OIL & GAS

Use of Synthetic Ropes in Deepwater Moorings
INTSOK Conference
Delivering Solutions: Deepwater Mega-Projects

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Outline

- Deepwater Moorings – Why Use Polyester Rope
- Synthetic Rope Development
- Addressing Remaining Challenges with Polyester Moorings
- Recent Deepwater Mega-Projects
- Summary

SOURCE: DSR Ropes
Deepwater Moorings – Why Use Polyester Rope

- Lighter weight
- Superb fatigue performance
- Smaller footprint
- Shorter lines
- Smaller vessel offset

SOURCE: Specialist Committee on Deepwater Mooring, 22nd ITTC
Synthetic Rope Development

- More than 35 years of rope testing & research
- Petrobras polyester field tests & full scale use starting mid-1990’s
- DeepStar polyester field tests & studies in 1990’s
- First use for permanent mooring in GOM was BP Mad Dog Spar installed in 2004
- **Currently over 50 permanent polyester mooring systems installed or planned (Offshore Magazine, 2013)**

BP Mad Dog Spar
Some Remaining Challenges with Polyester Moorings

- Characterization of polyester rope stiffness is difficult:
  - Visco-elastic material
  - Length/tension relationship is non-linear & load-path dependent
- No common, well-defined understanding of fiber rope change-in-length performance leading to:
  - Conservative sizing of mooring & riser components
  - Uncertainty in line lengths over time resulting in need to periodically adjust the lengths
- Potential soil ingress leading to rope abrasion
Polyester Mooring Line Challenges

- Damages due to Trawling
- Internal abrasion due to sand ingress

+ Polyester stiffness

Source: 2012-09-26 presentation by Øystein Gabrielsen, Statoil
How Are These Challenges Been Addressed?

- Joint-industry research projects, e.g.:
  - *Fiber Rope Damage Assessment and Acceptance Criteria*
  - *Improving Fiber-Mooring Design Practices*
  - *Managing the Safe Service Life of Fiber Ropes for Mooring*
  - *SYROPE Global Performance of Synthetic Ropes*

- Development of Standards & Recommended Practices, e.g.:
  - DNV-OS-E303: *Certification of Fiber Ropes for Offshore Mooring*

- Testing & qualification
  - Tensile, creep, fatigue testing
  - Force vs. stretch characteristics testing
  - Soil ingress testing

- Mooring analysis models incorporating nonlinear stiffness

- In-service condition monitoring

- Failure examination
Importance of Standardized Polyester Rope Testing Method (DNV-RP-E305 – draft)

- Need simple standardized test method to determine the rope viscoelastic change-in-length characteristics
- Accurate data on rope stiffness & stretch are important when designing deepwater mooring systems:
  - **Stiffness** affects required rope **break strength**
  - **Permanent stretch** affects required rope **length**
  - **Stiffness & stretch** influence max **platform offset** & required **riser length**
Importance of Standardized Polyester Rope Testing Method (DNV-RP-E305 – draft) Continued

- Designers of polyester mooring systems generally use results of only a few special tests on how the rope will stretch during installation and storms
  - Such tests are expensive, time consuming & applicable to only one project
- The newly developed standardized test method (DNV-RP-E305) determines the change-in-length performance of large polyester ropes, independent of the loading scenario
  - Test needs to be run only once for a particular rope design & test results can then be used on any project
DNV GL Testing Facilities for Polyester Ropes

Condition assessment of fiber ropes
(DNV Bergen)

2500 tonne tensile testing machine
(DNV Bergen)

Synthetic rope test machine
(DNV Oslo)

Test rig for fiber rope resistance to trawl wire damage
(DNV Bergen)

Break test of BP Mad Dog polyester rope
(DNV Bergen)
Deepwater Mega-Projects: Polyester Rope Testing by DNV GL

Shell Appomattox

Statoil Aasta Hansten

Chevron Jack St. Malo

Shell Stones
Summary of Support Activities to Mega-Projects

- **Chevron Jack St. Malo**
  - Qualification strength & stiffness tests

- **Statoil Aasta Hansteen**
  - Long term abrasion resistance of polyester
  - Full scale qualification of cut-resistant jackets
  - Numerical tools and guideline for design of polyester moorings
  - Pre-installation and storage of polyester mooring lines on seafloor
  - Final qualification stiffness & strength testing (underway)

- **Shell Stones**
  - Qualification strength & stiffness tests

- **Shell Appomattox**
  - Vendor screening strength & stiffness tests (according to ABS requirements)
  - Qualification phase testing scheduled
Use of Synthetic Ropes in Deepwater Moorings - Synopsis

- Development of synthetic mooring ropes has been an enabling technology for deepwater mega projects because of:
  - Light weight (essential for keeping hull size low)
  - Lower vessel offsets (essential for efficient riser design)

- DNV GL’s role includes:
  - Synthetic rope testing
  - Modeling of synthetic rope properties
  - Mooring system analysis incorporating nonlinear stiffness from synthetic ropes
  - Development of standards & recommended practices
  - Certification and technology qualification

- Mega-Projects Showcased:
  - Chevron Jack St. Malo
  - Statoil Aasta Hansteen
  - Shell Stones
  - Shell Appomattox