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COMPUTER ASSISTED WELL CONTROL FOR DEEP OCEAN ENVIRONMENTS

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ABSTRACT

A study has been completed to develop improved safety systems and procedures for reducing the risk of surface and underground blowouts in deep ocean environments. The deep ocean well control system developed has been designed to assist in the removal of kick fluids from the well bore by providing improved down hole pressure control during the well kill operation. Improved bottom hole pressure (BHP) control reduces the risk of a blowout by decreasing the potential for formation breakdown and for secondary kicks.

The tedious tasks of manually controlling the choke and mud pumps during the well kill process have been automated, affording the operators more time to focus on higher level decisions. A mud pulse telemetry system was incorporated in the test system to demonstrate that down hole data can potentially be used as the controlling parameter(s), eliminating the need to base decisions solely on surface pressures as is currently done. Inclusion of measurement-while-drilling (MWD) technology as part of the well kill operation expands the horizon for novel approaches in kick fluid removal from the well bore.

Development and testing of the system was completed at the Louisiana State University Petroleum Engineering Research and Technology Transfer Laboratory (PERTTL). A subsea-configured well simulating 3,000 feet of water and 3,000 feet of sediments and a 6,000 foot surface-configured well were utilized for testing. A test matrix inclusive of 20 natural gas kicks and in excess of 30 simulated salt water kicks was completed for system evaluation. Results indicate that BHP can be maintained to within ±20 psi, contrasting the ± 200 psi commonly incurred by experienced operators completing manual well control exercises utilizing the same facility. Not only is safety improved through better BHP control but also the reduction or elimination of repetitive and tedious tasks, such as pump and choke control, increases safety by alleviating operator stress.

INTRODUCTION

Today's technology within the oil industry supports exploration for new hydrocarbon reserves further offshore and at water depths approaching 7,000 feet. Well control planning has proven to be expensive and difficult to achieve when drilling in this environment, routinely requiring sophisticated well plans. However, increased well plan sophistication has not prevented the occurrence of kicks, the unintentional flow of formation fluids into the well bore. Maintaining proper control during a well kill operation is the focus of this study, realizing that loss of control can lead to either a surface or an underground blowout. Blowouts, the uncontrolled flow of formation fluids, can be catastrophic with the potential for loss of life, extensive environmental damage, waste of valuable natural resources, and loss of rig equipment.

Three geological phenomena, not inclusive of all factors, make well control for deep water operations much more difficult than for land. Those considered most important for this study include reduced fracture gradients for increased water depths, abnormally pressured formations commonly encountered at shallower solids penetration depths, and the frequent presence of natural gas as the formation fluid.

Figure 1 demonstrates the reduction in fracture gradients experienced offshore as compared to land operations. All fracture gradients shown are representative for solids penetration depths of 3,500 feet and are expressed in units of equivalent pounds-per-gallon (ppge). The reduced fracture gradients are basically a function of less dense sea water being present in lieu of solids, resulting in a reduction in the total overburden pressure at depth. As a consequence of the reduced fracture gradient, the margin for operator error and the kick fluid volume that can be safely removed from the well bore is diminished.