Secrets of a Healthy and Happy Old Age —

Putting Riser Monitoring Data to Good Use

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Introduction

- Why Monitor
- Monitoring System Design
- Example Applications
- Riser Fatigue Design
- How Monitoring Data Can be Used
- Questions
Why Monitor?

- Reasons not to
  - Not necessary from design perspective
  - Adds cost
  - Unreliable

- Reasons for
  - Novelty of arrangement or environment
  - Design or fabrication concerns/oversights
  - Observed in-service problems
  - Life extension
Monitoring System Design

- Direct or indirect measurement
- Measurement parameters
- Measurement frequency
- Program duration
- Instrument accuracy and resolution
- Data transmission
- Installation/attachment
- Redundancy
- Data verification methods
- Data processing methods
- Data storage and access
Example Applications

- Drilling riser vortex induced vibration (VIV)
- SCR hurricane and fatigue response
- Transfer line installation fatigue
- Pipeline span VIV
- Blockage induced vibrations
- SCR flex-joint degradation
- Export line wave and VIV fatigue
- Flowline slugging
Chevron Tahiti

TAHITI FIELD DEVELOPMENT
GREEN CANYON AREA - GULF OF MEXICO

PRODUCTION DRILL CENTER (NORTH)

PRODUCTION DRILL CENTER (SOUTH)
Chevron Tahiti SCR Monitoring

- Operator had 24 SCR’s by 2011
- Negligible measured response data available
- Online monitoring of motion and strain along full length
- Data analysis to confirm
  - Hurricane response
  - VIV suppression effectiveness
  - Model calibration
Transfer Line Fatigue

- 1.5km Horizontal Pipeline span, located at mid depth Offshore Malaysia
- New design concept
- Concerns about the response during launch and tow out
Transfer Line Response

![Image of a worker on a transfer line](image)

The graph shows the acceleration (m/s²) during different operations:
- **Towing Operations**
- **DTU Hookup**
- **FPSO Hookup**

The x-axis represents the dates from 06-May to 30-Jun, and the y-axis represents the acceleration in m/s².

The legend indicates different sensors and their dates:
- **HMS02**
- **HMS03**
- **HMS04**
- **HMS05**
- **HMS06**
- **HMS07**
- **HMS09**
- **HMS10**
- **HMS11**
- **HMS13**
- **HMS14**
- **HMS15**
- **HMS16**
- **HMS17**
- **HMS18**
Pipeline Span VIV

- Current Meters mounted to fixed bases
- Downstream River Flow
- Pipeline
- X, Y, Z axes
- +/− 2.4 g Data Loggers
- 1/4 Span, Mid Span

Plan View of Pipeline

Logger NO. T14 - Period NO. 1737

Graph showing FFT plots of acceleration and frequency.
Blockage Induced Pipeline Vibration

- North Sea gas export pipeline
- Vibration due to a trapped plug tool
Pipeline Vibration Response

- High frequency vibration present
- Monitoring enabled selection of safe flow rate
SCR Flex-Joint Integrity

- Camera bracket
- Upper sensor pod
- Straps
- Lower sensor and marshalling pod
- MAT
- MAT pod
- Riser
- Flex joint
- SCR Flex-Joint Integrity
- 15
Export Line Spool Fatigue

Platform North

Platform East

Clamp

Grout Bag Supports

Sliding Clamp

Piles Supports
Flowline Slugging

- Fatigue induced due to weight change and slug inertia
- Measurements of displacement and angle
- Objectives to measure fatigue and slugging characteristics
Riser Fatigue Drivers

- Waves
- Currents
- Vessel motions
- Slugging
Vortex Induced Vibration
Riser Fatigue Design

- Conduct analysis to simulate long term environment
- Combine fatigue damage from different phenomena
- Many variables to accommodate:
  - Environmental loading
  - Vessel motions
  - Soil characteristics
  - Response modelling
  - Material fatigue resistance

- Approach:
  - Conservative analysis parameters
  - Large factors of safety (10)
  - Design code objective to obtain target probability of failure (~10-5)
Calculated Fatigue Damage

- Calculated fatigue damage, A, obtained by dynamic analysis

- Uncertainty in calculated result due to:
  - Environmental loading
  - Vessel motions
  - Soil characteristics
  - Response modelling

- Calculation is typically conservative
Fatigue Strength

- Strength (fatigue curves) determined through testing

- Variability due to:
  - Materials
  - Welding procedures

- Design fatigue strength, $B$, defined by mean – 2 standard deviations
- Objective to achieve design code target probability of failure ($10^{-5}$ - the blue bit)

- Achieved by specifying a large safety factor to account for variability (B > 10 x A)
Use of Measurements

- Conduct verification
- Determine and apply transfer functions
- Calculate fatigue damage
- Compare measured vs calculated response
- Produce more realistic life estimates
  - Reduced safety factors / life extension
Calculated v Measured Fatigue (by event)

- Demonstrates conservatism in fatigue prediction by a factor of 20
- Bias is consistent regardless of severity
Fatigue Damage Accumulation

May use an event, time or environment based approach
Measurements enable definition of conservatism or bias = A/C

Benefit of Fatigue Measurements
What Other Benefits Can Be Gained?

- Use of bias alone gives 3 to 10 times improvement

- Measurements remove major uncertainties:
  - Wave loading and vessel motions
  - Hydrodynamic coefficients
  - Modelling
  - Soil parameters

- Uncertainty remains only in transfer function and local SCF’s

- Reliability analysis can be used to take advantage of reduced variability – DNV RP-F204, DNV CN 30.6
Reduction in variability can be defined using reliability analysis.
Conclusions

- Monitoring reduces uncertainties

- Determining bias and reducing uncertainty can be used to extend life, while achieving the same target probabilities of failure

- Monitoring provides information to confirm that equipment is healthy and to keep the people responsible happy

- Standardisation of reduced safety factors for monitored response should be feasible and is being investigated
Thank you for your time

Questions....

Further information:

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