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Permanent Fibre-optic Seismic System for Increased Hydrocarbon Recovery

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SUMMARY

Permanent seismic installations at the sea-floor have emerged as a potential tool for oil companies in their work to actively monitor oil/gas flows and injection processes in order to increase hydrocarbon recovery and optimize production. The passive nature of fibre-optic sensors, embedded into 4C receiver station, is an advantage since the in-sea sensor equipment is not prone to electrical noise, leakage and short circuit, in addition to that the life-time of the buried sensors may be longer compared to electrical systems. Fibre-optic based permanent seismic monitoring systems represent a great opportunity for the field engineers, in a cost effective way, to optimize production and increase the hydrocarbon recovery rate from existing fields.

Permanent seismic installations at the sea-floor have emerged as a potential tool for oil companies in their work to actively monitor oil/gas flows and injection processes in order to increase hydrocarbon recovery and optimize production (Figure 1). The passive nature of fibre-optic sensors, embedded into 4C receiver station, is an advantage since the in-sea sensor equipment is not prone to electrical noise, leakage and short circuit, in addition to that the life-time of the buried sensors may be longer compared to electrical systems (Thompson et al. 2006). Low power loss and large bandwidth of optical fibres enable extremely high data transmission rate over long lead-in cables and capability of transmission of huge amount of information over tens of kilometres when the field is operated from sub sea installations and the platform may be several kilometres away from the producing wells. Fibre-optic sensor systems allow for all the sophisticated instrumentation to be located at the surface, which makes it easy to maintain and upgrade and the in-sea receiver equipment is potentially less expensive than electrical receiver systems. Each 4C ocean bottom seismic station consists of an optical 3C-accelerometer unit and a fibre-optic hydrophone. The developed fibre-optic seabed monitoring system is scalable with a possibility to handle channels counts beyond 10,000. Depending on receiver station interval and receiver line separation, this should enable any field operator to cover reservoirs with seabed receivers in order to monitor the production area of interest. Analysis of the data from the pilot tests, and comparison with electrical receiver systems (Figure 2), confirms the fibre-optic system high degree of vector fidelity, high signal-to-noise ratio, very good ground-station coupling, reliability and excellent response in general to wave modes in connection with ocean-bottom seismic. Through the field tests, we have demonstrated that fibre-optic sensor technology can be utilized in permanent ocean bottom seismic applications. Fibre-optic based permanent seismic monitoring systems represent a great opportunity for the field engineers, in a cost effective way, to optimize production and increase the hydrocarbon recovery rate from existing fields. Permanent seismic installations have been introduced to offshore fields in Europe (Barkved 2004) and Caspian, and this technology should be taken into account as future field infrastructure in order to optimize oil and gas recovery from fields in the Middle East and North Africa region.

Figure 1: Permanently installed seismic cables.

Figure 2: Comparison of data from fibre-optic and electrical receiver systems.

Thompson, M., Amundsen, L., Karstad, P. I., Langhammer, J., Nakstad, H. and Eriksrud, M. [2006] Field trial of fibre-optic multi-component sensor system for application in ocean bottom seismic. 76th SEG Conference & Exhibition, Extended Abstracts 1148-1152.

Barkved, O. [2004] Continuous seismic monitoring. 74th SEG Conference & Exhibition, Extended Abstracts 2537-2540.