IMCA LIFTING & RIGGING SEMINAR

Ropes for Offshore Heavy Duty Applications & Integrity Management

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Thursday, 27th September 2018
TOPICS

Introduction
Ropes & Comparison
Maintenance Approaches
Conclusions
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INTRODUCTION

Background

For EPCI Contractors...

- In the medium-long term offshore market scenario the focus will be on the subsea field development segment
- SURF developments are moving to ultra-deep waters and typical topside processes are being relocated onto the seabed
- Tighter capital discipline enhances the search for flexibility, cost-efficiency and for optimized project schedule
- Subsea deployment and laying capabilities are pushed to their technological limits and innovative solutions are being investigated and developed by the market players to overcome present technological showstoppers

...ropes are becoming more and more crucial
INTRODUCTION

Applications, Needs and Alternatives

Applications
- Heavy duty subsea deployment
- Pipeline abandon and recovery
- Heavy lifting
- Mooring

Needs
- Higher SWL / Lower SF
- Low paying load reduction with water depth increase
- Low impact on existing / chartered assets (and equipment)

Alternatives
- Large diameter steel wire ropes
- Multi-fall / multi-cable steel wire rope systems
- Heavy duty fibre ropes
- Parallel fibre cables
- Hybrid rope concept
- Combined rope systems
- Improved and modern IMR approaches
INTRODUCTION

Areas of Improvement

IMR Approach

Rope Based System

Rope Design

Rope Equipment

Predictive Maintenance

CBM

Preventive Maintenance

Fibre Ropes

Steel Wire Ropes

Fibre Cables

Hybrid Ropes

Fibre Rope Systems

Multi-fall Systems

Hybrid Systems
TOPICS

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ROPES & COMPARISON

Considered Constructions and Materials

Steel Wire Rope
- Non rotating
- WSC core
- Steel
- Socket termination, ...

Fibre Rope
- Braided rope
- HMPE
- Eye termination, ...

Fibre Cable
- Parallel fibres
- HMPE
- Thimble termination
**ROPES & COMPARISON**

**Mechanical Properties Comparison**

*Weight in Water vs MBL*

*Diameter vs MBL*

*Weight comparison @ 1000 tons MBL*

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Note for any kind of rope: weight doesn't consider sockets, shackles, thimbles, or any other connection component.

... however a comparison merely based on rope mechanical properties would return only rough information about applicability on different field application ...
## ROPES & COMPARISON

### Technology Benchmark

<table>
<thead>
<tr>
<th></th>
<th>Steel Wire Rope</th>
<th>Fibre Rope</th>
<th>Parallel Fibre Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight</strong></td>
<td>😞</td>
<td>Specific weight (7.85 kg/dm³)</td>
<td>Same specific weight of fibre ropes (due to base materials)</td>
</tr>
<tr>
<td></td>
<td>Specific weight depending on fibres material</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>😊</td>
<td>High fill factors warrant low diameters</td>
<td>Same diameter of steel wire ropes (due to manufacturing process)</td>
</tr>
<tr>
<td></td>
<td>😞</td>
<td>Rope construction lead to higher diameters</td>
<td></td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>😊</td>
<td>No technical limits</td>
<td>Limited to EW plant length 150 m</td>
</tr>
<tr>
<td><strong>Temperature Resistance</strong></td>
<td>😊</td>
<td>Up to ab. 100°C</td>
<td>Up to ab. 70-90°C (depending on fibres material)</td>
</tr>
<tr>
<td></td>
<td>😞</td>
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<td></td>
</tr>
<tr>
<td><strong>Cyclic Load Resistance</strong></td>
<td>😊</td>
<td>CBOS condition can be managed</td>
<td>Infinite fatigue life under axial loading</td>
</tr>
<tr>
<td></td>
<td>😞</td>
<td>CBOS condition still critical for temperature build-up</td>
<td></td>
</tr>
<tr>
<td><strong>Chemical Resistance</strong></td>
<td>😞</td>
<td>Corrosion issues on marine/subsea environment</td>
<td>UV impact and water absorption (not for HMPE) can be managed</td>
</tr>
<tr>
<td></td>
<td>😊</td>
<td>UV impact and water absorption (not for HMPE) can be managed</td>
<td></td>
</tr>
<tr>
<td><strong>Spool-ability</strong></td>
<td>😊</td>
<td>Typical D/d ratio 18-20</td>
<td>Not spoolable under tension</td>
</tr>
<tr>
<td></td>
<td>😞</td>
<td>Typical D/d ratio up to 30</td>
<td></td>
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</tbody>
</table>
ROPES & COMPARISON

