Deep Water Umbilicals – Challenges & Technology Solutions

Ian Probyn – R&D Business Development Manager
Technip Today

- With engineering, technologies and project management, on land and at sea, we safely and successfully deliver the best solutions for our clients in the energy business
- Worldwide presence with 38,000 people in 48 countries
- Industrial assets on all continents, a fleet of 27 vessels (6 of which under construction)
- 2014 revenue: €10.7 billion

Energy is at the core of Technip
Strategically Positioned Manufacturing Locations

Technip Umbilicals Ltd. Newcastle, UK
- TPU, STU, ELE
- VHAM
- R&D Centre

Technip Umbilicals Inc. Houston, USA
- STU, ELE
- VHAM

Angoflex Ltda. Lobito, Angola
- STU, ELE
- Large storage carrousels

Asiaflex Products. Johor, Malaysia
- TPU, ELE
- Combined Flexible & Umbilical plant

Supply thermoplastic and steel tube umbilicals
Dedicated umbilical R&D centre
What is a Subsea Umbilical?

- The critical connection to control and supply subsea oil and gas extraction equipment.
Key Factors of Deep Water Umbilical Design

- Deep water presents a number of key challenges, each of which must be considered during the early design stage:
  - Umbilical design: component mix, capacities, manufacturing assets
  - Installation: hold back tensions, effect of DAF, friction, track length / equipment, crush load, heavier inner bundles, offshore hold time
  - In-service conditions: utilisation, fatigue, buoyancy, host vessel type,
Trends of Deep Water Umbilicals

- Increasing installation water depth
- Increasing number of components
- Increasing weight per length
- Increasing top tension

\[ Tension_{top} = \frac{Weight}{Length_{water}} \times Depth_{water} \times DAF \times CF \]

Deep water umbilicals drive greater installation loads
Deep Water Installation

- The install-ability of an umbilical is governed by key factors

Each factor can be related using the following:

\[ \text{Length}_{\text{track}} \times \text{Force}_{\text{crush}} \times N_{\text{tracks}} \times N_{\text{tensioners}} \times \mu_{\text{friction}} = Tension_{\text{install}} \]

Increasing top tension drives; Larger installation equipment, higher crush capacity, greater friction factor
Deep Water Installation – Crush Analysis

Typical industry approach

- **Physical Testing**
  - Prototype manufactured and prepared, tested
  - Expensive, time consuming
  - Gives answer but not much insight

- **Empirical or mathematical modelling**
  - Fast but typically lower accuracy
  - Many assumptions, elastic limit
  - Built from test data

- **2D FEA Analysis**
  - Quick and inexpensive
  - 3D effects can be missed

[Over conservative, unknowns unquantified and higher risk Unnecessarily high crush load]
Deep Water Installation – Crush Analysis

Technip Umbilicals approach

- FEMUS – 3D FEA modelling tool
- Proprietary software developed by Technip
- Fast and accurate generation of complex 3D FEA models
- Fully validated against physical test
Deep Water Installation – Crush Analysis

- FEMUS – 3D modelling tool
  - Allows interrogation of the umbilical and optimisation of design
  - Crush capacity tailored for installation scenario

- Increased confidence, reduced conservatism, reduced cost
- Greater insight into behaviour
Deep Water Installation – Installation Equipment

**Typical industry approach**

- Utilise sufficient FoS
- Physical test to explore / confirm umbilical limits
- Increase risk on product (unknowns not quantified)
- Larger, more expensive lay-spread
- Unnecessary high crush load

**Conservative FoS Unknowns, added cost and risk**
Deep Water Installation – Installation Equipment

- **FEMUS – 3D modelling tool**
  - Tool can be used to interrogate installation set-up
  - Advise best installation scenario: Pad width, type, spacing

Greater confidence, reduced risk and less cost
Deep Water Installation – Friction

Typical industry approach

- Accepted friction co-efficient & Factor of Safety
- Physical tests to confirm friction factor

Reliant upon high FoS, more unknowns, more risk
Deep Water Challenges & Solutions

Deep Water Installation – Friction

**Technip Umbilicals approach**

- Innovative, patent pending high friction tape “Compressi-Grip”
- When crushed, friction increased ~x2
- When crush removed, friction released
  - no affect on fatigue

Increased friction during installation; deeper water, less crush force, less risk, reduced cost.
Deep Water Operation – Top Tension

- Top tension is a function of the water depth, umbilical weight, vessel motion (DAF) and lay configuration.

- Axial strain is a function of the tension and stiffness of the umbilical cross section.

\[
T_{\text{topside}} = F[WD, DAF, Mass/m, Config]
\]

\[
e_{\text{topside}} = F[T_{\text{topside}}, EA_u]
\]

\[
e_{\text{topside}} = \frac{T_{\text{topside}}}{\int EA_i} = \frac{WD \times DAF \times Mass/m}{\int EA_i}
\]

- Reduce weight
- Increase stiffness
Deep Water Operation – Top Tension

*Reduce weight*

- Target, high density, low strength components = Cables
- Innovative and patented solution: Use high strength Aluminium

Less weight, higher strength, better fatigue, greater water depth capability, less risk
Deep Water Operation – Top Tension

*Increase axial stiffness*

- High strength strain members, increase stiffness, reduce strain
- Full ISO and material qualification
- In-service today

High stiffness, high strength, less strain, lower risk
Deep Water Operation – Top Tension

*Increase stiffness and reduce weight*

- **Innovative and patented solution**
  - Evolve the umbilical structure down the water column where extra stiffness is not required

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<tr>
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<th>Strain Member</th>
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<td>A</td>
<td>High Tensile Strand</td>
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<td>B</td>
<td>Evolving joint</td>
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<tr>
<td>C</td>
<td>Polymer Filler</td>
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- **Evolving Joint**

- **Tensile Test Results:**
  - PC Strand to PE Filler

- **Crush Capacity**
- **Number of Tracks**
- **Topside Tension**
- **Track Length**
- **Shear Friction**

**Installation**
Conclusions

- Ever more complex deep water umbilicals drive higher topside tension and higher installation forces, increasing risk and cost.

- **Upfront engineering analysis tools can deliver:**
  - detailed insight into structural behaviour and greater confidence in design
  - reduce conservatism and optimise the lay-system interaction

- **Technologies to improve deep water umbilicals:**
  - compressi-grip tape to increase friction
  - light weight, high strength aluminium cables
  - high strength strands
  - evolving structures

**Taking umbilicals further……. and deeper.**