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Subsea Wellhead and Riser Fatigue Monitoring in a Strong Surface and Submerged Current Environment

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Abstract

A drilling campaign was recently undertaken by Shell Oil Company in a region with high surface and submerged currents. The water depth ranged from 5500-7000 ft at the various well sites in the region. Strong surface currents with maximum speeds of 4.5-5.0 knots were measured using an Acoustic Doppler Current Profiler (ADCP). In addition, submerged currents with maximum speed of around 1.5 knots were recorded. High fidelity Subsea Vibration Data Loggers (SVDLs) were used to monitor the in-situ riser and BOP stack vibrations due to the arduous current environment, as well as wave and vessel-driven motions.

A semi-analytical method was developed to estimate wellhead fatigue damage directly using the measured BOP stack motion data. High quality vibration data from the SVDLs were used in conjunction with analytical transfer functions to directly compute stress time histories and S-N fatigue damage at any location of interest in the conductor/wellhead/BOP system. The method was utilized in a larger fatigue reconstruction scheme that was applied to subsea wellhead and riser fatigue monitoring activities during drilling operations in the region. ADCP data was correlated to the SVDL data to determine the source of vibrations at low and high frequencies.

Simultaneous ADCP and SVDL data were also used to calibrate SHEAR7 v4.2 parameters. In between SVDL deployments, wellhead and riser stress and fatigue values were determined using the calibrated SHEAR7 models, driven by the measured current profiles. Wellhead motions were tabulated from ROV video and used to validate vibration reconstruction from the SVDL data and predictions from SHEAR7 simulation. Using these methods, stress and fatigue life consumption estimates are robust to unavailability of ADCP data and/or ROV video and/or data from one or more SVDLs.

Normalized vibration, stress and fatigue consumption are presented over the riser deployment period. It was found that moderate speed submerged currents, which extend over a broad range below typical fairing depths, lead to significantly higher wellhead stress and fatigue life consumption rate compared higher speed surface currents. The sensitivity of a typical wellhead and BOP stack to lower-frequency vibrations was examined. It is shown that because the submerged currents are of a lower speed, they excite modes that are closer in frequency to the “flagpole” mode of the casing/wellhead/BOP subsystem, leading to higher wellhead motion and stress.

The methods introduced herein provide rapid turn-around of raw data to fatigue consumption, enabling informed decisions to be made in adverse conditions. The methodology is easily extendable to real-time fatigue monitoring using a cabled system or acoustic modem to transmit data to the surface. In addition, the significance of regional submerged currents for wellhead stress and fatigue is highlighted, as well as considerations for vibration mitigation.