Pipeline Design & Integrity: Fatigue Monitoring of Pipeline Spans

AECC, June 2015

www.pulse-monitoring.com
Agenda

- Introducing Pulse
- Pipeline Span Monitoring
- Slugging Monitoring
- FIV Monitoring
- Summary and Questions
Introduction
Introduction

Introducing Pulse

- Established in 1998 as part of 2H Offshore
- >17 years monitoring experience
- Spun out of 2H in 2010
- >500 subsea monitoring systems deployed worldwide
- An Acteon company
Recognised branded service providers, aligned across four Expert Capabilities

Note: Our branded services each align with one lead capability, but this does not preclude offering additional services according to client need. The segments highlight a primary activity driver, but are not mutually exclusive.
Key capabilities aligned to OPERATORS and CONTRACTORS

ACTEON SERVICES

Survey, Monitoring and Data
Risers and Moorings
Seabed Foundation Technologies
Project Support Services
Global Presence

>17 years experience

6 regional offices

3 Project execution centres

>80 employees globally
Pulse Services
Integrated service model

Understanding of real world environment critical for effective product design

Knowledge of offshore operations allows optimised data retrieval, management & software configuration

Deep understanding of customers data, identifies issues & improves product development cycle
Pipeline Integrity Monitoring Services

Overview

Free Spans
• Potential damage from VIV, FIV and slugging

Slugging
• Cyclic stress and inertial loading cause fatigue

FIV
• Increasing flow rates causing enhanced fatigue
Monitoring Systems

Motion

**INTEGRIpod™**
- Standalone logger
- Acoustic logger

Strain

**INTEGRIsensors™**
- Subsea strain gauge
- Dynamic curvature

Interfaces

- ROV deployable magnetic holder
- ROV deployable holder
- Diver deployable holder for mooring lines

Software

**ASSURE™ software**

Field proven systems

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Communication Approach

S (Standalone)

H (Hardwired)

A (Acoustic)

Selected to suit project objectives
Pipeline Monitoring
Monitoring system specification
Benefits of Monitoring

**Improve operational efficiency**
- Optimising inspection and maintenance strategies
- Reducing downtime

**Asset life extension**
- Greater understanding of asset fatigue history
- Provides more robust case for asset life extension

**Enhance operational safety**
- Understanding how much fatigue is being accrued over the length of the operation

**Proactive integrity management**
- Adhere to industry regulations and standards
- Protect individual and corporate reputation

**Design verification**
- Creating an information feedback loop
- Providing an extensive understanding of the environment

**Understanding for future improvements**
- To quantify the unknown
- Reducing conservatisms in analysis through the use of real world data
Pipeline Span Monitoring
Pipeline Span Monitoring

Intro

• Span- unsupported areas of subsea pipeline
• Two types of span that can cause integrity concerns:
  – Natural spans (pipeline profile / geometry of seabed)
  – Pipeline sleepers (installed to prevent lateral buckling)
• Various potential fatigue damage
  – VIV, FIV and slugging
Primary Regions With Free Span Issues

- Southern North Sea
- NW Australia
- Canada
- GoM
- Arabian Gulf
Pipeline Span Monitoring

Typical system layout
## Pipeline Span Monitoring

**Motion Loggers**

![Motion Logger Image]

<table>
<thead>
<tr>
<th>Sensor Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tri Axial Accelerometers</td>
<td>X, Y and Z</td>
</tr>
<tr>
<td>Range [g]</td>
<td>± 2</td>
</tr>
<tr>
<td>Accuracy [m/s²]</td>
<td>± 3.5% of measured acceleration or ±0.002 m/s² (whichever is greater)</td>
</tr>
<tr>
<td>RMS Noise [m/s²]</td>
<td>30µV</td>
</tr>
<tr>
<td>Tri Plane Angular Rate</td>
<td>XZ, YZ and XY</td>
</tr>
<tr>
<td>Range [deg/s]</td>
<td>± 4</td>
</tr>
<tr>
<td>Accuracy [deg/s]</td>
<td>± 3.5% of measured angular rate or ±0.05 deg/s (whichever is greater)</td>
</tr>
<tr>
<td>RMS Noise [deg/s]</td>
<td>2000µV</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Communication Specification</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Serial Communication Ports</td>
<td>4 RS232 Ports</td>
</tr>
<tr>
<td>USB Port</td>
<td>For Data Download</td>
</tr>
</tbody>
</table>
Pipeline Span Monitoring

Current monitoring

- Measures the speed and direction of ocean currents
- Battery Operated
- 20-30min recording per hour
## Pipeline Span Monitoring

### Sensor interfaces

<table>
<thead>
<tr>
<th></th>
<th>Diver/ Topside</th>
<th>ROV</th>
</tr>
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<tbody>
<tr>
<td>Motion</td>
<td><img src="image" alt="Motion" /></td>
<td><img src="image" alt="ROV" /></td>
</tr>
<tr>
<td>Strain</td>
<td><img src="image" alt="Strain" /></td>
<td><img src="image" alt="ROV" /></td>
</tr>
<tr>
<td>Current</td>
<td><img src="image" alt="Current" /></td>
<td><img src="image" alt="ROV" /></td>
</tr>
</tbody>
</table>

