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Improvements in Dynamic Loading of Ultra Deepwater Catenary Risers

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Abstract

This paper gives results of numerically modeling several examples of steel catenary risers (SCR's) with a variety of buoyancy and damping devices. Conventional and modified strakes, short segments of conventional plain cylindrical floats, and modified buoyancy units were investigated. A key configuration studied is a "short-lazy-wave" configuration where buoyancy is used on the lower section of riser of length equal to 10% of the water depth. The dynamics of variations of the short-lazy-wave SCR's are compared with that of similar conventional free hanging SCR's.

The variations and modifications of the buoyancy units and of the strakes involved adding damper/added mass surfaces, so that those devices increased the riser drag per unit length in up to three local dimensions: in the tangential, normal and bi-normal directions. The dampers can be installed on the riser in-between the conventional devices (i.e., strakes and floats). They can be attached to those devices or they can be built integrally with those devices. The devices investigated can be used with newly installed risers, but are also suitable for retrofitting existing risers.

The touchdown zone (TDZ) fatigue is one of the important design considerations of SCR's. In addition to controlling the SCR design, TDZ fatigue is significant enough that it can affect the selection and design of the production vessel. For the riser examples shown, most of the improvements achieved over the base case conventional riser were due to the decoupling character of the short-lazy-wave. The variations investigated resulted in a considerable increase in the TDZ fatigue life of the modified SCR's – fatigue lives were increased by between one to three orders of magnitude. In the cross and near configurations, using dampers on the buoyancy allowed fatigue life improvements above those pertaining to plain floats by factors of 1.05 to 4.4. Effective tension/compression was eliminated. Mean and maximum dynamic hang-off loads were decreased 13% to 24%. The configurations investigated may allow reductions in pipe wall thickness for new risers and they allow the use of SCR's in water depth/metocean conditions where it may be difficult or impossible to use free hanging risers. Of particular note is the possibility of using SCR's from FPSO's and semisubmersible in conditions which have heretofore been considered limiting.

Introduction

SCR's are commonly used in deep and ultra-deep water; they have traditionally provided a low cost and reliable solution for export lines and flowlines to/from remote wells and floating systems.

Design controlling limitations in use of SCR's are typically fatigue due to dynamic stresses at the top and in the touch down areas, and compression in large motion conditions. Fatigue due to dynamic stresses may also become more troublesome in particular where sour service is combined with high design pressures.