

#### IMPROVING SAFETY IN WIRE ROPE INSPECTION BY UNDERSTANDING MODES OF DETERIORATION

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#### About TEUFELBERGER-REDAELLI

Improving safety in wire rope inspection by understanding modes of deterioration



### TEUFELBERGER STANDS FOR



- Global leadership in yachting cordage and industrial fiber ropes
- Worldwide success with high performance steel wire ropes in harbors, on oil platforms mountains and bridges
- The world's largest system-independent manufacturer of PP and PET strapping



FACTS AND FIGURES 2017



1300 employees / 12 locations / 5 % of all employees in R&D / 100 % family owned



#### EXPERTISE FROM 225 YEARS OF EXPERIENCE





#### **TEUFELBERGER PORTFOLIO**











#### **CRANE ROPES**

High performance steel wire ropes for cranes in the construction industry, in harbors, aboard ships, and on offshore drilling platforms

#### ROPES FOR ROPEWAYS

- Passenger and cargo ropeways
- Slope groomer winches
- Underground mining







#### TENSOSTRUCTURES

High performance wire ropes for bridges, stadiums, and observation wheels like the London Eye

#### TECI/ROPE AND SAFETY

- Distribution in Austria and Italy
- Equipment for lifting, conveying and securing







- OIL & GAS: offshore-cranes, marine riser tensioner, drilling rigs
- HARBOUR: container cranes, harbour mobile cranes, RTG, RMG, Van Carrier
- CONSTRUCTION: special deep foundation, mobile & crawler cranes
- INDUSTRIAL: gantry and bridge cranes



#### **ROPEWAY UND MINING**



- PASSENGER- AND MATERIAL ROPEWAYS: Multicable, jig-back ropeways, funicular, cabelways, rescue equipment
- UNDERGROUND- MINING: guide ropes, hoistropes, balance ropes, shaft sinking ropes
- SLOPE GROOMERS: slope groomers, drum and spill winch systems
- INSTALLATION AND SERVICE







#### PLASTFILL®

 Lubricated steel insert is extruded with compact plastic cover

#### SUPERFILL®

 Compactions of each rope strand, using a special procedure

DUOFILL®

Double compaction – strands and rope



#### WE CARE MORE – OUR R & D





#### TEST RIGS

 Bending fatigue testing machines, crane rope test rigs, test rope way, vibration measurements

#### LABORATORY

 Metallographic lab, computer aided engineering

#### APPLICATION KNOW HOW

- Customer specific solutions e.g. fitting; CAD-designs & tests
- Life time calculations
- Customer focus



### WE CARE MORE-SERVICE







- Installation
- Assembled according to customer specifications
- Calculations
- Training for customers and partners
- Inspections personal protection against fall (PPE)
- Hotline 24 hours/ 365 days/year



#### CERTIFICATES



Together in Motion

### EXCELLENCE THROUGH LIFELONG LEARNING



- We invest about 1 % of personnel costs in offering opportunities for further education and training to our staff.
- Year after year, almost 85 % of our employees take part in our educational and training programs.
- TEUFELBERGER Academy
  - Foundations for shaping the future
  - Lifelong employability
  - Professional and personal development
  - Mental and physical fitness



#### INNOVATION AT TEUFELBERGER



"Every implemented idea of perceived economic benefit to our customers and our organization through the active involvement of all employees."

- More than 50 well trained staff in Research & Development
- Customer-focused application engineers
- Close-knit partnerships with industrial partners, universities, and research institutions
- Unique testing and development facilities (laboratory, technical center, test applications)



#### ACTING SUSTAINABLY



- TEUFELBERGER products consist of environmentally friendly materials
- TYCOON® PET strapping is made of PET bottles
- TEUFELBERGER products are recyclable
- Safety and health management certified to OHSAS 18001



### THE BASIS OF OUR SUCCESS





- Local presence at the customer location for optimum service offerings
- Concentration on core markets to achieve a high level of expertise
- Innovations for enhanced performance and cost effectiveness
- Targeted investments in quality and growth
- Independent family owned enterprise



### A STRONG PARTNER ALL AROUND THE WORLD







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### WHY DO WIRE ROPES FAIL?



