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# Understanding the Response of Pipe-in-pipe Deepwater Riser Systems

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## ABSTRACT

Pipe-in-pipe top tensioned risers, in the forms of TLP/Spar dry tree risers and freestanding hybrid risers, are used in numerous deepwater developments worldwide.

During the detail design of pipe-in-pipe systems, the complex interactions between the pipes are often misunderstood, leading to conservatism or possible errors in the estimation of the system fatigue life.

This paper aims to provide an explanatory note on the interaction response of pipe-in-pipe riser systems and the considerations that are required to assess the stress, fatigue and VIV response of such systems. The methods considered in this paper could also be applied to multi tube risers.

KEY WORDS: Risers; Pipe-in-pipe; Fatigue; VIV; Stresses

## INTRODUCTION

The industry has seen an increasing number of application of multiple pipe risers, ranging from TLP/Spar dry tree riser and freestanding single line hybrid risers, in deepwater. All these designs have a fundamental design challenge of determining the response of two or multiple pipes within the system, in order to determine the extreme stress and fatigue life over the length of the riser.

In all pipe-in-pipe risers centraliser are included in the design between the pipes and are considered essential to reduce differential bending in the system. Also centralisers can stop propagation buckling, when one string is in compression.

Analysis of pipe-in-pipe risers is often performed considering an equivalent composite model forming a unique pipe, as analysis of a detailed dual pipe model is considered time consuming. This assumes that the equivalent pipe bending and tension are shared equally based on the bending and tension capacities of the pipes. Using a composite model is justified if the pipes have equivalent differential bending or that the bending moment of the system is small, therefore little fatigue or minimal stresses in pipes is expected. However, for certain riser systems, where the bending moment is high near the top and bottom assembly of the structure, it is important that the interaction between the pipes is clearly understood.

In areas of high riser curvature, the presence of centralisers and/or contacts between pipes may lead to discrepancy in the local bending moment response compared to those predicted by using the equivalent composite model. Therefore a detailed FE analysis modeling the inner and outer pipes and interaction between them is necessary to determine the response of the individual pipes to insure that the local bending in one pipe is not under or over-conservative for extreme storm event or first order fatigue analysis. Results from this detailed analysis can then be used in conjunction with the equivalent model to achieve an accurate assessment of riser response.

A detailed model also enables the following centraliser design parameters to be considered:

- The maximum annular gap size requirement between the centralizer and the outer pipe.
- Number of centralisers.
- Optimisation of centralizer spacing.

The centralisers design parameters cannot be determined from the analysis of an equivalent pipe system. Usually the smaller the gap between the pipes, the better; the same applies for the spacing as the closer the centralisers are for each other, the more the pipe in pipe system will have a tendency to behave together uniformly. An example of centralizer design is given in Figure 1.

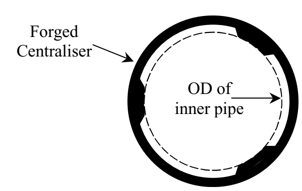


Figure 1 – Example of centraliser on outer pipe

Comparison between the equivalent pipe model and the detailed model leads to development of bending moment magnification factors which are used to understand to effect of the pipe-in-pipe system. Those