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Optimised Snaked Lay Geometry

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ABSTRACT

Global buckling of exposed HPHT (High Pressure / High Temperature) subsea pipelines has to be critically assessed during detailed design. By safely triggering controlled buckles at predetermined locations, snaked lay design is often the preferred method to manage lateral buckling. For a snaked lay design, a large number of sensitivity analyses would normally be performed to find an optimized configuration and verify code compliance. Because this is a very time consuming process, it is essential that the engineer acknowledges the main drivers that influence the snaked pipeline in-place behaviour. Using FE analyses, a parameter study is presented that establishes how variations in snake lay geometry influence the buckle initiation force and the resulting bending moments and strains in the buckle. Based on this, guidance of how to optimise the snake geometry is presented.

KEY WORDS: Lateral buckling, subsea pipelines, out-of-straightness, snaked-lay, finite element, high pressure / high temperature.

INTRODUCTION

The traditional method of controlling thermal buckling of subsea pipelines has been by trenching and burying, i.e. in order to constrain the pipeline configuration and prevent pipeline movement of any kind.

With the trend that subsea pipelines are being designed to operate under increasingly higher temperatures and pressures, the amount of required overburden to prevent upheaval buckling is becoming more uneconomical. Designers have increasingly addressed the thermal buckling issue by adopting an approach that allows buckling to occur provided it is demonstrated that the resulting high loads and deformations are acceptable.

This approach would normally involve ensuring that any axial thermal expansion is distributed among a number of controlled buckle sites rather than being concentrated at a few random locations. The common denominator for these techniques is to reduce the critical buckling force 'Fcr'(or the buckle initiator force) at the selected locations, which in turn increases the probability that buckles occur at these locations and at the same time reduces the probability of rogue unplanned buckles.

A number of recent industry projects have adopted techniques that increase the robustness for thermal buckling to occur at preferred locations. Some of the methods that have been used or assessed on recent projects to control the number of buckles are:

Using the terrain irregularities. Alone or in combination with other buckling and expansion control methods, the seabed terrain may include the required shape and distribution of vertical imperfections to ensure the appropriate distribution of buckles. Project references are the 10"-20" Åsgard Flowlines (Slettebø et al 2001) and the 42" Åsgard Transport (Nystrøm et al 2001).

Vertical Triggers. This method is most common for relatively flat seabed and requires pre-lay installation of artificial vertical imperfections, e.g. using rock berms or concrete or steel sleepers. These introduce point locations of lower buckling forces than naturally occurring vertical imperfections on the surrounding seabed and ensure buckling at these pre-determined locations. Projects where this has been adopted are the 42" Åsgard Transport (Nystrøm et al 2001) and the 8"/12" King PIP (Harrison et al 2003).

Snake lay. Zig-zag laying has been used on a number of projects over recent years. Two project references are the 16"/22" Penguin PIP (Matheson et al (2004)) and the Echo Yodel project (Wagstaff (2003)). Snake lay may also be used in combination with lateral counteracts to allow tighter radius curves than normally allowed by seabed friction alone.

A summary and general discussion of these and additional design strategies for global buckling control is discussed by Tørnes et al (2004)

SNAKE LAY GENERAL DESCRIPTION

The main purpose of installing deliberate horizontal lay imperfections is to trigger a sufficient number of thermal buckles at pre-determined locations along the pipeline so that the thermal expansion is distributed among a number of buckles rather than being concentrated at a few buckle sites.