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Measured Swabbing Pressures and Implications for Shallow Gas Blow-Out

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Abstract

Swabbing pressures can affect borehole stability. Temporary and local pressure reductions in the borehole fluid can disrupt the in-situ gas-fluid-soil equilibrium and may trigger a shallow gas blow-out.

This paper presents swabbing pressures measured during riser-less drilling and testing activities. Results show pressure reductions of up to about 1.2 MPa below hydrostatic values. Borehole depths were up to about 400 m below seafloor. Some measurements were made in boreholes in which gas blow-outs occurred shortly after acquisition of the data. The magnitude of the measured swabbing pressures cannot be correlated with water depth and depth below seafloor and soil type. The riser-less drilling and testing practice appears to dominate the magnitude of the measured swabbing pressures.

A procedure for shallow gas hazard assessment is proposed. This procedure serves as input for risk management for riser-less drilling and associated logging, sampling and testing.

Introduction

Shallow gas in marine soils is a hazard for open-hole or riser-less borehole drilling, depending on quantity and pressure of the shallow gas. Riser-less drilling is common for (1) oil and gas drilling, (2) logging, sampling and testing for geohazards (Peuchen and Raap, 2007), and (3) sampling and testing for geotechnical data acquisition (Kolk and Wegerif, 2005).

Subsurface gas may be present in three different forms (Sills and Wheeler, 1992):

1. In solution in the pore water. This gas will have little effect on drilling and testing unless the ambient pressure is reduced by, for example, drilling or in-pipe tool handling. Then the gas may come out of solution and become free gas.
2. Undissolved gas bubbles. Bubbles may be present in soil pores (Judd and Høvland, 2007). The bubbles may accumulate in high pressure pockets or layers, trapped beneath an impermeable capping layer. Sufficient quantities of undissolved gas may present a blow-out hazard.
3. As gas hydrates. These may be hazardous because they melt and release free gas when exposed to ambient pressure relief. However, few incidents due to drilling in gas hydrates have been reported to date (Judd and Høvland, 2007).

Many blow-outs during riser-less drilling happen when pulling drill pipe or a tool. Pulling drill pipe or a tool often generates an under-pressure, or swabbing pressure, which may lead to a blow-out. Local pressure reductions in the borehole fluid can initiate flow of free gas or allow dissolved shallow gas to become free gas. The presence of the gas will further decrease the drilling fluid pressure, which in turn will increase the potential for gas to enter the borehole, further decreasing the ambient pressure in a self-perpetuating cycle.

Surge and swab calculations are common for oil and gas drilling. These are used to protect the borehole from overpressure and fracture whilst running pipe or casing, and to negate the effects of swabbing during tripping operations. There are a few papers that present measurements of swabbing and surge pressures during oil and gas drilling. These measurements were used to validate swab-surge response models. Swabbing pressures of 500 kPa to 900 kPa have been measured while pulling pipe from 1130 m to 1070 m depth (Samuel et al., 2001; 2003). A pressure of 900 kPa was measured during reciprocation without circulation at 1300 m to 1270 m depth (Samuel et al., 2001; 2003). Swabbing pressures collected while pulling the pipes from an offshore well after cementing the liner were 650 kPa to 830 kPa. The pipes were pulled out of the hole with an average velocity of 0.5 m/s (Wagner et al., 1993). The authors know of no records of swabbing pressures measured during geohazard and geotechnical drilling and testing.

The following sections focus on swabbing pressures and their potential for triggering a shallow gas blow-out. The measurements and supplementary observations have contributed to improving safe offshore practices.