Mooring Line Monitoring to Reduce the Risk of Line Failure

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Agenda

- Introduction – Facts & Figures
- Mooring monitoring
- Case study
- Conclusion
Mooring Line Integrity Management

Introduction

- Number of FPUs increasing
- Deeper water-harsher environments-climate change
- 20+ mooring incidents since 2001

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Mooring failures versus installed FPUs

Floating Production Facilities
Mooring Failures
Linear (Mooring Failures)

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Mechanisms contributing to failure

- **Wear:**
  - Component rubbing
- **Fatigue:**
  - Axial and bending stress
- **Abrasion:**
  - Contact with sediment
- **Corrosion:**
  - Common in splash zone

- **Damage**
- **Strength**
- **Excessive Tension:**
  - Severe environmental conditions
- **Operational:**
  - Various, i.e. Disconnect failure

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Typical failure locations

- Fairlead/ hawse pipe
- Shackles/ H-links
- Buoys, clump weights, tri-plates
- Thrash zone
- Where line descends into seabed

2006- Noble Denton Europe Limited- “FPS Mooring Integrity”

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Location of mooring integrity incidents

- Chain: 47%
- Connector (shackle, H-link, Triplate etc): 19%
- Wire Rope: 24%
- Polyester Rope: 5%
- Yoke Column: 5%

2013- Kai-Tung Ma et al- “Historical Review on Integrity Issues of Permanent Mooring Systems”

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Consequences of mooring failure

- Vessel drift
- Riser rupture
- Production shutdown
- Hydrocarbon release
- Cost of repairing damaged lines

2006- Noble Denton Europe Limited- “FPS Mooring Integrity”
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Recent mooring failures in APAC

HYSY 113
Liuhua
Nan Hai Fa Xian
FPSO Kikeh

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Cyclones in Australia

Tropical Cyclones
1970 to 2006

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FPSOs in Australia

- Glas Dowr
- Northern Endeavour
- Montara Venture
- Ichthys
- Prelude
- Modec Venture 11
- Ohka
- Armada Claire
- Maersk Nguima-Yin
- Pyrenees Venture
- Nganhurra
- Stybarrow
- Ningaloo
- Vision

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Inspection

Overview

• Main focus is on inspection and maintenance
• Visual, ROV & 3D camera inspection
  – Marine growth, Missing stud, Mud line
  – Change in Geometry, Line length, Damage

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Inspection

Pros & cons

• Pros:
  – Immediate Results
  – Non-Invasive
  – Limited Interruption to Production

• Cons:
  – Not Quantitative
  – Hidden Defects
  – Not Instant Warning
  – No record of Tension History

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Benefits

- Failure to detect line breakage
  - Severe weather event

- System degradation
  - Multiple line failure

- Failure detected promptly
  - Spares/procedures/vessels available to repair line
  - Inspect & possibly refurbish other lines
  - System fit for continued operations

Initial Failure

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Monitoring Options

- Instrumented chain stopper (load cell)
- In-line tension (strain gauge on chain link)
- Line inclination
- Sonar
- GPS Position Monitoring

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Inclination monitoring

- Fewer design requirements
- Inclinometers
- Measure angle
- Calculate tension using look-up tables
- Acoustic communication
- Retrofittable

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Case study: FPSO in South China Sea

Overview

- Region of frequent typhoons-number of recent failures
- STP buoy
- 9 mooring lines (3 sets of 3)
- Retrofitted to FPSO in operation
- First ever diver installable inclination system
Case study: FPSO in South China Sea

System overview

- Magnetic holder for acoustic DAU
- Magnetic clamps attach cable to vessel
- Acoustic receiver

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Data loggers

- 9 Acoustic loggers
- Attached using diver installable holders
- Typically 5 years battery life

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Case study: FPSO in South China Sea

Data acquisition units

- 2 DAUs mounted on underside of hull
- Specially designed magnetic holders
- Ensure constant communication with loggers
- No cables along mooring line

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Case study: FPSO in South China Sea

Cable

- Cables required to transfer data from DAU to control room
- Magnetic clamps attach cable to vessel hull
- On vessel- 2 x cables from turret to control room

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Case study: FPSO in South China Sea

Installation

- Diver team and support vessel
- Mooring lines/hull cleaned of marine growth
- System has been installed 1 year resisting currents and typhoons

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Case study: FPSO in South China Sea

Software

- Adjustable logging frequency
- Angle/Tension Conversion
- Historical Tension Data
- Alarm if over tension or failure
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Limitations of inclination monitoring

- Indirect tension measurement
- Tension must be inferred from angle
- Some accuracy lost
- Slight delay with acoustic communication

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Conclusion

• Mooring failures are a real threat with significant cost implications if not dealt with quickly
• Mooring line monitoring provides reliable data on mooring integrity
  – Warning of line failure
  – Record of tension history
• Allows informed decisions to be made

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Conclusion

- Don’t wait for a failure to happen; monitoring systems can be installed without affecting operations

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Thank You

Any Questions?

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