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Experimental Study of Erosion in Diverter Systems Due to Sand Production

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ABSTRACT

When drilling from a bottom supported structure, the best procedure for handling a threatened blowout from a shallow gas formation is to divert the gas flow away from the structure and drilling personnel. Case histories were reviewed in which failures occurred during diverter operations due to erosion caused by sand production. A model diverter system was constructed to evaluate this problem and provide information that can be used in the design of diverter systems. A number of pipe fittings used at bends in diverter systems were experimentally evaluated. The effect of flow velocity, liquid content, and sand concentration were included in the study.

It was found that very rapid wear can occur at velocities near sonic velocity. Wear rates of 8-in./hr were measured for short radius "Ells." The rate of erosion was found to be about two orders of magnitude higher for gas/sand mixtures than for liquid/sand mixtures. An equation was developed for predicting the wear rate for various field conditions. Recommendations are given for improving the erosion resistance of diverter systems.

INTRODUCTION

Blowouts are among the most dangerous hazards of offshore oil and gas exploration. When a well threatens to blowout, the quick use of properly designed blowout prevention equipment is necessary to avoid harm to personnel and loss of the drilling structure. Well control is especially difficult when a threatened blowout situation occurs at a shallow depth, prior to setting surface casing in the well. Under these conditions, closing the blowout preventers can lead to severe well control complications. If the well is closed at the surface, hydraulic fracturing is likely to occur in an exposed shallow formation due to the build-up of pressure in the well. If one or more fractures reach the surface, the resulting flow can destroy the foundations of a bottom-supported structure (Figure 1).

Tables and illustrations at end of paper.

Because of the difficulties in handling gas flows while drilling at shallow depths, considerable attention should be given to preventing such flows when planning the well and when drilling the shallow portion of the well. Seismic techniques and data from nearby wells can sometimes be used to identify potential shallow gas zones prior to drilling. These data can also be used to estimate formation pore pressures and required mud weights to safely control the well through these zones. If localized gas concentrations are detected by seismic analysis, hazards can sometimes be reduced when selecting the surface well location.

Unfortunately, use of existing technology does not always prevent the occurrence of shallow gas flows. Historical drilling records since 1965 for the Outer Continental Shelf of the Gulf of Mexico indicate that shallow gas flows have been encountered approximately on 1 well out of every 900 drilled. Shallow gas blowouts have accounted for 25% of all blowouts experienced in this area. Thus, contingency plans must be developed to address this possibility. Since 1975, a diverter system has been required for rigs drilling on the Outer Continental Shelf of the Gulf of Mexico. The function of the diverter system is to permit flow from the well to be directed overboard, away from the drilling personnel and rig structure. The essential elements of a diverter system includes:

(1) a vent line for conducting the flow away from the structure that is large enough to prevent a pressure build-up in the well to values above the fracture pressure.

(2) a means for closing the well annulus above the vent line during diverter operations, and

(3) a means for closing the vent line during normal drilling operations.

There has been considerable uncertainty as to the best procedure to follow when shallow gas flows are experienced. Some operators use a contingency plan which calls for a volume of weighted mud to be maintained and a dynamic well kill procedure to be attempted as soon as the well is placed on the diverter. However, a recent study [Koederitz et. al., 1987]