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Pipeline Span Monitoring
ROV deployable strain monitoring

ROV grab bars for clamp control
INTEGRIPod
Pipe
Pulse INTEGRISTick
dynamic curvature sensor
Recent projects

- Humber Estuary Pipeline - 2005
- Pipeline bundle tow out & span monitoring - 2009
- Gas pipeline span monitoring - 2010
- Gas pipeline span slugging monitoring - 2012
- Gas pipeline span slugging monitoring - 2014
Case Study: Humber Estuary Pipeline

Overview

- Monitoring pipeline free span in river estuary
- Issue:
  - Client wanted to determine the flow velocities and directions that are incident upon the exposed section of pipe
  - Wanted to establish whether the pipeline is experiencing VIV and potential fatigue affects
- System
  - 2 x INTEGRIpod SM
  - 2 x current meters
Case Study: Humber Estuary Pipeline

Outcome

- No evidence of VIV was found to be present in either the cross-flow or in-line direction

- Typical VIV Spectrum

- Data monitored
Case Study: Pipeline Bundle Tow

Overview

- Monitoring of a pipeline bundle for response to towing and in service operations
- Issue:
  - Client required confirmation of the structural response and fatigue life
  - Part of design verification process
- System
  - 18 x INTEGRIpod SM
  - ROV deployable/retrievable
  - Continuous logging
Case Study: Pipeline Bundle Tow

Outcome

- Fatigue damage was accumulated during tow out
- Response was found to be within limits
- Proved analysis model was fairly accurate
Pipeline Span Monitoring

Conclusion

• Pipeline spans can cause major fatigue concerns

• Off the shelf sensors available for rapid deployment

• Monitoring systems tailored to meet needs of specific project

• Monitoring data improves understanding of pipeline response
Slugging Monitoring
Slugging

Intro

- Occurs due to separation of liquids and gas in multiphase flow
- Causes cyclic loading leading to fatigue damage
- Certain infrastructure particularly susceptible to slugging:
  - Pipeline spans
  - Rigid jumpers
  - Sleeper crossings
- Can push structural utilizations above allowable limits
Case Study: Slugging Monitoring

Overview

- Monitoring ‘super span’ on 30” gas flowline
- Issue:
  - Pipeline unsupported as it crosses subsea ridge
  - Vulnerable to fatigue from slugging & VIV
- System:
  - 6 x INTEGRIPod SM
  - Record vertical & lateral structural response
  - ROV installable/ retrievable
Slugging Monitoring

Summary

- Slugging can cause particular fatigue concerns
- Systems offer a cost efficient solution
- Monitoring systems tailored to meet needs of specific project
- Monitoring data improves understanding of pipeline response
High Speed Vibration Monitoring
Flow Induced Vibration (FIV)

Intro

- Subsea vibration due to process excitation an increasing issue:
  - Higher flow rates
  - Increasing flexibility in pipework
- Particularly problematic on manifolds, jumpers and valves
- Issue may occur subsea with no obvious sign topsides
FIV Monitoring
High speed vibration sensors

Magnetic Sensor

Lightweight Sensor
Case Study: North Sea FIV Monitoring

Overview

- Monitoring a gas export pipeline in the North Sea
- Issue:
  - FIV inside pipe caused by trapped plug tool
  - A vibration monitoring system was requested for detecting the existence of such vibration
- System
  - High frequency monitoring system
  - Magnetic vibration sensor
  - 2 x INTEGRIpod SM High Speed logging continuously
Case Study: North Sea FIV Monitoring

Outcome

- System found high frequency vibration present
- Aided the operator to select a safe flow rate

Fast Fourier Transform (FFT) of the X-axis showing frequency of vibration
Case Study: Jumper Monitoring-India

Overview

- Subsea jumper connecting to a producing well in India
- Issue
  - Client wanted to determine level of FIV on subsea jumpers due to internal production flowrate
  - Jumpers tie-in xmas trees to subsea pipelines and subsea pipelines to the manifolds
- System
  - 2 x INTEGRIpod SM High Speed logging continuously
  - 2 x magnetic spider clamps for high speed vibration monitoring
FIV Monitoring

Summary

- Increasing focus on FIV as a driver of fatigue
- Particular issue on jumpers, manifolds and valves
- Pulse have a strong track record of effective FIV monitoring
- Data that helps operators quantify and reduce fatigue concerns
Summary

Pulse Structural Monitoring offers:

- >17 years experience
- A proven track record with major operators worldwide
- Standard & proven sensors for all systems
- Solutions for all offshore assets
- Simple systems for maximum information and understanding
- Improve safety and maximise operational life of assets
Thank you!

Pulse Structural Monitoring
Brian Taylor
M: +44 (0)7711 842 649
Brian.Taylor@pulse-monitoring.com

www.pulse-monitoring.com