

Grove Maniwoc National Crane Potain

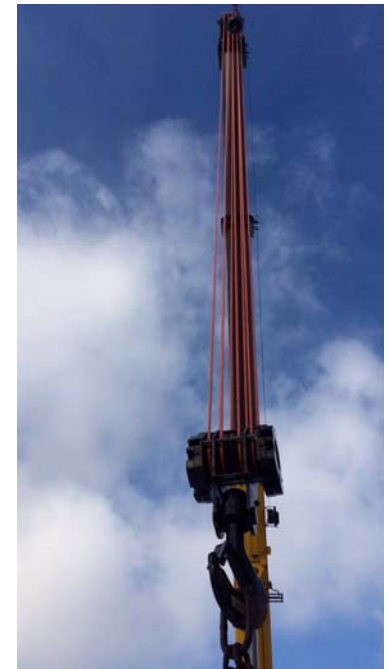


# Innovative Lifting Experience with synthetic fiber technology

Sammy Munuswamy PhD, PEM  
Sr Manager Global Engineering & Innovation  
February 25, 2015

## **“Nothing New Under the Sun” Fiber Rope is not new!**

- 3.8 Billion years of Mother Nature’s Innovation for the happiness of mankind
- Fiber Rope 10,000s of years old
- “Fiber below the hook” in use more than 30yrs
  - Polyester and HMPE round slings
  - Nylon web slings & Braided rope slings
- **“Fiber above the hook”** is Synthetic Rope KZ100



# Overview

## Manitowoc Lifting Experience with fiber



Grove Manitowoc National Crane Potain



# Innovation

Innovation is.....

PEOPLE creating EXPERIENCE through CONNECTION  
and IMPLEMENTATION of ideas for disrupting the  
status quo and staying AHEAD.

- Sammy Munuswamy

# Agenda

- **Why** synthetic fiber technology for cranes?
- **How** fiber rope meets industry needs?
- **How** it was tested and validated?
- **How** did we develop the technology?
- **How** we redefine the value proposition?
- **What** is KZ100?
- Outlook

## Why synthetic fiber technology for cranes ?

- Industry trend & need: superior lifting experience
  - Lighter, portable and user-friendly equipment
  - Fun and rewarding crane operation
  - Increased lift capacity with same footprint
  - Improved jobsite efficiency with ROI
  - Easy handling and meeting transportation regulation
- Lightweight & user-friendly equipment is not an option, but **necessity to remain competitive** and meet industry needs

Why fiber rope?  
Puts smile on Operator's face



Why fiber rope? .....contd:  
Fun & rewarding working experience

Placeholder for  
video

Quick, easy  
installation from  
ground level



Why fiber rope? .....contd:  
Obsoletes jobsite complacency

Placeholder for  
video

Torque neutral  
eliminates load spin  
& cabling

## How fiber rope meets industry needs?

- Key factors considered:
  - Modulus, breaking strength, creep, UV & abrasion resistance, Bending fatigue & cost
- High performance fibers
  - HMPE (Dyneema<sup>®</sup>)
  - LCP- Liquid Crystal Polymer (Vectran<sup>®</sup>)
  - Aramid (Kevlar<sup>®</sup>, Technora<sup>®</sup>, Twaron<sup>®</sup>)
  - PBO- Poly-Paraphenylene-2 6-Benzobisoxazole (Zylon<sup>®</sup>)



## How it meets?.....contd: Fiber comparison chart

Fiber	Specific Gravity	Tenacity (gpd)	Elongation at Break (%)
Nylon	1.14	7.5 – 10.5	15 – 28%
Polyester	1.38	7.0 – 10.0	12 – 18%
Aramid	1.39 – 1.47	18 – 29	1.5 – 4.6%
<b>HMPE</b>	<b>0.97</b>	<b>32 – 44*</b>	<b>2.8 – 3.9%</b>
LCP	1.40	23 – 29	3.3 – 3.6%