A Real Case: OIE Carrier Mooring Ropes

The Offset Installation Equipment carrier has been designed to intervene in case of blow out event when no vertical access is possible.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Length</th>
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<th>Chemical Resistance</th>
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<td>Steel Wire Rope</td>
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<tr>
<td>Fibre Rope</td>
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<td>😊</td>
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<td>Parallel Fibre Cable</td>
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<td>😞</td>
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</tr>
</tbody>
</table>

A spoolable, light and temperature resistant fibre rope was finally selected.
MAINTENANCE APPROACHES

Trends and Comparison

Maintenance has evolved from a corrective process, performed after a functional failure, to a preventive activity where items are maintained according to a time-schedule based on the assumption that a component has a defined lifetime. However, estimates of lifetime have large uncertainties. In order to reduce the uncertainty condition-based maintenance, based on the assessment of asset condition, emerged enabling also more sophisticated predictive approaches.
MAINTENANCE APPROACHES

Rules & Regulations Ropes Integrity Management

Third Parties Requirements

- ISO 4309:2010 and API-RP-9B: establishes general principles for the care and maintenance, and inspection and discard of steel wire ropes used on cranes and hoists
- IMCA-SEL-022: provides guidance on the elements of an IMR system required to achieve an acceptable level of ongoing safety for the use of wire ropes in a marine environment
- DNVGL-ST-E407: provides the structure for assuring that rope based deployment and recovery systems will function as intended until discarded

Internal Requirements

- Dedicated Work Instructions, complementary or narrowing the above mentioned standards, can be put in place providing instructions to ensure the correct condition of wire ropes by periodic inspections and maintenance on-board OCVs

General Note

- It has to be noticed that DNVGL-ST-E407 and IMCA-SEL-022 opens to a continuous monitoring and predictive approaches for wire rope monitoring, while other above mentioned standards mainly reflect a preventive maintenance approach
MAINTENANCE APPROACHES

Focus on Construction Vessels

An Offshore Construction Vessel is a complex system, which ropes need different maintenance strategies depending on their usage, criticality and also associated capital and operating expenditure.
MAINTENANCE APPROACHES

Adopt, Adapt, Improve Philosophy

- Three possible complementary and incremental strategies can be adopted depending on technology maturity, application and equipment specificity, operations associated risks:

- **Adopt** methods, procedures and regulations that have proved so sound in the past; suitable for standard equipment and operations (e.g. on deck lifting)

- **Adapt** them to the changing needs of the times, depending on the scenario peculiarities (e.g. heavy lifting for offshore modules installations)

- Wherever possible, **improve** them to cope with all those specific and peculiar cases not covered by available methodologies (e.g. ultra deep water deployment with large diameter heave compensates steel wire ropes)
MAINTENANCE APPROACHES

Wire Rope Monitoring System

Rope Fatigue Monitoring System*
- Records and logs the accumulated number of bending cycles along the entire rope length and life
- Returns for each rope meter the number of cycles the rope has experienced and the equivalent percentage of rope fatigue life

Machine Vision System
- Monitors the wire rope geometry along the entire rope length
- Returns information about the rope geometry in terms of diameter, ovality and spikes

Temperature Monitoring Vision System
- Monitors the wire rope temperature at the exit point of the fixed sheave of the AHC
- Returns the rope and the sheave temperatures

Data Sharing
- Data are shared with WRMS specialist of the Maintenance and Upgrade Technical Service, Vessel Asset Managers and maintenance surveyor

* Deeply presented in 2016 IMCA rope workshop
PRESENT & FUTURE IMR APPROACHES

Further Developments

Predictive Tools

- Data driven predictive tools are under development based on semi-empirical models and on opportunities related to digital technologies (e.g. big data management, machine learning, ...)

Operations Automation

- Higher level of automation and support to operators in standard lifting and rigging operations are pursued aiming at increasing unmanning of the offshore installation activities and vessels and a subsequent safety enhancement
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CONCLUSIONS

General Outcomes

- Ropes and related systems and technologies are becoming more and more crucial for an offshore EPCI contractor

- Different rope technologies, alternative to steel wire ropes, are available on the market and can be effectively adopted depending on the application

- Beside rope technologies also IMR procedures are under improvement exploiting also digital technology opportunities aiming at increase operations safety and efficiency