- Forced fracture due to overload
  - Applied load exceeds the sustainable load
- Fatigue fracture due to non-detection of discard criteria
  - Ropes are wear parts and they have a finite lifetime dependent on their usage
  - Rope failure will in all probability occur at a given point in time.
  - Deterioration in use reduces the sustainable loads
  - Premature rope replacement is required to prevent rope failure



### TIME BASED MAINTENANCE

- Standard Bathtub Curve as per literature introduced in the 1960's for aviation
  - Maintenance decision follows failure data analyses



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Source: Ahmad, Kamaruddin, An overview of time-based and condition-based maintenance in industrial application, Computers & Industrial Engineering, Volume 63, Issue 1, 2012, Pages 135-149, ISSN 0360-8352,

### TIME BASED MAINTENANCE

- Asymmetric Wire Rope Bathtub Curve
  - Wear out failure rate is depending on utilization
  - Still maintenance decision follows failure data analyses





Adapted from: Ahmad, Kamaruddin, An overview of time-based and condition-based maintenance in industrial application, Computers & Industrial Engineering, Volume 63, Issue 1, 2012, Pages 135-149, ISSN 0360-8352,

## TIME BASED MAINTENANCE

- Asymmetric Wire Rope Bathtub Curve
  - Random failures are unpredictable and dependent on external influences





Adapted from: Ahmad, Kamaruddin, An overview of time-based and condition-based maintenance in industrial application, Computers & Industrial Engineering, Volume 63, Issue 1, 2012, Pages 135-149, ISSN 0360-8352,

#### RANDOM FAILURES – EXAMPLE I

• Rope jumped off the sheave





#### **RANDOM FAILURES - EXAMPLES II**





In most cases time-based maintenance is pointless



## CONDITION BASED MAINTENANCE



- Inspection intervals shall be <u>under any circumstances</u> smaller than the P-F interval to detect a failure before it occurs
- Inspection intervals shall be smaller than the P-D interval to discard the rope in time.
- D-F interval is mainly dependent on the rope. (e.g. Design, Quality, etc.)



Adapted from: Ahmad, Kamaruddin, An overview of time-based and condition-based maintenance in industrial application, Computers & Industrial Engineering, Volume 63, Issue 1, 2012, Pages 135-149, ISSN 0360-8352,

## CONDITION BASED MAINTENANCE – EXAMPLE I



- Boom Hoist Rope Offshore Crane
  - After rope replacement, safety wraps are not properly tensioned.
  - Rope has a lower radial stiffness in those sections because of lack of tension
  - Peening and strand deformation occurs at cross over points => POINT P
  - Visible Wire breaks ⇒ POINT D
    ISO 4309 RCN 09: 18 visible broken wires over a length of 6d for sections of rope spooling on a multi-layer drum signaling discard
  - Loss of load bearing wires lead to rope failure
    ⇒ POINT F
- Understanding modes of deterioration is crucial for Condition Based Maintenance



## CONDITION BASED MAINTENANCE – EXAMPLE II



- Boom Hoist Rope Offshore Crane
  - After rope replacement, actual groove radii are too tight for the new rope
  - Rope gets a diameter reduction unless strand-to-strand contact occurs
  - Fretting corrosion (red debris) is visible in strand valleys ⇒ POINT P
  - Valley wire breaks are visible ⇒ POINT D ISO 4309: "Two or more wire breaks in a rope lay length" give rise to discard
  - Loss of load bearing wires would lead to rope failure ⇒ POINT F
- Understanding modes of deterioration is crucial for Condition Based Maintenance



## **INSPECTION & MAINTENANCE PROCEDURES**

## CRANE OPERATIONS & MAINTENANCE MANUAL





#### EN 12385-3

Edition: 2008-09-01

Steel wire ropes - Safety

Part 3: Information for use and maintenance

## INTERNATIONAL STANDARD

ISO 4309

Fifth edition 2017-11

Guidance on

Wire Rope Integrity

Management for Vessels in the Offshore Industry



Teufelberger · Re

Together in Motion



## Cranes — Wire ropes — Care and maintenance, inspection and discard

Appareils de levage à charge suspendue — Câbles en acier — Entretien et maintenance, inspection et dépose

#### API Recommended Practice 9B

Application, Care, and Use of Wire Rope for Oil Field Service



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### BOOM HOIST WIRE ROPE LINE FAILURE RESULTS IN FATALITY – AUGUST 2011 - GOM



Cause:

- The Crane's boom hoist wire rope parted due to being weakened by internal and external corrosion, with loss of integrity, ductility and strength.
- Probable Contributing Causes
  - The crane's corroded and damaged boom hoist wire rope was found to be systemically lacking lubrication.
  - The annual inspection of the crane by a third party contractor did not include a comprehensive examination of the boom hoist wire rope.

