Proceedings of the Seventeenth (2007) International Offshore and Polar Engineering Conference
Lisbon, Portugal, July 1-6, 2007

ISBN 978-1-880653-68-5; ISBN 1-880653-68-0(Set); ISSN 1098-6189 (Set)

Advances in 3-D FEA Techniques for Metallic Tube Umbilicals

Ian Probyn (DUCO), Alan Dobson (DUCO), and Michaël Martinez (IFP)

DUCO LTD.
Newcastle upon Tyne
UK

IFP (Institut Français du Pétrole)
Applied Mechanics Division
Vernaison
France

ABSTRACT

This paper describes the application of FEA techniques to assess the structural performance of a subsea umbilical system. A 3-D FEA (finite element analysis) model of a steel tube umbilical was constructed and validated against full scale test data for tensile, bending and crushing loads cases. Once confidence in the validity of model had been gained, it was used as a virtual prototype to simulate an installation load (combination of tensile load and bending, as well as contact force between components) which resulted in plastic straining of the steel tubes. During this operation, ovality of the steel tubes was monitored to assess handling limits.

KEY WORDS: Finite Element Analysis, FEA, Umbilical, DUCO, IFP.

INTRODUCTION

The primary function of a subsea umbilical is to provide a control and supply link between top side vessels or platforms, to subsea oil and gas equipment, or subsea links between equipment. A typical steel tube umbilical is shown in Figure 1. The specific design is dependent upon the requirements of the particular application but typically an umbilical will consist of the following components;

- Fluid Conduits
  - Hydraulic supply and control.
  - Chemical injection for flow assurance.
- Electrical Cables
  - Electrical power supply for subsea pumping.
  - Electrical control.
- Fibre Optic Cables
  - Subsea monitoring and data acquisition

In addition, shaped thermoplastic fillers are used to separate components and fill out voids in the cross section. Each layer is helically wound and wrapped in fibre reinforced tape to provide radial reinforcement and a protective polymer outer sheath provides mechanical protection.

An umbilical is either designed for dynamic or static service. A static umbilical is installed along the seabed or trenched and once installed the fluid conduits are only subjected to internal and hydrostatic pressure. This type of umbilical is used to connect subsea equipment, or provide long distance tie-backs to onshore control centres, or fixed platforms. A dynamic umbilical is used to link a floating top-side vessel to subsea equipment and is designed to withstand high pressure fluid containment and a high tensile load with fluctuations generated by the vessel motion causing fatigue mechanisms.

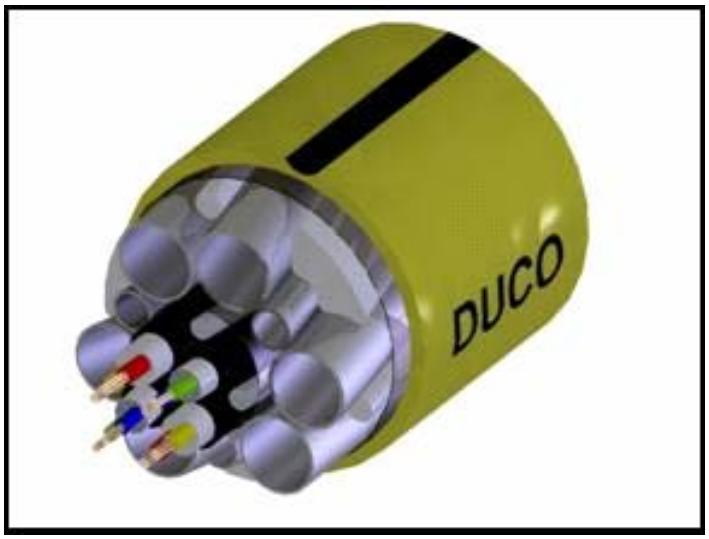

Figure 1 – Typical Steel Tube Umbilical

Umbilicals are typically installed by spooling off a carousel via an over-boarding chute which guides the product in a controlled radius over the vessel side, or through a VLS (Vertical Lay System). The principle of a VLS is to hold the umbilical in a vertical position through radial compression between three or four caterpillars. During installation a nominal internal pressure of 69 bar (1000psi) is typically applied to the tubes to monitor integrity, prevent hydrostatic buckle propagation subsea, and increase crush resistance. A consequence of deeper water operation is greater installation loads for both static and dynamic umbilicals which can expose components to undesirable loading conditions due high tensile load coupled with low radius bending. As a result, plastic deformation can occur and understanding