Underlying Causes of Mooring Lines Failures Across the Industry

Guy Drori
24th March 2015
Content

• Introduction
• Overview of industry failures in recent years
• Location of failures along the line
• Reliability of long-term moorings systems
• Line failures across the industry - contributing factors
• Mitigation measures
• Conclusions
• Audience Response Questions
Introduction
Industry Failures In Recent Years

- Deepstar®: 107 mooring incidents from 73 facilities across the industry (1997-2012)
  - 51 single line failures,
  - 9 multiple line failures,
  - 38 pre-emptive replacement events
  - 9 reports of severe degradation
Location of Failures Along The Line

- Chain - splash zone and thrash zone
- Wire rope - terminations, wire touching the seabed
- Fibre rope – damage due to external source (e.g. trawler net, offshore support vessels equip.)
- Long term connectors
Reliability of Long-term Moorings

Industry Mooring line failure rate, per line, per year of exposure (1997-2013)

- Long term Mooring system design life is approximately 15 to 25 years
- In context, 1:50 chance of a failure per asset, per annum. If a design life of a floater is in about 25 years, than there is a 1:2 chance of a failure during its life cycle
Likelihood - Loss of One Mooring Line

Probability of a single line failure

$2.5 \times 10^{-2}$ p.a., per floater

Underlying Causes of Mooring Line Failures | 24th March 2015 | This information is for public use
Reliability of Long-term Moorings

Ref: Offshore Standard DNV-OS-E301, October 2010 - Table H1, probability levels (for ultimate limit state)
Line Failures Across the industry - Contributing Factors

Design

• Design of supporting systems & end terminations
• Unreachable areas for maintenance and overhauls
• Out of plane bending (OPB) effect
• Implementation of passive and active corrosion prevention systems
• Seabed – chain interaction affect on chain abrasion (soil properties - stiffens, damping, etc.)
• The use of new technologies
• Late changes to the original design
Line Failures Across the industry - Contributing Factors

Manufacturing and Transportation

- Material properties and traceability for QA
- Quality control procedures, inspections and testing methods
- Approval process by classification societies
- Preservation after manufacturing – storage, handling, loading, etc.
- Transportation to the installation site via general cargo ships

Thanks to Ramnäs Bruk
Line Failures Across the industry - Contributing Factors

Installation

- Physical damage due to poor handling
- Operator skill-level and equipment used including Installation aids
- Cold bending or local heating (spot welding) causing reduced fatigue life
- Inappropriate deployment, anchors non-aligned to pull direction, lines dog-legged, hockles, twists, wire kinking, bird caging, etc.
- Storage of fibre ropes on board the vessel
- Incorrect tension in the lines
Line Failures Across the industry - Contributing Factors

Operation and Maintenance

- Excessive corrosion and wear
- Pre-emptive maintenance activities
- Lack of system knowledge and inadequate training for operators
- Quality and efficiency of offshore inspections
- Deferral of inspections
- Dropping lines / re-tensioning of lines
- Reusing mooring components
- *Lack of proper monitoring systems

Thanks to SCORCH & AMOG
Mitigation Measures

Design, manufacturing and installation of new systems

- Design Standards are fit for purpose but a common approach to local stresses (e.g. OPB) and analysis methods can add value
- Manufacturing needs honest and realistic expectations by all parties in terms of quality and reliability delivered
- Operators need better quality assurance and level of engagement from the contractors and manufactures
- Installation needs more awareness and emphasis on maintaining long term integrity and costs arising from poor installation
- Operators should continue to share their knowledge and experiences with the rest of the industry
Mitigation Measures

In service measures

• Improve the inspection and supervision during installation and in the first five year of operation

• Maintain the mooring lines supporting systems on-board the floater (e.g. fairlead, winches)

• Use the information generated in various cross industry activities to improve the integrity management plans

• Operations understanding of design and need to maintain integrity

• Use of the measured data (e.g. met-ocean, line tensions, offset, etc.) as a feed for a more dynamic mooring Integrity management plan
Conclusions

- Single mooring line failure on production floater maybe on average around $2 \times 10^{-2}$ p.a. (1 in 50) (~5 events/yr) globally

- Multiple mooring line failure on production floater maybe on average around $3 \times 10^{-3}$ p.a. (1 in 350) (~1 event/yr) globally

- For any individual floater, mooring system, location, etc. the risk and contribution of causes can be / will be different

- Improvements in standards and increased operator awareness are expected to reduce causes in design and operation

- Manufacture and Installation phases need increased planning assurance

Thanks to SCORCH & AMOG
Thank you, Any Questions?

Guy Drori

Naval Architect & Floating Systems Engineer

Email: guy.drori@uk.bp.com