

Coupled Spar Response with Buoyancy Cans vs. Tensioners

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ABSTRACT

Most of the Spars installed to date have used buoyancy cans to provide tension at the top of production/drilling risers. For moderate water depths, top tensioned risers with buoyancy cans are appealing because they do not impose vertical loads on the Spar hull and their vertical movements inside the center well are independent of the Spar hull itself. However, for ultra deep waters, top tensioned risers require larger buoyancy cans, resulting in a larger center well and larger Spar hull. Therefore, top tensioned risers with buoyancy cans could become uneconomical and might not be feasible for Spars in ultra deep waters. To date, technology in tensioners has advanced significantly. As a result, using tensioners at the top of a Spar hull to provide the required tension for production/drilling risers has become increasingly attractive for deeper water depths.

This paper assesses the effect of two different top tensioned riser configurations, risers with buoyancy cans and risers with tensioners, on the motion responses of a Truss Spar in a water depth of 5,600 ft (1,707 m). Motion analyses are carried out in time domain based on a fully coupled system in terms of mass, damping, and stiffness of the Spar, risers, and mooring. Nonlinear spring properties of tensioners and hydrodynamic loadings on the risers and mooring are included in the fully coupled analyses. The Spar motions with buoyancy cans are compared to those with tensioners. Differences in motions due to the use of buoyancy cans and tensioners are then discussed. In addition, a semi-coupled analysis considering only the riser and mooring stiffness is performed to evaluate the effect of mass and damping of risers and mooring on the Spar responses.

The results presented in this paper will provide an insight to the differences in Spar motion responses due to the use of buoyancy cans or tensioners for top tensioned risers. The findings should be beneficial for Spar design in an early project stage.

KEY WORDS: Spars; top tensioned risers; buoyancy cans; tensioners; semi-coupled; fully-coupled.

INTRODUCTION

A tensioning device is typically required to provide tension and support for dry tree risers in deep waters. Buoyancy cans and tensioners are the two most widely-used tensioning systems. Most Spars installed to date have used buoyancy cans to provide tension at the top of production/drilling risers. For moderate water depths, top tensioned risers with buoyancy cans are appealing because they do not impose vertical loads on the Spar hull itself, and their vertical movements inside the center well are normally not influenced by the Spar hull. However, for ultra deep waters, risers require larger buoyancy cans for tensioning, resulting in a larger center well and larger Spar hull. Top tensioned risers with buoyancy cans could thus become impractical and could pose a significant hurdle for Spars in ultra deep water applications. Tensioners, on the other hand, do not have negative impact on the center well and Spar hull sizes. But, they do add tension loads on the Spar hull and may have a functional constraint in terms of stroke requirements. However, it has been shown that the cost implication on Spars from tensioners due to additional tension loads and stroke constraints would be far less than that from buoyancy cans for ultra deep water. Technology in tensioners has also advanced significantly to date to accommodate larger stroke requirements. Therefore, using tensioners at the top of a Spar hull to provide the required tension for dry-tree production/drilling risers has become increasingly attractive for deeper water developments.

A deck mounted hydraulic tensioner system has been used on TLPs for vertical riser tensioning. Holstein was the first Spar to implement RAM type tensioners to support drilling/production risers (Perryman, Gebara, Botros, and Yu, 2005). The RAM style tensioner is a hydro-pneumatic passive tensioner system utilizing ram cylinders mounted parallel to the risers. Yang, Tahar, and Kim (2007) presented and discussed linear and nonlinear modeling of tension behavior of hydro-pneumatic tensioner and its effect on motion responses of a Spar.

This paper studies the effect of two different top tensioned riser configurations, risers with buoyancy cans and risers with tensioners, on the motion responses of a Truss Spar. The Spar is located in a water depth of 5,600 ft (1,707 m) in the Gulf of Mexico and is designed with a topsides payload of 10,000 short tons (9,072 tonnes). Motion analyses