- Specific Gravity: Ratio of yarn density to that of water
- Tenacity: Ratio of yarn strength per weight; tested per ASTM D885
- Elongation at Break: Percent of length change; tested per ASTM D885

## How it meets?.....contd: Example: RT770E Model Crane

- Direct replacement for steel wire rope
  - Same hoisting system (sheave, drum, hook block)
  - 22mm replaces 19mm diameter wire rope
  - Break Strength 38.1 mT (per ISO 2307)
  - Max line pull at 5:1 Safety Factor
  - Elongation – 1.2% at max line pull
  - 12-strand torque neutral construction
  - 83% lighter weight
    - 22mm KZ™100 – 32 kg/100m
    - 19mm wire – 193 kg/100m
    - Weight Saving on 364m = 586kg = 1292lbs



## How it meets ?.....contd: Chemical considerations

Chemical	Chemical Resistance (EFFECT ON FIBER TENSILE STRENGTH)
Acetic Acid	++
Acetone	++
Calcium Hydroxide	++*
Common Detergent	++
Ethanol	++
Hydrochloric Acid	++
Nitric Acid	++
Oil	++
Sodium Hydroxide	++*
Sulfuric Acid	++
Toluene	++
Water	++

\* Tensile strength is significantly reduced (to --) as time and temperature are increased

- Highly chemically inert
- Not affected by common acids, bases, or oils

## How it meets?.....contd: Inspection

- Similar inspection events as with wire ropes
  - **Daily visual** inspection (prior to shift)  
Focusing on high bend zone areas, flange contact points, crossover points and repetitive pickup points
  - **Monthly Periodic full line** inspection  
focusing on gross abrasion/damage level, broken core, glazing or melted fiber, chemical discoloration
- Maintain inspection log & record findings



## How it meets?.....contd: Retirement Criteria



- Abrasion measurement - visual comparison guide
- Retirement or required action based on the following:
  - Internal/External **abrasion** level (higher than 4)
  - Gross damage or deterioration of the end connections

## How it meets? ....contd: Retirement Criteria

**CUT STRANDS** Any cut strands should be reported to a qualified person



**COMPRESSION** Visible sheen, stiffness reduced by flexing the rope, not to be confused with melting, often seen on winch drums



**PULLED STRAND** Strand pulled away from the rest of the rope, is not cut or otherwise damaged



**MELTED OR GLAZED FIBER** Fused fibers, visibly charred and melted fibers, yarns, and/or strands, extreme stiffness, unchanged by flexing



**DISCOLORATION/DEGRADATION** Fused fibers, brittle fibers, stiffness



**INCONSISTENT DIAMETER** Flat areas, lumps or bumps



**ABRASION** Broken filaments and yarns





## How it was tested and validated? Efficacy & Reliability

- Spooling
- Crane calibration
- Tensile break
- Tension fatigue testing
- Cyclic bend over sheave(CBOS)
- Elevated temperature
- Accelerated UV exposure
- Accelerated life cycle simulation
- KZ™ 100 vs. Wire Rope life cycle
- Residual strength testing
- End-users: Operator/Rigger at Plant & field environments
- Test data on cranes & at labs:
  - Testing hrs = 5,105
  - Test cycles = 94,892
  - Length of ropes 31,680 ft (6miles)

## How it was tested?.....contd: Fatigue, Reliability and Life Cycle data

- Fatigue, Reliability and life cycle testing (Jan,5) = 93,215 cycles
  - Tension Fatigue = 50,000 cycles
  - Reliability = 36,508 cycles
  - Life cycle comparison = 6,707 cycles



