Well Integrity and Corrosion inspection of surface casings and conductors of offshore wells with the D-PEC inspection technology

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Abstract. In the past years, the offshore industry has faced a new phenomenon of damage on their wells. The surface casing, on which the Xmas tree relies on for support, is collapsing because of corrosion.

As the number of incidents is increasing, reactive measures by mobilising local response teams are not appropriate any longer.

TÜV Rheinland Sonovation has a total well integrity concept available, which contains; -D-PEC, -Modern CAD/FEM tools, -Corrosion and chemistry analysis, global well safety analysis.

TÜV Rheinland Sonovation operates the D-PEC technology to be able to measure accurately the corrosion of the surface casing and the conductor at the splash zone level. D-PEC is an application for offshore wells, using pulsed eddy currents. The inspection can be executed during production of the offshore well.

The corrosion is unpredictable and concentrates mainly around the splash zone between the highest (HAT) and lowest astronomical (LAT) tide but can also be present at the top side and other locations of the well. The D-PEC probe will be inserted in the annulus between the conductor and the surface casing to make the measurements.

The technique has been validated and extensively proven in the field. The corrosion measurement has an accuracy of 10% at a 95% confidence interval.

The D-PEC corrosion measurement information is high value information for gaining advanced knowledge of the integrity of the offshore well to enable better planning of production and well-abandoning activities.

Introduction

In the past years, the offshore industry has faced a new phenomenon of damage on their wells. The surface casing and conductor on which the XMAS tree relies on for support, is collapsing because of corrosion. Safety of the well during production is at stake, but also safety during maintenance programs or abandoning activities is at stake because of this phenomena.
Corrosion at Surface Casing and Conductor

The XMAS tree relies for support on the surface casing. When the well is cemented, loads are partially offloaded from the surface casing to the conductor. During the inspection of hundreds of offshore wells by TÜV Rheinland Sonovation around the globe it was noticed that the corrosion is concentrated near the fluid interfaces within the “D” annulus (annulus between the conductor and surface casing). The fluid interface is between the highest (HAT) and lowest astronomical (LAT) tide. When wells were cemented, corrosion was measured at the top side of the well, close under the XMAS tree, because of moisture. Other facts which can be concluded from the measuring data of these hundreds of offshore wells are: -the corrosion cannot be correlated with the age of the well; -there is no correlation between corrosion on the conductor and corrosion on the surface casing; -there is no correlation between corrosion in different wells at the same platform. In a few occasions in just a few wells were corroded under one platform at random positions, while the other wells were not corroded at all.

TÜV Rheinland Well Integrity approach

In close partnership with one of the oil majors in Europe, TÜV Rheinland Sonovation developed a total approach to determine the integrity of offshore wells. The approach consists of the following activities; -Wellhead “gap” measurements; -Camera inspection; -D-PEC wall thickness measurement; -Fluid water samples; -Well Integrity calculations.

Wellhead Gap measurement: During the production phase of the well, wellhead growth caused by natural production and rise in temperature occurs. TÜV Rheinland Sonovation is using a standardised approach to measure the distances of the different parts of the wellhead against each other. For example the distance from the spacer rings to the supporting ring is measured, but also the distance from the platform deck to the side arms & valves of the wellhead. Photos of the wellhead position are made and included in the report. This is important information for future reference during monitoring campaigns.

Camera Inspection: A video survey is executed to determine the accessibility of the well annulus; -record elevations of features and conditions of centralisers, corrosion product, anomalies etc.; -measure fluid levels and observe fluid movements (bubbles etc); -measure elevation of tubular connectors. The results are reported and the video is stored and attached to the inspection report for future reference.

D-PEC wall thickness measurement
Pulsed Eddy Current (PEC) is an electromagnetic method to determine wall thickness of metal objects. A simplified explanation of the method is illustrated in the figures below. A magnetic field is created by an electrical current in the transmitting coil of the probe. This field penetrates through the marine growth and magnetizes the pipe wall. Cleaning of the annulus is not needed. The electrical current in the transmission coil is then switched off, causing a sudden drop in the magnetic field. As a result of electromagnetic induction, eddy currents will be generated in the pipe wall. The eddy-currents diffuse inwards and
decrease in strength. The rate of decrease of the eddy-currents is monitored by the PEC probe and is used to determine the wall thickness. The thicker the wall the longer it takes for the eddy-currents to decay to zero.

Collapsing primary field induces eddy currents, distributes in material and generates a secondary magnetic field.

The PEC instrument probe is lowered into the offshore well to measure the surface casing or the conductor.

The standard TÜV Rheinland Sonovation approach is to at least have two inspection runs executed on one wind direction of the offshore well. One run to measure the surface casing and one run to measure the conductor.

The probe is lowered into the annulus to a depth of maximum 50 meters and the following measurement elevation is followed:

<table>
<thead>
<tr>
<th>Distance from top of Conductor [m]</th>
<th>Measurement Interval [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0m to 3m</td>
<td>0.2m</td>
</tr>
<tr>
<td>3m to LAT-5m</td>
<td>0.5m</td>
</tr>
<tr>
<td>LAT-5m to LAT+2m</td>
<td>0.2m</td>
</tr>
<tr>
<td>LAT+2m to LAT+7m</td>
<td>0.5m</td>
</tr>
</tbody>
</table>

Positioning of the probe is done with a special developed “umbrella” which is deployed after the probe has been lowered in the annulus. A diagonal positioning measurement is done, to check if the probe is positioned perpendicular to the tubing under measurement. The quality of the PEC signals are real time controlled on the computer during the measurement.

The equipment is not intrinsically safe, therefore a hot work permit is required. For safety reasons a continuous double gas measurement is done. One gas measurement next to the wellhead on the outside and one gas measurement down hole in the annulus, just above the fluid level.

Fluid water samples;
From each well a sample will be collected of the fluid in the well for chemical analysis in a laboratory. Condition of rapeseed oil and potential bacterial corrosion can be determined and when needed inhibitors can be added to neutralise the potential damage mechanisms.

Well Integrity calculations:
The management of well integrity is a combination of technical, operational and organisational processes to ensure a well’s integrity during the operating life cycle.
Analyses of fatigue damage due to regional loads and new boundary conditions (long period of operation, bigger blowout preventer, vessels, etc.).

Load case calculation will be performed together with fracture mechanical break-before-leakage analysis. Wellhead fatigue can occur because of loads due to: - motion of the platform, - wave load (regional issues), - vibrations, - movement from Blowout-Preventer. Especially on low and high pressure casing, surface casing and welds of all casings, fatigue can occur.

3D numerical simulation and visualisation tools for realistic evaluation of material behaviour under external loading, together with 3D numerical computation for realistic assessment of external loading, leads to a reliable prediction of damage accumulation, development of recommendations for further safe operation.

**Conclusion**

-Advanced knowledge of well integrity enables better planning of production and well abandoning activities.
-Saves production and avoidance of unnecessary, costly remediation on non-corroded wells.
-Regular health checks of the corrosion status of wells will also help operators to plan more targeted and cost-effective workover programs.
-Considerable reduction of health, safety and environmental risks.