Subsea System Design: Same Dog New Tricks

By K.Milne
Same Dog...

- OGA analysed 58 oil and gas projects
  - Input from 11 Operators
- Less than 25% delivered on time
- Average overspend = 35%
Case Study: Subsea Production Tree Leak

The Issue
The Traditional Response
What We Did
Key Point Comparison
Example Key Item Design Philosophy
Case Overview

• 2 well subsea tie-back

• Sour 3-phase production
  – Well A ~30,000ppm H₂S
  – Well B ~ 3,000ppm H₂S

• Water depth is ~60m
  – Designed for routine ROV intervention
  – Installed by sat divers
Bypass Requirements

- Leak Identified in 2014
Case Overview

- Horizontal production tree
- Leak point identified at Tree / Flowbase interface
- No leak during stable flow, only during shutdown
  - Estimated 42 pressure cycles observed in 2015
  - Leak observed to continue even when pipeline was blown down
- PFIV failed ~60% /Open
How to Repair a Leaking Tree?

- The tried and tested method is:
  - Change out the Tree and Flowbase

### Equipment & Services Required

- DSV – Preparation & deconstruction
- Drill Rig – Tree & flowbase change Out
- DSV – Re-connection & commissioning
- Horizontal production tree
- Production flowbase
- Upper completion inc. valves & sensors
Tree Change Out Scenario

**Campaign One: DSV**
- Isolate tree
- Flood pipeline
- Remove tie-in spool
- Disconnect subsea control system

**Campaign Two: MODU**
- Set downhole isolation plugs
- Pull upper completion
- Recover tree & flowbase
- Install new tree & flowbase
- Recomplete well

**Campaign Three: DSV**
- Install tie-in spool
- Leak test pipeline
- De-water pipeline
- Re-connect subsea control system
- Commission well

A presentation by Wood.
Tree Change Out Scenario

• Campaign One: Est. 6 Days (inc. Mob)
• Campaign Two: Est. 30 Days
• Campaign Three: Est. 7 Days (inc. Mob)
• Total Repair Cost £53.5M not economically viable for this Asset

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Engineering</td>
<td>18 months</td>
<td>£4.5M</td>
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<tr>
<td>Equipment</td>
<td>12 months</td>
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<tr>
<td>Offshore Execution</td>
<td>44 days</td>
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<tr>
<td>Lost Production</td>
<td>42 days*</td>
<td>£7M</td>
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<td>Total</td>
<td>19 months</td>
<td>£53.5M</td>
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*Does not allow for delays between campaigns
...New Tricks: Bypass Solution
...New Tricks: Bypass Solution
...New Tricks: Bypass Solution
…New Tricks: Bypass Solution

Bypassed Functionality

- Production choke valve
- Flowbase Isolation Valve (PFIV)
- D/S choke pressure sensor
- D/S choke temperature sensor
...New Tricks: Bypass Solution

Key:           Normally Open                            Normally Closed                               Failed (Open)

Tree
Flowbase

Future Tie-in Valve
Choke Skid

Production
Bypass Requirements

• Bypass is a DSV based approach
• Opportunity to improve existing field architecture

Equipped & Services Required

- DSV – isolation, repair & commissioning
- Proprietary choke bypass tool (modified)
- Remote choke skid (inc. valves and sensors)
- Choke control jumper extensions
- Tie-in spools

Improvements

- Increase LP hydraulic supply
- Local subsea control system isolations
- Include isolation points at future tie-in point

A presentation by Wood.
Bypass Scenario
Bypass Scenario

- **DSV Repair campaign: est. 21 days (inc. Mob)**
  - Assumed metrology spools delivered to worksite

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</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
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<tr>
<td>Equipment</td>
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<td>Lost Production</td>
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<td><strong>Total</strong></td>
<td><strong>21 months</strong></td>
<td><strong>£17.5M</strong></td>
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- **Actual repair time: 20 Days (inc. Mob)**


