Contents

- Introduction to pipelines
- Where do you as engineers fit in?
- Diversity of the pipelines industry
- Example projects
Different types of pipelines

**Trunklines (export)**

Large diameter gas transmission lines. 40” plus diameter, up to circa 1000 km

**Interfield and Infield lines (flowlines)**

Transporting oil or gas within / to fields. 6-20” diameter, few km up to approx 100 km

**Langeled Pipeline**

- Transport 20bcm gas / year
- 44” diameter concrete coated, 1200km in length
- 150 -250 bar internal pressure
- Steel rods for concrete sufficient for 3 Eiffel T!
Example of a subsea field development

BP Rhum Field Development
Overall Field Layout

CSO Apache
CSO Constructor
Where do engineers fit in today?

Operators (owners)

Suppliers and Technology Inst

Discovery | Evaluation | Implement | Production | Decomm

Contractors (builders)

Engineering Houses (designers)
Diverse disciplines and skills for newcomers

- Diverse disciplines
  - Mechanics
  - Geotechnics
  - Dynamics
  - Fluids
  - Materials

- Diverse skills
  - Concept to detailed design
  - Analysis including F.E
  - Technology development
  - Code development
Globally diverse industry – exciting challenge!

- Geographical diversity of pipelines industry
- Varying levels of maturity
- Varying regulatory regimes (prescriptive or not)
- Different regions bring diverse technical challenges
- Multi-cultural
Diverse technical challenges

- Deep water
- Very shallow water
- HP-HT
- Aggressive gasses
- Harsh Environments
- Heavy oils
- IRM
- Decommissioning

- Safety
- Environment
- Design for installation
- Flow assurance
- Insulated pipelines
- Material selection and behaviour
- Limit state pipeline design methods
- Upheaval buckling
- Lateral buckling and pipeline walking
- Highly irregular seabeds
- Spans and fatigue
- Geohazards; routing, stability
- Seismic
Project Examples

- Consulting
- Design
Technical Challenges – Lateral Buckling

- Many subsea pipelines operate under high pressure and temperature
- This generates large axial compressive forces in the pipe due to the frictional restraint from seabed
- The axial compressive force causes the pipeline to buckle laterally at an imperfection e.g. out-of-straightness
- The pipeline will expand, feeding-in towards the buckle resulting in large lateral displacement, e.g. 10m
- The bending moment and strains in the buckle apex could exceed the allowable limits and lead to local buckling or fracture and hence pipeline failure
- Advanced engineering analysis can be used to assess all aspects of this phenomenon

- **The results can be used to determine effective mitigation solutions**
Potential solutions

- Do nothing, prove lateral buckling is ok without mitigation
- Expansion spools
- Snake lay
- Sleepers
- Buoyancy
- Intermittent rock dump

Engineering from first principles – global analysis
Engineering from first principles – local analysis
Aqaba Pipeline Design

15km of 36” Pipeline across the Gulf of Aqaba. Part of a transmission system taking gas from Egypt to Jordan, Syria and then on to Turkey.
Technical challenges

- **Deepwater** (remains the deepest water 36” pipeline). 856m at deepest point

- One of the most active **seismic** areas in the world. Egypt moves 2cm relative to Jordan annually. Pipeline designed to withstand 7.5 on Richter scale

- **Steep slopes,** deep gullies and long spans. Drop nearly 900m in 4km

- **Environmentally** sensitive (corals). Also lack of water meant that hydrotest was a problem
Harsh environment

- High quality survey and current data allowed optimal route to be chosen to minimise spans
- Spans in deep water are very expensive to rectify using supports or rock
- Largest spans up to 450m were reduced to 220m by:
  - Carried out advanced engineering using limit states
  - Specified concrete half shells as overweight and mattresses
- Environmentally sensitive area (corals)
- Lack of water was a problem for hydrotesting the pipeline
  - First pipeline in the world not to be hydrotested
Span analysis and route selection
Buckle arrestors

- High external pressure means that pipeline collapse due to buckle formation is an issue
- Most likely during construction
- Buckle will propagate at about the speed of sound!
- Mitigation is the use of buckle arrestors. The number and had to be designed
Ongoing inspection – Design versus actual

- Fatigue Life of and Installed Pipeline is Primarily Governed By:
  - Span Length
  - Current and Wave Loads
  - Distance to and Size of Adjacent Spans
- Analysis Using Finite Element
  - Determine the Modal Response
- Fatigue Life Calculated Based Upon
  - DNV-RP-F105: Free Spanning Pipelines
- Survey Quality of Free Spans is Important.
Summary

- Pipeline Engineering is diverse and challenging within the subsea sector

- There is a significant shortage of engineers in our field, opportunities are therefore abundant for young engineers

- KW Ltd currently have 2 ENSAM graduates working in their London office – we would be happy to talk to you.

Thank You