## There is an unexplained and perplexing reluctance to use proper wire rope safety procedures



Source: OCS Report BSEE 2013-01, Boom Hoist Wire Rope Line Failure Results in Fatality, High Island Area Block A557, Platform "A" OCS-G 03484 16 August 2011, Gulf of Mexico OCS Region

## WHY EMPLOYEES DO NOT FOLLOW PROCEDURES

The Direct Motivators	Behavior Modifiers
Making life easier	Poor perception of the safety risks
Financial gain	Enhanced perception of the benefits
Saving time	Low perceptions of resulting injury or damage to plant
Impractical safety procedures	Inadequate management and supervisory attitudes
Unrealistic operating instructions or maintenance schedules	Low chance of detection due to inadequate supervision
Demonstrating skill and enhancing self- esteem	Poor management or supervisory style
Real and perceive pressure from the boss to cut corners	Poor accountability
	Complacency caused by accident free environments
Real and perceived pressure from the workforce to break the rules	Ineffective disciplinary procedures
	Inadequate positive rewards for adopting approved work practices



#### COMPETENT PERSON - ISO 4309

Person having such knowledge and experience of wire ropes on cranes and hoists as is necessary for that person to assess the condition of the rope, make a judgement as to whether it may remain in service and stipulate the maximum time interval between inspections.



# WHY MAINTENANCE TECHNICIANS ARE A VALUABLE ASSET IN HAZARD IDENTIFICATION





- 4% of hazards are known by the top management
- 9% of hazards are known by the middle management
- 74% of hazards are known by the supervisors
- 99% of hazards are known by the maintenance technicians



### SUMMARY I - APPROACH



- Periodic condition assessment is inseparably linked to the application of wire ropes.
- Time-based maintenance is not sufficiently able to determine the point of discard in a timely manner.
- Many failures are random in nature, but frequent inspection helps to predict them or mitigate their consequences.
- The consistent application of a condition-based inspection is crucial for a safe use of wire ropes.



## SUMMARY II – IT IS ALL ABOUT THE PEOPLE



- There are enough safety procedures and rules available but they need to be respected, learned and applied consistently.
- Management needs to provide an environment in which employees follow procedures accordingly.
- "Expert problems arise when an expert has some degree of knowledge, but not as much as he thinks he has." Nasim N. Taleb
- Outsourcing rope maintenance and inspection may be cost effective but bears huge risks, too. Hence, a thorough selection of service providers is required.



## FOOD FOR THOUGHTS – RELATED SAFETY ALERTS

To stimulate thinking, please use the following links on safety alerts about incidents with wire ropes in the O&G industry:

- https://www.bsee.gov/sites/bsee.gov/files/panel-investigation/incident-andinvestigations/hi-a557-panel-report-final-1.pdf
- https://www.bsee.gov/sites/bsee.gov/files/safety-alerts/safety/sa-304.pdf
- https://www.bsee.gov/sites/bsee.gov/files/safety-alerts//safety-alert-329potentially-catastrophic-crane-and-lifting-incidents.pdf
- https://www.imca-int.com/download/alerts/315/IMCASF-27-17.pdf
- https://www.marinesafetyforum.org/wp-content/uploads/2019/01/msf-safetyalert-18.18.pdf
- www.iadc.org/wp-content/uploads/2007/07/sa-07-39.pdf
- http://www.iadc.org/wp-content/uploads/2005/07/sa05-44.pdf
- http://www.iadc.org/wp-content/uploads/2014/04/sa99-05.pdf
- http://www.hse.gov.uk/safetybulletins/flemish-eye-crane-pennant.htm



Note: The list is randomly collected and doesn't claim to be complete; actuality can not be guaranteed



## THANK YOU FOR ATTENTION! FURTHER QUESTIONS?

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