OTC 17864

Developments in Assessment of Fluid Loading Regime Contributions To Fatigue for Deepwater Flexibles

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This paper was prepared for presentation at the 2006 Offshore Technology Conference held in Houston, Texas, U.S.A., 1–4 May 2006.

Abstract

A large body of mostly contiguous structural monitoring data has been gathered for a dynamic deepwater umbilical in the UK Atlantic Margin. These data from the Foinaven FPSO have been the subject of extensive detailed scrutiny which has led to the development of techniques in fatigue assessment which have not previously been applied in such a detailed way to risers. From the outset the monitoring system was designed to separate the fluid loading contributions (and responses) owing to mooring system, vessel motions/wave action, and currents including VIV. This has enabled a clearer understanding of the relative importance of these various phenomena to emerge. Techniques which measure the frequency contributions of the responses, including improved methods which enable representations of variations with time (and thereby offering better insight with variations in fluid loading such as current and waves), have also been developed and implemented using these data. These techniques have also been adopted to enable alternative simplified means of assessment of fatigue damage to conventional rainflow counting. Examples of these behaviours are presented with general comments on contributions of the various loading components, and interaction effects. The implications for future monitoring and assessment strategies are discussed, along with those for existing data sets.

Introduction

Vortex Induced Vibration continues to be a source of major concern in the offshore industry, particularly with risers and umbilicals. The accurate prediction of response e.g. Lyons (1986a) proves to be rather difficult for realistic applications owing to the complexities of geometry and environmental loading.

Given this, it is preferable not to rely upon prediction alone, but also to monitor the behaviour in the installed condition. By this means it is possible potentially to take corrective action in advance of likely (fatigue) failure, and also to improve our understanding of the shortcomings of the predictions made. Part of the complexity of VIV response is as a consequence of marine riser and umbilical systems' ability to respond simultaneously to several (potentially many) modes of vibration. The extent to which this may happen is described as response bandwidth. Plainly it is of interest to measure this frequency response as well as having basic information concerning amplitude. Whilst it is possible to perform spectral analyses, this approach arguably provides too much information for routine consideration. A single-value measure of bandwidth variation with time (and varying environmental loading) referred to as epsilon has shown to be of practical use, Trarieux and Lyons (2003, 2004).

The utility of this function is increased by its application (with standard deviation) in a fatigue damage assessment method. This is demonstrated herein with data from the Foinaven Umbilical Monitoring System for which a wide range of umbilical response and environmental loading data are available. This system was developed and installed and is maintained by BPP Technical Services on the BP Foinaven Petrojarl IV FPSO in the Atlantic Frontier West of Shetland province of the UK. It was designed to measure (for the life of the field) the curvature in the umbilical along with vessel motions and environmental data. These data combined with current profiles enable effective analysis of the dynamic response of the umbilical. In the method presented, curvature time series are processed so as to identify in particular the occurrence of VIV using the bandwidth parameter epsilon. This is also extended to consider the relative behaviour for mooring and wave frequency contributions.

Nomenclature

a, b	empirical constants
D	fatigue damage
$E[D_{NB}]$	mean or expected value of D for narrow band stress
D_{RFC}	value of D using a rainflow counting technique