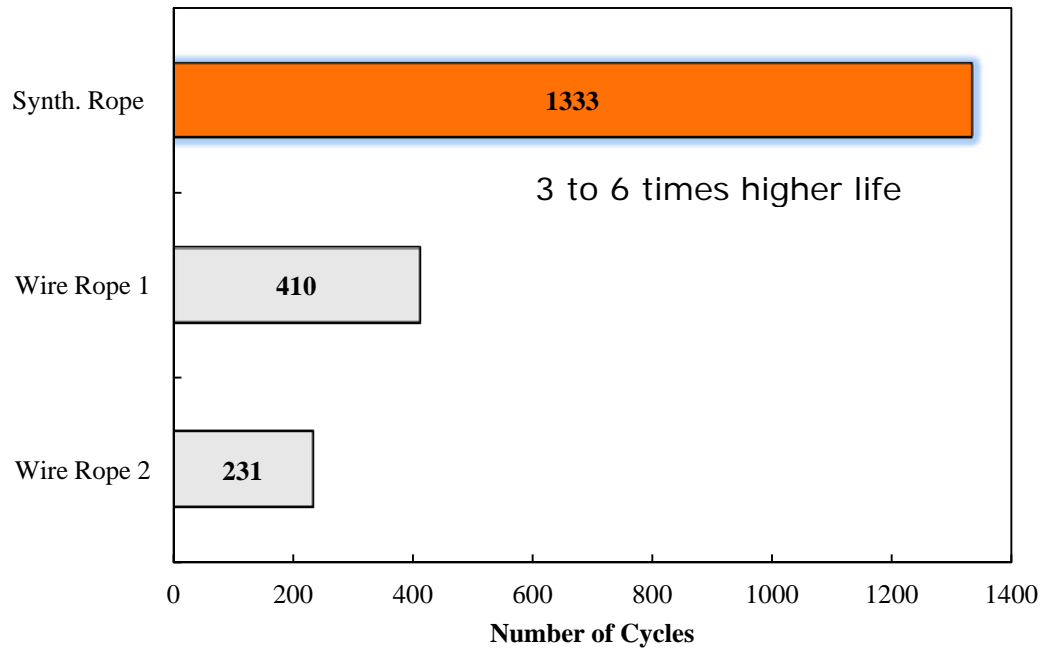
## Manitowoc Testing Facility Product Verification Center (PVC)

18,000 sq ft facility with 7 acres of test area for full crane testing.

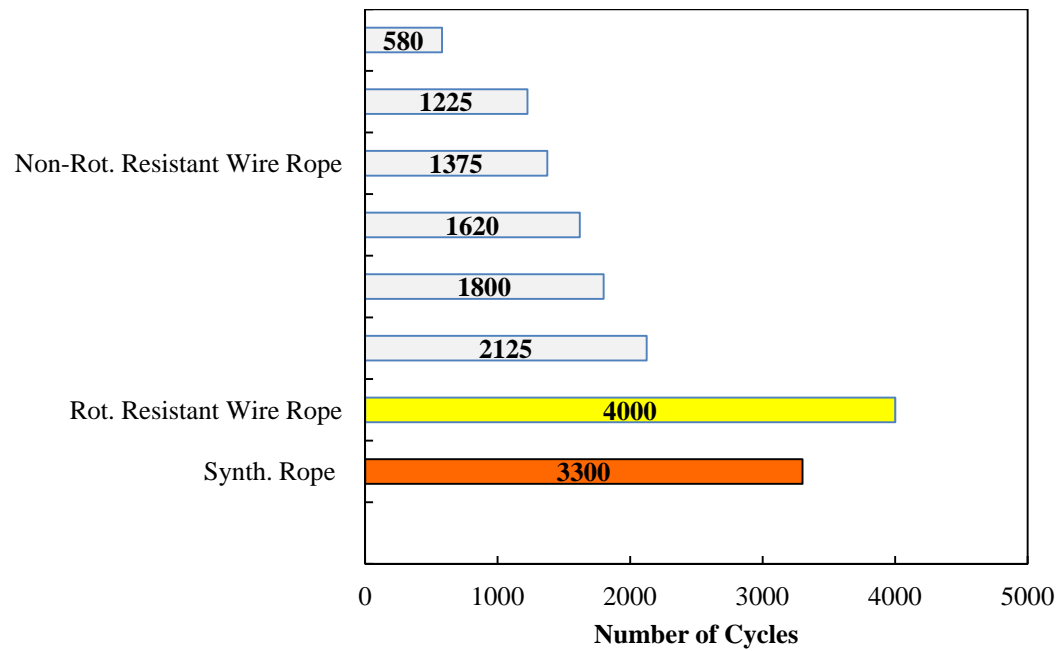
Strategy: Develop upfront verification activities to evaluate product design and supplier components.



