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Hydraulic Intelligent Well Systems in Subsea Applications: Options for Dealing with Limited Control Line Penetrations

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Abstract

Throughout the past decade, the reservoir management and interventionless flow control benefits of Intelligent Well Systems have made them a perfect fit for deepwater developments. Approximately 90% of current deepwater wells are subsea, and the number of subsea wells is expected to continue to grow. To enable subsea operators to reap the rewards of intelligent well technology, the industry (operators and service companies) is working to interface downhole intelligent well equipment with subsea trees and controls. Currently, the hydraulic penetration requirements of intelligent wells and the limited number of hydraulic penetrations in many existing subsea trees prohibit some subsea operators from using intelligent well technology. Manufacturing lead times for subsea trees and control systems are usually quite long. Rather than interrupt rig and operation schedules for an extended period while waiting for new equipment with more penetrations, operators often choose not to run intelligent well systems, and sacrifice the resulting benefits.

This paper will address various technologies and methodologies that are currently available to enable operators to benefit from intelligent well technology in subsea wells with limited number of penetrations. The case histories covered will illustrate how it is possible to reduce the number of hydraulic control lines required to remotely operate downhole flow-control valves without sacrificing overall system reliability.

Introduction

The industry has generally defined Intelligent Wells as wells equipped with downhole remote flow-control devices used to open, close, or regulate flow from and to multiple zones without the need for well intervention. Furthermore, Intelligent Wells are usually complemented by downhole permanent monitoring systems which provide valuable information used in the decision making process for the control of production or injection. All these systems require multiple control lines and cables to link the downhole tools to the associated surface equipment which serves as the interface between the operator and the system.

Subsea systems are employed in deepwater applications or in shallow water fields where the economics do not justify the construction of dedicate platforms to support the wells. In subsea systems, the wellhead and Christmas trees are installed on the seabed and are submerged in the water, hence the name “wet trees.” Wet trees, just like the surface “dry trees,” provide a means of controlling the wells through a series of valves, piping, chokes and other related equipment. Subsea trees can be manually controlled by divers (shallow water operations) or by remote-control systems by means of hydraulic actuators. These control systems can be on surface linked to the trees by means of dedicated lines in an umbilical or they can also be sophisticated electro-hydraulic multiplex systems mounted on the trees, controlled through a subsea electronic module.

Electro-hydraulic multiplex systems are becoming more popular due to faster response time, increased reliability, and lower umbilical costs. These subsea control systems not only need to control functions on the trees, but also need to be able to interface with and control downhole equipment (i.e. safety valves, downhole chemical injection valves, permanent instrumentation, and intelligent well valves). Penetrations through the tubing hanger provide a means of communication between the subsea control system and the downhole equipment. Subsea control systems normally have two hydraulic circuits for controlling downhole functions: one high pressure (HP) normally dedicated for the safety valve and one low pressure (LP) normally used for the intelligent flow control valves.