TRACKING CHALLENGING GAS PIPELINE CONDITIONS

Monitoring Ormen Lange

Ormen Lange is a large gas field in the northern North Sea (the Norwegian Sea) at water depths ranging from 800 to 1,100 metres and close to the back wall of the Storegga sub-sea rock slide. The slide left an extremely rough seabed with a profusion of hills and valleys. This article focuses on the pipeline from field to on-shore processing facilities and presents solutions to strong currents and rough seabed. Ormen Lange is estimated to be the second largest gas field on the Norwegian shelf. Norsk Hydro is responsible for the development phase of Ormen Lange and has extensively explored the field in close co-operation with Norwegian scientists ever since its discovery in 1997. A key issue has been whether something similar to the Storegga slide may happen again. The conclusion is now that conditions that caused the Storegga slide are no longer present.

Field Conditions

The field consists of 24 sub-sea wells in four seabed templates. The gas will be transported through 120-kilometre pipelines from depths of 850 metres to the on-shore production facilities in Aukra (Nyhamna). Current conditions are variable, with observed currents close to the bottom of 60cm/s. Depth, unpredictable and rough seabed, strong currents, temperatures below zero, extreme winds and enormous waves make Ormen Lange an extremely challenging task. The Ormen Lange field probably poses the biggest challenge in Norwegian offshore history so far, see Figure 1. The interface between warm Atlantic water and cold Norwegian Sea water has a strong influence on the current conditions at Ormen Lange and at the slope of the continental shelf. The interface between the water masses here lies at approximately five to seven hundred metre depths but the interface depth is very variable, from up to three to four hundred metres and down to eight to nine hundred metres.

This stratification has a strong influence on current conditions. Current meters have been deployed to measure the current conditions along the path of the pipeline. Current conditions have been simulated and analysed in papers and theses. The influence of near-bottom currents on the pipelines and seabed constructions has been assessed. Analyses indicate that near-seabed currents at Ormen Lange show significant spatial and temporal variability. Events where the near-bottom current exceeds 60cm/s have been observed. The mechanisms behind the events vary, but currents and internal waves generated by atmospheric forcing are probably the dominant reason, together with internal pressure gradients.

Vibration Monitoring

The pipeline route from Ormen Lange to Nyhamna goes though areas of thirty to sixty-metre high hills. The route has been prepared to make it smoother but this rough terrain means that several segments of the pipeline are not in contact with the seabed. These long, free spans and variable oceanographic conditions call for a reliable and efficient monitoring system during operation of the pipeline. Strong sea currents (Figure 2) may induce vibration in the free spans, which may in turn cause leaks or even breaks in the pipe. The Norwegian government required development of a vibration monitoring system to identify movement that might result in damage. Bjørge AS is thus to install its solution, a long-term vibration monitoring system based on NAXYS technology, on the pipeline when it goes into production in 2007. Synchronised measuring points called “Clamp Sensor Packages” (CSPs) are attached to the pipeline at regular intervals to record vibration in all three axial directions. The CSPs are controlled by an inertial “Master Sensor Package” (MSP), which is installed on the seabed. The MSP records water current, salinity, temperature and pressure, for complete characteristics. The links between the CSP and the MSP units are wireless, via acoustic modems.

Power consumption is a key issue forthis monitoring system. Sleep mode is extensively used to save power, and the sensors may be polled at different times. Aanderaa Data Instruments (AADI) in Bergen, Norway has de–livered the sensors for conductivity, current, temperature and pressure. Low power consumption and ruggedness having been two major issues in their design. The monitoring system offers three basic modes of oper–ation:

-long-term data logging: the MSP wakes up at a configurable time interval, typically every three hours; it first measures distance to each CSP for compensation, then distributed analogue data recording at 10 to 20Hz for ten to thirty minutes is initiated by sending a group call to all CSP nodes. The MSP then starts reading water current, salinity temperature and pressure through serial interfaces. When logging is finished the data is processed and stored to removable memory. After programming the next wakeup, (RTC) both the MSP and CSPs go to sleep andthe whole process is repeated.

-event monitoring: there is continuous monitoring of all vibration and water-current levels. If the MSP detects high water-current values or any CSP whilst asleep detects acceleration values higher than predefined limits it wakes up and sends a signal to the MSP to initiate the logging scheme. A CTD measurement is then taken, in addition to a current measurement. The current measurement is taken as an averaged value over a predefined measurement time.

-ROV rendezvous: the monitoring system is installed and maintained by remote operated underwater vehicles (ROV). Through acoustic communication with ROV or topside modem all vital parameters can be changed at run time, as well as uploading of sampled or Fourier-analysed data for a requested time period. ROV are able to request data from either a CSP or MSP at any time and in parallel with itscurrent mode of operation. This reliable communication interface is a key feature of the embedded hard- and software.

Built-in Redundancy

Redundancy was a big challenge in this system. Every action is monitored for errors. In the case of such an error a node performs self-correction and informs its caller of the situation. All nodes communicate to decide if the error is within the node itself or any other. If the real MSP fails any CSP can become the new MSP to sustain the operation. The pipeline monitoring system has a life–time of several years and will be submerged for at least six months at a time, thus the highest demands are placed on hard- and software re–liability, in-program error-handling and efficient energy management.

Concluding Remarks

The Ormen Lange project is the largest Norwegian industrial project ever. The project has challenged the oil industry and pushed technologic-al limits. Large scientific programmes have been conducted for exploration purposes and valuable experience and knowledge has been gained. Production is due to start in October 2007 and this will represent a milestone in the history of the oil industry.