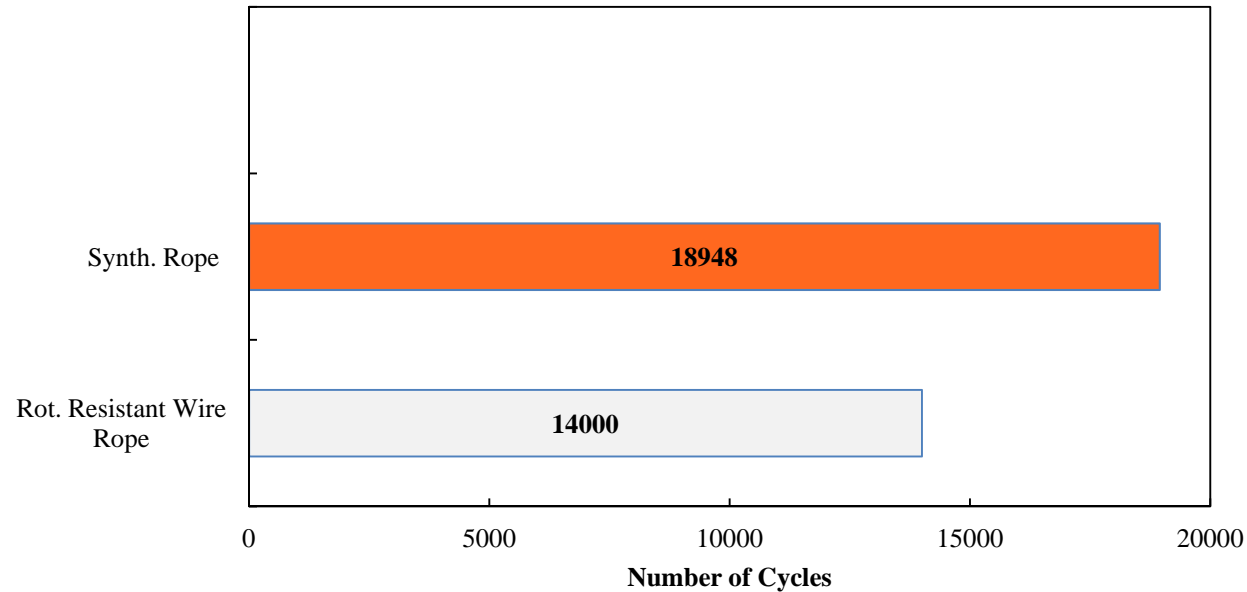
## PVC Lifecycle Testing: KZ100 Vs Non-Rotation Resistant Wire Rope



# PVC Lifecycle Testing: Synthetic Rope Vs. Wire Rope



## PVC Reliability Simulation Testing: Synthetic Rope Vs. Wire Rope



## How it was tested?.....contd: Pre-production partner (PPP) strategy

### **1,677 total lifts at plant & field (January 2015)**

- RT9130 at All Cranes different job sites
- RT9130 at Shipbuilding (Newport News, VA)
- RT770E at H&E (Grove Equipment, TX)
- RT770E at H&E (Phoenix, AZ)
- RT540 at US Navy, (Pearl Harbor-Hickam, Hawaii)
- YB Industrial Cranes at SEI, PA
- RT765 at Shady Grove, PA (Manitowoc Facility)
- RT540 at Niella, Italy (Manitowoc Facility)





