Managing Flowline Buckling and Walking with Real time Position Monitoring
Subsea Monitoring, Analysis and Reporting Technology

Stephen Fasham
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What is Pipeline/Flowline Buckling?

Why Should we Care About it?
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Over the last 20 years temperature and pressure of pipeline product has increased dramatically

• Pressures > 15 MPa (HP)
• Temperatures > 120°C (HT)

Pipelines also insulated to mitigate wax and hydrate formation

HTHP causes expansion which, if restrained, induces compressive axial forces
How is it Different to Buckling

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  - Unlikely to buckle so everyone happy and no problems...
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  - But still have expansion – calculate expansion, put in loop and no problems...
Axial Walking

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  – But still have expansion – calculate expansion, put in loop and no problems...

• True for symmetrical conditions but – the real world is rarely ideal
Analytical and FEA Modelling

Current Design Approach

Analytical Methods

Initial assessment involves Hobb’s analytical solution. Atteris has developed tools to carry out analysis and the expertise to interpret them. Determines propensity of pipeline to lateral buckling. If not susceptible then only axial walking assessment required.
Analytical and FEA Modelling

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FEA Modelling
Determine if uncontrolled buckle acceptable
If not determine spacing so rogue buckles are acceptable / planned buckles reliable
Determine mitigation measures and initiation forces
Ensure global acceptability
Confirm walking compliance
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FEA toolset can also be used to examine fatigue and local buckling
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Effective Axial Force & Buckle Initiation Force

Susceptible to lateral buckling

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Mitigation Strategies

Pipeline/Flowline Buckling and Axial Walking

Buckle Initiator

Zero Degree Bend Radius

Sliding Flowline Termination Assembly
Pipeline/Flowline Buckling and Axial Walking

Why Should we use Near-Realtime Monitoring?

- There have still been pipeline failures despite knowledge of failure modes
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• Designs showing no susceptibility for buckling at Start of Life (SOL) may be susceptible before EOL – particularly if life extension is considered
Why Should we use Near-Realtime Monitoring?

- There have still been pipeline failures despite knowledge of failure modes
- Field data can improve modelling techniques
- Designs showing no susceptibility for buckling at Start of Life (SOL) may be susceptible before EOL – particularly if life extension is considered
- Knowledge of actual behaviour allows operation optimisation - including possibility of reversing movement by changing operation parameters
In-situ Long Term Movement Monitoring

Robust Acoustic Monitoring System

High Accuracy Acoustic Ranging + Sensor Inputs

- Each unit an **Autonomous Monitoring Transponder (AMT)**
  - Two way ranging
  - High accuracy depth sensor
  - High accuracy inclination
  - Sound velocity sensor

- Create fixed reference array
- Units on suspect movement points (FTA, Flowline close to buckle initiator)
- Pre-programmed data logging (autonomous)
- Each unit generates around 3 pages (1500 Bytes) of data/day for typical settings
- Typical 5 unit array (for FTA) generates 7500 Bytes/day
- Topside collection when vessel available
In-situ Long Term Movement Monitoring

Field Data Results

- Range and sensor data processed topside to produce movement information
- Plot shows a 25mm movement over 3 days – validated as change seen to two fixed transponders
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PROBLEM – Surface Vessel Required for Data Retrieval – Irregular and expensive
Near-Realtime Solutions

Option 1 – Lower Cost Persistent Vehicles
In-situ Long Term Movement Monitoring
Near-Realtime Option 2 > Subsea Monitoring, Analysis and Reporting Technology (SMART)

FEATURES

• Flexible interfacing to A/D internal and external sensors,
• Secure low power data logging
• Data processing to provide summary updates/alerts/alarms via acoustic telemetry
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• Flexible interfacing to A/D internal and external sensors,
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Data processing all done subsea by SMART unit
Typically SMART placed on movement risk point
Fixed array simple Compatt (known baselines perform SV verification
3D Location (Latitude/Longitude/Depth) stored as 3 4byte packets
288 Bytes/day 25x Reduction from 7500 Bytes/day
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On-board processing capability also enables movement data to be thresholded

Movement < Defined Threshold = Device status Byte only to be transmitted

Data relayed to Transceiver connected at nearest field communications position

Reduced data packet means “multi-hop” relay to connection point >10km away is reasonable
Near-Realtime Monitoring System

Relay Network Layout

- Remote choke monitoring over 10km
- No cable availability
- Challenging acoustic conditions
- Life of field deployment
• Remote choke monitoring over 10km
• No cable availability
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• Same approach now available for more complex data sets – processed subsea
• Requires small data packets to manage fire and forget or error checked transmission
Conclusions

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• Addition of accurate position monitoring allows for validation of analysis
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- Moving to SMART data processing allows for:
  - Lower cost system operation – through connection to existing infrastructure (“Vessel Free”)
  - Near-Realtime inputs to control systems to maximise operational efficiency
  - The possibility of tailoring operating parameters to “unwind” previous movement
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• **Consideration of monitoring systems during design (or for existing) will remove uncertainty and conservatism of theoretical behaviour modelling.**
• **We have an opportunity to implement a truly evidence based behaviour model for reliable predictive modelling.**
Questions?

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