

Subsea control and chemical injection umbilicals are becoming a major component in the development of new offshore oil fields. This is seen in the move, by an increasing number of oil and gas companies, towards the use of subsea production systems.

These systems are tied back to an adjacent installation by at least one umbilical, depending on the complexity of the wellhead. They are then able to be remotely controlled by electric, and hydraulic signals sent through the various copper conductors and hoses contained within the umbilical.

Owing to the differing conditions, and hence requirements, of each subsea production system nearly every umbilical will have a unique design. Also, as there is often no redundancy built into this vital communication link the umbilical becomes a very high cost/risk product. Therefore minimising the risks to the umbilical is of great importance.

Invariably, once installed and trenched, umbilicals operate under static conditions. They are therefore designed primarily for a static application. During manufacture and installation though, an umbilical will experience dynamic loading.

High cost prohibits the manufacture of fully dynamic umbilicals for all applications. It is therefore essential to know the limits, of each component of the umbilical, under loading. A full understanding of the loading conditions the umbilical will experience during manufacture, installation and operation is also required to enable risk minimisation.

Installation Operations

Simultaneous lay and trench operations can subject an umbilical to the highest loads of its service life. The greatest potential for damage, to the umbilical, will occur during unexpected vessel motions as a result of adverse weather conditions, and especially when laying needs to be stopped due to an installation equipment failure. This can lead to an umbilical being kept suspended from the lay vessel for substantial periods. The vessel motions subject the umbilical, in its catenary configuration, to continuous bending. This occurs mostly at the sea bed touchdown point and at the departure point from the lay chute.

Careful assessment of the lay operation, throughout its duration, is needed to ensure none of the umbilical structural limits are exceeded. As the vessel motions are the main risk to the umbilical, by relating these to the resulting forces experienced by the umbilical, a method of assessing the lay operation conditions can be established.

Umbilical Structural Analysis

The first stage is to carry out a structural analysis of the umbilical to be installed. This involves using advanced structural analytical models to predict the axial, torsional and flexural mechanical behaviour of the whole structure. Minimum bend radius values can be obtained for each component of the umbilical which will then give the limiting bend radius for the umbilical as a whole.

Vessel Motion Analysis

The second stage involves analysing the motions of the lay vessel. Hydrostatic and hydrodynamic analyses are carried out using pressure integration, and

three dimensional diffraction methods respectively. The latter give the required information about the vessel accelerations due to wave induced motion.

Umbilical Dynamic Analysis

The third stage consists of taking the results from the previous two stages, and using them to perform hydrostatic and hydrodynamic analyses on the umbilical. Firstly, the catenary profile is calculated, and then the umbilical is loaded with the wave forces, and vessel induced excitations, which are to be expected during the lay operation.

This stage is carried out using a finite element method. The results enable lay operational limits to be made. This can be done by relating the vessel heave accelerations, to the respective induced maximum bending moment within the umbilical, taking account of the values produced in the structural analysis together with appropriate safety factors.

Installation Monitoring

The final stage is to monitor the actual installation of the umbilical from the lay vessel. By measuring the vessel accelerations, an instant value of maximum bending moment can be obtained during the lay-out. This data can be recorded to form short, and long term time histories of the operation, with respect to the forces induced by the vessel into the umbilical. At any time during the operation, the data can be examined giving an insight into the trends of the vessel motions, and hence the umbilical loading conditions due to the weather conditions.

BPP-TECH has the in-house capabilities to carry out umbilical structural and installation analyses for clients.