Maintaining Structural Integrity of Ageing Platform Conductor Wells

P. Enuganti – 2H

IMechE Offshore Engineering
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Riser & Conductor Engineering

Houston | Rio de Janeiro | London | Aberdeen | Kuala Lumpur | Perth

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Prahlad Enuganti
8\textsuperscript{th} December 2015

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Agenda

- Introduction - 2H Offshore
- In-service Platform Conductor Wells
- Engineering Assessment of Aging Wells
- Repair/Remedial Measures
- Case Study

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Platform Wells – North Sea Status

- ~190 fixed platforms in the North Sea
- Average age of 18 years
- ~120 platforms > 15 years
- 50 facilities are 25 years or older and are still active
- Older conductors and surface casings may be subjected to corrosion with wall loss of 50% or more

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Degradation Mechanisms

- Corroded Conductor

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Degradation Mechanisms

- Valve meets conductor

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Degradation Mechanisms

- Connector Failure and Missing Centraliser

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Examples of Corrosion

- Shell, North Sea, 2007
  - 7+ well structural failures
  - Surface casing corrosion 11 mm (~43%)
  - Conductor corrosion of 15%
- 2H Offshore, Zadco, Abu Dhabi 2014
  - Conductor failures
  - Conductor corrosion 13mm (~60%)

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Factors Affecting Condition

- Well Design and Construction
  - Conductor or surface casing support of wellhead
  - Casing preload sharing between wellhead and shoes
  - Soil support

- Operational Loading
  - Severity of temperature changes and associated load redistribution
  - Loads from intervention equipment
  - Intervention platform motions

- Time Dependent Deterioration
  - Corrosion leading to wall loss
  - Ancillary equipment such as centralisers

Assessment required to determine need for action

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Potential Implications

- Inadequate extreme condition strength
- Ability to conduct work-over and drilling operations impaired
- Need to implement remedial measures / repairs
- Maybe none of the above

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Engineering Assessment of Ageing Platform Wells

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Engineering for Ageing Wells

- **Data Collation and Review**
  - Well arrangement, piling records, drilling records, operating temperatures, wellhead movements

- **Strength and Stability Assessment**
  - Extreme load analysis
  - Corrosion limit definition

- **Fatigue Assessment**
  - Gaps at guides (failed centralisers)

- **Management Plan**
  - Condition assessment tool
  - Corrosion measurement
  - Preload measurement
  - Remedial action plan

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The axial loads in the conductor and each of casings
- Initially based on well construction (top of cement in each annulus, soil etc.)
- Loading is dominated mostly from casing and tubing depths and weights
- Can change during the course of operations based on pressures and temperatures

Example 1 – Conductor Supported Wellhead
Example 2 – Casing Supported Wellhead
Example 3 – Load shared between conductor and casing

In each case, the inner strings could be partially bottom supported and the entire load is not applied on primary member

Load out calculations form basis for understanding current condition

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Assessment Tools

- Wells grouped into different categories
  - Well construction design/type
  - Cement levels
  - Preload
  - Operations

- Review stability, strength and fatigue performance

- Determine guidelines
  - Define critical component/location
  - Identify allowable corrosion limits
  - Determine repair / abandonment threshold

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Corrosion Measurement

- Measurement Requirements
  - Conductor supported wells – conductor
  - Casing supported wells – casing and conductor

- Coverage
  - Capture local circumferential defects – say 8 points around circumference
  - Capture local longitudinal defects – say every 0.5m

- Repetition, dependent on:
  - Previous measurements
  - Degradation rates
  - Measurement accuracy

<table>
<thead>
<tr>
<th>Elevation above Seabed (m)</th>
<th>WT Along Conductor Circumference (mm)</th>
<th>Mean WT Loss (mm)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0deg</td>
<td>90deg</td>
<td>180deg</td>
</tr>
<tr>
<td>Bottom</td>
<td>Top</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>28</td>
<td>16.0</td>
<td>16.8</td>
</tr>
<tr>
<td>24</td>
<td>26</td>
<td>17.2</td>
<td>16.5</td>
</tr>
<tr>
<td>22</td>
<td>24</td>
<td>15.3</td>
<td>17.5</td>
</tr>
<tr>
<td>20</td>
<td>22</td>
<td>14.5</td>
<td>16.0</td>
</tr>
<tr>
<td>18</td>
<td>20</td>
<td>15.0</td>
<td>16.5</td>
</tr>
<tr>
<td>16</td>
<td>18</td>
<td>8.7</td>
<td>9.0</td>
</tr>
<tr>
<td>12</td>
<td>16</td>
<td>11.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>
Why is it needed

