

## Assessment of Free Spanning Pipelines Using the DNV Guideline

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### ABSTRACT

This paper addresses free span assessment of pipelines both in the design phase and during operation. The assessment is based on the new DNV Guideline for free spanning pipelines.

Free spans often become a problem both in the design phase and during operation of pipelines. The spans may develop due to several reasons such as installation on uneven seabed or due to scouring effects. Such spans may be subjected to fatigue damage caused by direct wave and vortex induced vibrations (VIV). Despite of the significant costs involved with free spans, they are normally designed according to unduly conservative concepts and very simple analytical methods.

An official DNV Guideline (draft version) for free spanning pipelines has been issued in December 1997. The objective of this guideline is to provide rational state-of-art design criteria and guidance on fatigue design methods for free spans subjected to combined wave and current loading. It is based on the technical development within free span technology in recent R&D project as well as design experience in recent and ongoing projects.

This paper gives a brief introduction to the DNV Guideline. Then strategies for different phases with respect to free span design and span intervention are discussed. Some examples are presented to demonstrate the use of these strategies in connection with the calculation methods and acceptance criteria given in the guideline.

Keywords: Pipelines, Free Spans, Vortex Induced Vibrations, Fatigue Calculations

### INTRODUCTION

Free spans often become a problem in pipeline design and operation due to uneven seabed or seabed scouring effects. The costs related to seabed correction and span intervention is often considerable. On the other hand the potential cost related to a fatigue failure of the pipeline are enormous. However, free spans are normally designed applying unduly conservative concepts and often very simple analytical tools. Therefore, a free span strategy that ensures an acceptable safety level at a minimum of costs is needed. Such a strategy must include accurate calculation methods and state-of-art acceptance criteria.

Assessment of free spans have during the last decade often been governed by an onset criteria for vortex induced vibrations. Given the maximum water particle velocity caused by wave and current, an onset criterion may be converted into a maximum allowable span length by making conservative assumptions about the boundary conditions and hence the natural frequencies of the spanning section.

Such a criterion has some obvious weaknesses. It is based on the extreme water particle velocity caused by combination of some extreme wave and current velocities. A rational extreme flow velocity for wave and current in combination with an additional safety factor must be capable of providing a sufficient safety margin against fatigue. The argument is that fatigue failure occurs if cross-flow vibrations can exist for a short period of time. This may be true for relatively short spans subjected to pure current but may not hold in general for extreme wave conditions or a wide scope of spans since the criticality of exceeding an onset criterion depends on the induced stress range as well as on the natural frequency. Hence, long spans may not suffer from cross-flow VIV. Further, it is in general difficult to define a single extreme flow condition sustained over a given time period that will cause a critical reduction in the fatigue life. A criterion based on fatigue will have contributions from a range of seastates over the lifetime of the pipeline, and thus, it becomes insensitive to the choice of extreme seastate parameters.

In recent years analysis tools and empirical models calibrated against test data to predict free span vibration of pipes exposed to various flow conditions have received increased attention. In order to reflect these developments a new DNV Guideline for free spanning pipelines has been issued recently. The objective of the Guideline is to provide rational state-of-the-art design criteria and guidance on fatigue design methods for free spans subjected to combined wave and current loading. The premises for the Guideline are based on the technical development within pipeline free span technology in recent R&D projects as well as design experience from recent and ongoing projects, see e.g. (Tura *et al.*, 1994) and (Mørk *et al.*, 1997).

The objective of this paper is to give an introduction to assessment of free spanning pipelines with respect to fatigue. The problems related to both design of pipelines on uneven seabed and assessment of free spans detected during survey are addressed. First, the detailed fatigue design criteria with appropriate load and response models are given and the different aspects relating to different life-cycle phases are discussed. The design procedure will be illustrated by an example. A more detailed discussion of the technical