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# Free-Span VIV Testing Of Full-Scale Umbilical

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## ABSTRACT

The general design procedures for free spanning umbilicals are discussed. They may be classified as something between risers, where in-line VIV response normally is disregarded, and free spanning pipelines, where in-line VIV-response controls the VIV fatigue damage.

To investigate this free span VIV test a 20m full-scale prototype-section of the Ormen Lange umbilical was tested in the Ocean Basin at MARINTEK. The umbilical consists of hydraulic stainless steel tubes and electrical and fibre optic control cables. The main objective of the tests was to verify VIV induced stresses.

The umbilical was heavily instrumented to acquire records of bending and axial strain and lateral acceleration in both cross-flow and in-line directions. A unique new instrumentation system was developed consisting of two separate instrumented cores (one with accelerometers and one with fibre optic strain measuring sensors) which were put inside and glued to each tube. The latter core was located inside the most critical tube for direct measurement of stresses.

The umbilical was towed from a carriage above the Ocean Basin in a speed range 0.3-2.5m/s, corresponding to Reynolds numbers 30,000-260,000. The velocities up to 0.9m/s represent full-scale velocities. The higher velocities were included for studying multi-mode response and critical Reynolds number response. The umbilical was tested bare and with different straked configurations.

The measured data has been extensively studied using statistical analysis, modal analysis and fatigue analysis. The tests gave high quality and consistent data. The key result from the tests was that measured fatigue damage was orders of magnitude less than obtained from standard design procedure. This was due to both lower cross-flow and in-line modal responses than assumed in standard design procedures.

The results are relevant for free spans with significant sag and may be important for future design of longer free span length of pipe lines and umbilcals.

## KEY WORDS:

Vortex Induced Vibrations; Free span; Prototype; Testing; Sag effect, Fatigue.

## INTRODUCTION

At the Ormen Lange field two umbilicals are to be installed from shore to the subsea templates. Each of the 120 mm diameter umbilicals are approximately 120km long and crossing a very uneven seafloor. The umbilicals are to be trenched into the seafloor. However, during the temporary phase, after laying and before trenching, the umbilicals will possess a large number of free spans. During the laying process a certain tension will be introduced to the umbilical, which will give a continual pretension of the umbilical at seafloor. This pretension should be a low as possible in order to reduce the number of spans and to reduce the length of the spans. However, a minimum pretension is needed in order to precise control the laying process of the umbilical, and there will also be some uncertainties related to the magnitude of the tension during the laying process. In the present case the actual range of pretension at seafloor was considered to be from near zero up to 15 kN. Questions were raised if vortex-induced vibrations (VIV) may cause fatigue of the internal tubes in the umbilical during this temporary phase.
To investigate this free span VIV test, a 20m full-scale prototype-section of the Ormen Lange umbilical was tested in the Ocean Basin at MARINTEK.

## EXPERIMENTAL SET-UP

**Test rig**
The rigid test rig shown in Figure 1has been used to suspend the umbilical horizontally. It consists of a horizontal truss girder of length 22 m used as support for the umbilical test section and a pretension/axial stiffness system to give the specified axial stiffness and to handle the rather high axial tensions, which were up to 15kN. The test rig is a re-built version of the test rig used in the previous Ormen Lange single span and multispan large diameter pipe tests (Nielsen et al., 2002), except the length has been extended and the pre-tension