- Casings might not be supported from surface as is conservatively assumed
- Any load path between casings or casing/conductor can redistribute loads on each string
- Any change in configuration (cutting of conductor, installation of tensioning clamp etc.) affects load distribution in the strings
- Significant improvements in strength response can be obtained upon demonstrating load relief
Repair and Remediation Solutions

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Remedial Actions

- Annulus corrosion – fill/top up annulus with rape-seed oil

- Casing – grout conductor/surface casing annulus, conductor mounted support clamps

- Conductor – centraliser replacement, weld-on or clamped sleeve reinforcement

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Middle East – Arabian Gulf

- Conductor & guide repair designs
- Crack growth mitigation
- Corrosion modelling (external & internal)
- Bolted sleeve design
- Conductor guide reinforcement
- 3D Finite Element Analyses

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Case Study
North Sea (Early 1990’s)

- Connector separation, centraliser degradation observed on 20” tieback
- Larger than expected gaps between the conductor and guides in the splash and wave zone region
- Wall thickness measurements were unavailable
- As-is condition strength response found to be acceptable for extreme 50yr and 100yr conditions

<table>
<thead>
<tr>
<th>Component</th>
<th>Elevation of Maxima W.R.T. MWL (m)</th>
<th>50Yr Wave and Current</th>
<th>100Yr Wave and Current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>As-designed</td>
<td>As-is</td>
</tr>
<tr>
<td>20 inch Casing</td>
<td>72.50</td>
<td>0.391</td>
<td>0.625</td>
</tr>
<tr>
<td>13 inch Casing</td>
<td>84.39</td>
<td>0.118</td>
<td>0.317</td>
</tr>
<tr>
<td>30 inch Conductor</td>
<td>0.00</td>
<td>0.105</td>
<td>0.103</td>
</tr>
</tbody>
</table>

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North Sea (Early 1990’s)

- Stability of internal casing affected in current configuration for different Baur&Stahl checks
- Interaction Ratios exceed 1.0 for as-is configuration for different load factors
- Remedial centraliser and/or removal of surface wellhead equipment improves stability of the casing

<table>
<thead>
<tr>
<th>100-Year Storm, Internal Casing Centralised</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Loading</strong></td>
</tr>
<tr>
<td><strong>Axial Load Factor</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>No Corrosion of External Casing</td>
</tr>
<tr>
<td>1.3</td>
</tr>
<tr>
<td>1.7</td>
</tr>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>3mm External Corrosion of External Casing</td>
</tr>
<tr>
<td>1.3</td>
</tr>
<tr>
<td>1.7</td>
</tr>
<tr>
<td>1.0</td>
</tr>
</tbody>
</table>

Notes:
- IR<1.0 required for adequate strength and stability
- 1.0<IR<4.0 indicates unstable configuration
- IR>4.0 indicates high instability

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North Sea (Early 1990’s)

- SCF of connectors is unknown and range of SCF’s are used for analysis
- Fatigue of as-is condition unacceptable for high SCF connectors
- Installation of remedial centralisers needed to improve fatigue

<table>
<thead>
<tr>
<th>Component</th>
<th>Un-factored Fatigue Life</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D Class Connector Weld</td>
<td>Connector SCF = 1</td>
<td>Connector SCF = 2</td>
<td>Connector SCF = 3</td>
<td>Connector SCF = 4</td>
<td>Connector SCF = 5</td>
</tr>
<tr>
<td>20 inch Casing</td>
<td>4,846</td>
<td>&gt;100,000</td>
<td>39,892</td>
<td>5,253</td>
<td>1,246</td>
<td>408.5</td>
</tr>
<tr>
<td>13 inch Casing</td>
<td>35,262</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
</tr>
<tr>
<td>30 inch Conductor</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design (years)</th>
<th>As-is (days)</th>
<th>Remedied with centraliser (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 inch Casing</td>
<td>777</td>
<td>526</td>
</tr>
<tr>
<td>13 inch Casing</td>
<td>595</td>
<td>17.5</td>
</tr>
<tr>
<td>30 inch Conductor</td>
<td>&gt;100,000</td>
<td>&gt;100,000</td>
</tr>
</tbody>
</table>

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Conclusions

- Most conductors on ageing platforms are fit for purpose
- Corrosion is biggest uncertainty affecting conductor condition
- Corrosion & centraliser degradation doesn’t imply a need for remediation/repairs
- A pre-emptive condition management strategy with regular inspections can ensure continued safe operations

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