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Fatigue Monitoring of Flexible Risers Using Novel Shape-Sensing Technology

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Abstract

Flexible risers are subject to significant fatigue caused by both environmental impacts and vessel motions; specifically at the high stress hang-off point. Traditional monitoring systems estimate riser fatigue accumulation by monitoring vessel motions and employing complex theoretical models to estimate riser shape. An alternative approach selected by BP for the Schiehallion flexible risers was to implement a monitoring system that directly measures the motion of the flexible at a number of locations along its length. The system provides a direct measurement of the bending stress in two orthogonal directions. This enables an accurate calculation of the fatigue accumulation profile at each measurement location along the instrumented section of riser.

The monitoring system comprises of a glass fiber / epoxy composite Rod with a number of embedded optical strain gauges along its length. The Rod is mechanically coupled to the riser to follow the shape of the riser. The strain sensors within the Rod determine the curvature of the Rod and therefore the curvature of the riser. For Schiehallion the region of interest to be monitored was the hang-off area, and 5 measurement stations were configured within the rod at separations of 1m. The rod was 10mm in diameter and 40m in length. It was mechanically coupled to the riser by inserting the rod in a hole within the bend stiffener designed specifically for the application. Measurement instrumentation and a data logger were located in the turret. Workshop testing of the system has demonstrated significantly high resolution and accuracy such that all wave classifications could be monitored.

The configuration selected for Schiehallion was constructed to operate as a stand-alone system monitoring individual risers. Data is stored to a removable hard drive, which is removed periodically and processed to report on the flexible's operating conditions. Indicator lights on the

hazardous area acquisition enclosure define extreme operating events and threshold breaches.

Data from the monitoring system allows fatigue accumulation and damage rate for the flexible risers to be computed to ensure the flexible is operating within safe parameters. The direct measurement data can further be compared to theoretically predicted values to satisfy long-term integrity management philosophy and improve models.

This paper presents the first known direct measurement of the curvature magnitude and direction profile of a region of a flexible riser using fiber optic sensing technology.

Introduction

The BP Schiehallion field, located West of Shetland, is produced through an FPSO. As part of the Schiehallion NWAD Development (2006), an additional 9.5" production dynamic flexible riser was planned to be installed. BP also wished to incorporate a riser fatigue monitoring system as part of the campaign and chose to deploy a fiber optic shape sensing sensor in the bend stiffeners on the new NWAD 9.5" production riser and in the previously installed Phase III 9.5" production riser.

The shape monitoring systems collects real-time information about the curvature and orientation direction of the risers along the length of the bend stiffeners and can act as a warning system should the curvature and fatigue value exceed a predefined limit. Both bend stiffeners incorporate 14mm holes within which the optical fiber curvature sensor Rods are inserted post installation of the risers.

Currently the fatigue analysis is conducted based on the theoretical behavior of the riser. The wave spectrum is divided into 6 classes depending on wave height as shown in figure 1.