Approach Comparison

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<tr>
<th></th>
<th>Engineering &amp; Equipment</th>
<th>Offshore Campaign Costs</th>
<th>Deferred Production Costs</th>
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<tbody>
<tr>
<td>Tree Change</td>
<td>£11.5M</td>
<td>£35M</td>
<td>£7M</td>
<td>£53.5M</td>
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<tr>
<td>Bypass</td>
<td>£9M</td>
<td>£5M</td>
<td>£3.5M</td>
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<td>Saving</td>
<td>£2.5M</td>
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- Bypass Option was ~1/3 of the estimated cost
  - Repaired tree has been in operation since Q2 2018

- This was achieved by applying the same strategy to all elements of the system
Leak Bypass: Manifold Design
Case Study: Manifold Design

Traditional Design

Modified Design

Comparison
Manifold Requirements

Bypassed Functionality
- Production choke valve
- Flowbase Isolation Valve (PFIV)
- D/S choke pressure sensor
- D/S choke temperature sensor

Tie-in Functionality
- Well B tie-in
- Future tie-in point

Design Requirements
- Sour service materials
- Chemical injection
- Diverless choke insert change out
- Local hydraulic/chemical isolations
- Fishing friendly
- Gravity base
Traditional Manifold Design

- Sloped side gravity based design
- Removable roof & hinged side panels allow access for interventions
Traditional Manifold Design – Valves

- 4 x 6” Manual gate valves
- 1 x 1” Hydraulic gate valve inc. check valve
- 2 x ½ Double block and bleeds
- 1 x Production choke
Traditional Manifold Design

- Valves arrangement dictates size and weight of this structure
  - Valves arrangements were identified as key area for optimisation

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<tr>
<th>Item</th>
<th>Qty</th>
<th>Cost</th>
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<tbody>
<tr>
<td>6” Manual, Slab Gate Valve (5ksi)</td>
<td>4</td>
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<tr>
<td>½” Needle Valve Double Block and Bleed Assembly</td>
<td>2</td>
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<tr>
<td>1” Actuated Gate Valve with Check Valve</td>
<td>1</td>
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<tr>
<td>Structural Fabrication, Pipework and Assembly</td>
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<td>£840k</td>
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<td><strong>Total</strong></td>
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<td><strong>£1.3M</strong></td>
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Double Expanding Split Gate Valves

Equipment Overview

- First used subsea by Shell on the Pelican Expansion Manifold
- Seals are mechanically energised not pressure energised and spring loaded
- Mechanical rather than spring return prevents split gate not retracting on closure
- Allow for a double isolation to be achieved using a single valve
  - IMCA recognised
Modified Design – Valves

- 2 x 6” Manual double expanding gate valves
- 1 x 1” Hydraulic gate valve inc. check valve
- 1 x Production choke
Modified Design – Footprint Comparison
Modified Design

- Split Gate valves are more expensive on a 1-to-1 basis
  - ~£80k for manual gate valve
  - ~£95k for double expanding split gate valve
- Halves the number of valves required
- Removes the need for double block and bleed assemblies

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<td>Structural Fabrication, Pipework and Assembly</td>
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<td>£650k</td>
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<tr>
<td><strong>Total</strong></td>
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Manifold Design Comparison

- One of a number of non-traditional approaches taken
- All technologies used were field proven

<table>
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<tr>
<th>Item</th>
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<th>Expanding Gate</th>
<th>Saving / Reduction</th>
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<tbody>
<tr>
<td>Skid Length</td>
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<td>8.8m</td>
<td>1.8m</td>
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<tr>
<td>Skid Width</td>
<td>10.6m</td>
<td>8.8m</td>
<td>1.8m</td>
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<tr>
<td>Skid Weight (air)</td>
<td>75 Te</td>
<td>59.3 Te</td>
<td>15.7 Te</td>
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<tr>
<td>Valve Costs</td>
<td>£486.5k</td>
<td>£211.5k</td>
<td>£275k</td>
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<td>Skid Cost</td>
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<td>£861.5k</td>
<td>£438.5k</td>
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If you always do what you’ve always done, you’ll always get what you’ve always got.

- Source Unknown