Proceedings of the Eighth (1998) International Offshore and Polar Engineering Conference
Montréal, Canada, May 24-29, 1998
Copyright © 1998 by The International Society of Offshore and Polar Engineers
ISBN 1-880653-34-6 (Set); ISBN 1-880653-36-2 (Vol. II)

Finite Element Analysis of Pipeline Bundles on Uneven Seabed

Olav Fyrileiv and Asle Venås
Det Norske Veritas
Høvik, Norway

ABSTRACT

This paper discusses different finite element models to assess the structural integrity of pipeline bundles installed on uneven seabeds.

A pipeline bundle consists of an outer carrier pipe and several internal flowlines. This concept offers many advantages compared to conventional pipelines such as fabrication and pressure testing onshore, simplified installation, thermal insulation and mechanical protection of the internal flowlines. The high bending stiffness of the bundle cross section implies that longer free spans can be accepted compared to the case where the flowlines are installed separately. However, large axial compression forces may develop in the bundle due to high operating temperatures and pressures in the internal flowlines. These forces may give raise to significant additional bending in free spans due to second order effects.

Some of the compression force is released at the bundle ends due to axial expansion. Restraints at the ends and soil friction acting along the carrier pipe may, however, give raise to high compression forces, particularly for long bundles. The high bending stiffness in addition to the lateral soil resistance normally prevent lateral buckling when the bundle rests on a flat seabed. However, the second order bending effects caused by the compression forces have to be considered when the bundle is to be installed on an uneven seabed.

In this paper the second order bending effects arising from the compression forces in bundles are addressed. Different finite element analysis models to assess the structural integrity are described. These models are applied to a real life case and the results are discussed.

Keywords: Pipeline Bundles, Uneven seabed, Finite element models, Non-linear effects.

INTRODUCTION

Often several interfield flowlines are needed to connect the subsea wells and the production and exportation facilities in an offshore oil/gas field. If several flowlines run in parallel it may be beneficial to bundle them into an outer carrier pipe. Then the internal flowlines are kept in place by spacers at regular intervals. In fig. 1 a bundle with three internal flowlines is shown. These are placed within a larger diameter pipe, a sleeve, with an external insulation layer. Spacers ensure that the flowlines and the sleeve are kept in position within the outer carrier pipe.

Up till now nearly 30 pipeline bundles have been installed by the controlled depth tow method (Fielding, 1997). The first one was installed at the Murchison field in 1980. The longest pipeline bundle installed is the 6950 metres long, 40" bundle at the Piper/Saltire field. Fabrication and installation limits the total length of bundles. However, the total length may within some practical/economical limits be increased by use of intermediate towheads and several bundle sections.

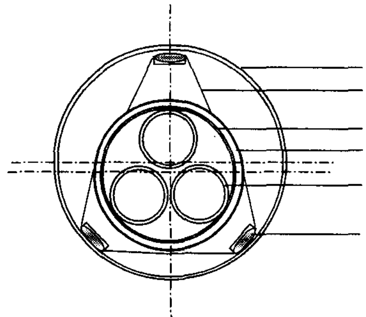

Fig.1 - Cross-section profile of a bundle with three flowlines and internal spacers.

Pipeline bundles offer the advantages of fabrication onshore under well-controlled conditions. Testing of the complete system is also performed onshore. Bundles may be installed as a whole system with integrated manifolds, riser bases and valve stations.

The carrier pipe offers mechanical protection and a corrosion free environment for the flowlines. Trenching or burial for protection against trawling loads and for stability reasons is avoided. The bundle concept also offers possibilities for thermal insulation of the flowlines in addition to heating and cooling systems if such are needed to avoid waxing and hydrate problems.

In the controlled depth tow method the bundle with its towheads is towed to the field between two tugs. Then it is suspended in a controlled way by means of buoyant volumes and chains and installed in its final position at the seabed. This implies a simple and