## How did we develop the technology? Co-Creation with Innovation Partners

- Building Innovation Ecosystem and Co-Creating lifting experience
- More than R&D, **Connect & Develop (C&D)** is the key for the success of the project:
  - Manitowoc – crane technology
  - Samson – rope and coating technology
  - DSM Dyneema® – fiber technology
  - Kuraray – fiber technology
  - Customers as Pre-Production Partners (PPP) – lifting technology
  - 5+ years of development, testing, verification and validation
- Design thinking approach for developing and implementing specific rope for dynamic loading and hoisting application





## How we redefine the value proposition?

- Improves jobsite efficiency and reduces the total cost of ownership as follows:
  - Reduced maintenance cost gets ROI less than 1yr
  - 80% lighter weight helps easy handling and faster reeving improves jobsite efficiency
  - No grease, Clean, no broken wires, smooth to skin and fun to work make operators happy
  - Reduction of rope replacement due to common damage such as load spin, cabling, bird caging, kinking and diving
  - Good for cold weather package due to 10% increase in strength at  $-50^{\circ}\text{C}$  ( $-58^{\circ}\text{F}$ )

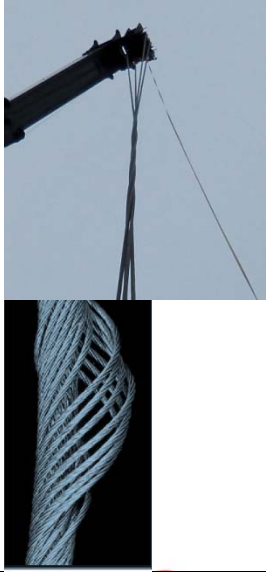


“Customer don’t know what they need until you show different experience”

## Redefining Value -Synthetic Rope: Finding Understanding in Misunderstanding

Misunderstanding	Understanding
<ul style="list-style-type: none"><li>• Lack of strength</li><li>• Degradation in cold weather</li><li>• Bad spooling</li><li>• New technology</li><li>• High elasticity and stretch</li></ul>	<ul style="list-style-type: none"><li>• Strength is comparable to wire rope</li><li>• Stronger in cold weather</li><li>• Robust spooling</li><li>• 1000s of years old, Fiber Sling is used under the hook</li><li>• Stretch is comparable to wire rope</li></ul>

## Redefining Value - Wire Rope: Finding Understanding in Misunderstanding

Misunderstanding	Understanding
<ul style="list-style-type: none"> <li>• Good spooling all the time</li> <li>• Tested thoroughly</li> <li>• Rotation resistant</li> <li>• Easy to handle</li> <li>• Impervious to "rugged" use</li> <li>• Maintenance free</li> </ul>	<ul style="list-style-type: none"> <li>• Sensitive to tension &amp; requires attention</li> <li>• Limited lab data</li> <li>• Spins / Rotates</li> <li>• Need extra equipment &amp; space</li> <li>• cabling, bird caging, kinking, popped core or wire</li> <li>• Need grease &amp; dry</li> </ul> <div style="text-align: right;">  </div>

## What is KZ100?

KZ100 is a Synthetic Rope made from a combination of high performance fibers braided in a torque neutral construction.

It is designed to offer a fun and rewarding lifting experience with similar strength at 1/7<sup>th</sup> weight, improved bending fatigue durability, and robust spooling capabilities compared to steel wire rope.



Grove Maniwoc National Crane Potain



## Outlook

- KZ100 Rope deeply connects people with equipment and provides fun and rewarding **lifting experience**.
- Cranes with KZ100 improve **jobsite efficiency and ROI**.
- Manitowoc and Samson designed and validated a lifting experience with Synthetic fiber technology
- Co-creation and collaboration through innovation ecosystem speed up creating superior customer experience at reduced cost.

# Discussion

