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Fatigue in Deep Water Steel Catenary Risers–A Probabilistic Approach for Assessment of Risk

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Abstract

Deep water developments are being pursued vigorously in various parts of the world (West Coast of Africa, Gulf of Mexico etc.). The riser system is a critical part of the field architecture. Riser failure results in reduction or cessation of revenue. It may also lead to spillage or pollution and could endanger lives. Hence, riser design must carry a high degree of reliability.

Steel Catenary Risers (SCRs) are considered to be technically feasible and commercially efficient solutions especially when high temperatures and pressures are involved. However, in terms of fatigue, SCRs are very sensitive to environmental loading. The procedure for fatigue analysis is essentially deterministic.

This paper concentrates on the *probability of fatigue failure* associated with the design of current practice of fatigue analysis of SCRs. The procedure is illustrated with sample calculations with first order vessel motion and a flow chart for assessing the probability of fatigue failure is also given. The example is chosen so as to highlight the issues involved. The probability of failure is used to determine the ‘safety index’. The probability calculations have been reformulated so that they are applicable for the design of SCRs. The probability of fatigue failure, associated with the recommended factor of safety in API RP 2RD, for the example chosen, is also reported. The overall aim is to increase the confidence in the design of such systems in deep water environment.

1.0 Introduction

A typical SCR attached to a Floating Production Storage & Offloading (FPSO) vessel and part of a deep water field development is shown in Fig. 1. The riser is continuously subject to oscillatory environmental loads. The principal source of structural loading is the ocean waves that impact the riser coupled with the complicated movements of the vessel which itself comprise high frequency response to the waves and low frequency (slow drift) excursion. This paper is concerned with wave induced fatigue only. Stresses resulting from environmental loading and corresponding structural dynamic response at a joint (node) are typically random in nature, as shown in Fig. 2. Metal fatigue in the weld at the joint, due to these oscillatory stresses, is one of the likely causes of failure.

Most vulnerable to fatigue are the welded joints near the touch down point (see Fig. 1) because of high cyclic bending stresses and stress concentration due to both joint geometry and weld defects.

Fatigue life prediction in SCRs is a complicated process involving many factors and has been discussed at length by Campbell (1999). Current practice, mainly deterministic in nature is summarised first.