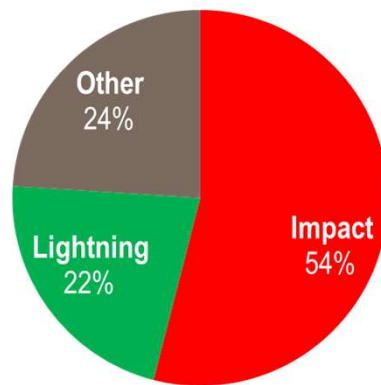
- Fuselage & wing



- Carbon laminate
- Carbon sandwich
- Fiberglass
- Aluminum
- Aluminum/steel/titanium pylons

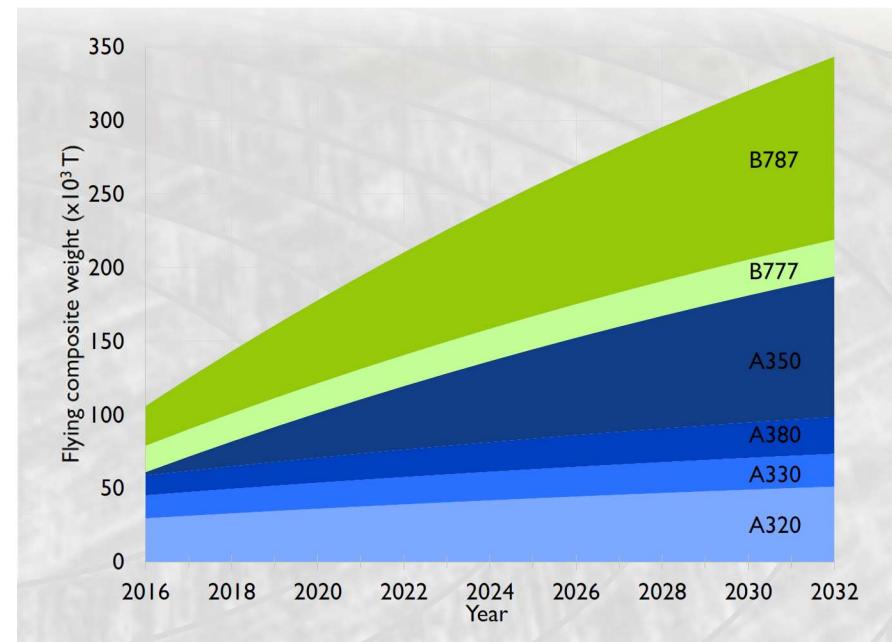


Boeing 787 – 50% Composites



- Alu alloy
- Carbon
- Monolithic
- Carbon Sandwich
- Quartz, Glass

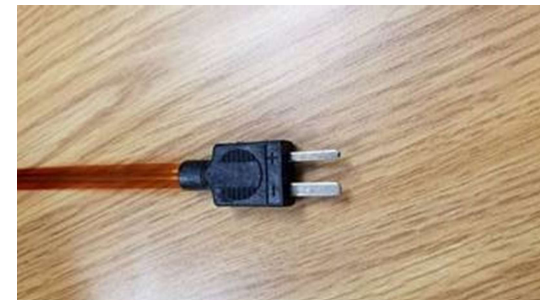
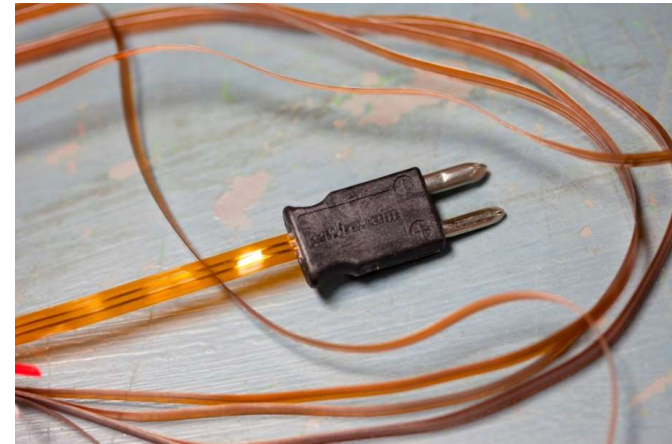
Airbus A350 – up to 53% Composites



# Solutions to Measurement Problems – *AccuFlex™*



- **Applications:** Field repair of damaged composites assemblies (aerospace, aircraft, automotive). Autoclave applications requiring a quick and easy seal between vacuum bag, fuel tank, and instrumentation. Applications where thermocouple measurements require fitting through narrow spaces and openings yet require the low resistance advantage of larger gauge wire.
- Low profile makes creating a seal between vacuum bag and instrumentation quick and easy.
- Minimal mark-off – 4× thinner than equivalent 28 gauge round cable.
- Ready to use assemblies save setup time, reduce downtime.



# Questions?

