Kick Prevention and Detection

- All techniques used in vertical wells for avoiding and detecting kicks can be applied to high angle or horizontal wells.
- Kick intensity is potentially high when drilling a horizontal well due to the longer exposed hole section to the producing formation.
- The swab/surge pressure is relatively higher in a high angle or horizontal well. To prevent swabbed kicks, it is important to ensure that:
    - The mud rheology is conditioned prior to tripping out.
    - The tripping speed is controlled below the maximum allowable speed.
    - The correct tripping procedures are followed.
- The equivalent circulating density (ECD) is relatively higher when drilling a high angle well. This means a greater bottom-hole pressure reduction when circulation stops. Therefore it is important to flow-check the well prior to making a connection or tripping to ensure that the well is stable without the ECD effect.

Well Shut in and Gas Kick Migration

- Use hard (fast) shut-in method to shut in the well upon detecting a kick to minimise the kick volume. Studies showed that the potential water-hammer effect associated with the hard shut-in is negligible.
- When a kick occurs in a high angle or horizontal hole section, the shut-in drillpipe pressure (SIDPP) will be close or equal to the shut-in casing pressure (SICP). This is because the kick only causes a small or no hydrostatic pressure reduction in the annulus.
- Zero shut-in pressures (SIDPP & SICP) does not mean there is no kick. Together with a positive pit gain, this may indicate that the kick is still in the horizontal hole section which may be caused by swabbing or improper hole fill up on trips.
- The conventional method, which determines the influx density/type (gas/water/oil) based on pit gain, SIDPP and SICP, can not be applied in a high angle or horizontal well. There is no simple alternative method for field applications. However, a gas influx can be recognised by the continuous increase in the casing pressure due to gas expansion above the horizontal hole section, which may be caused by gas migration during shut-in or by mud circulation.
- During the well shut-in period, the free gas usually migrates up the annulus if the angle is below 90°. Experiments showed that, for a mud with PV=10 cP and YP=6 lbf/100sqft, the gas migrates at 10,000, 9,500 and 7,500 ft/hr at vertical, 50° and 80°,respectively. The migration rate will be lower if the mud has a higher yield stress or gel/
- Do not calculate the migration rate based on the increase in SICP, as it often seriously under-predicts the migration rate.

- **Gas does not migrate if:**
  - **The hole angle is 90° or higher**
  - **The gas is dissolved in the OBM, or**
  - **The gas is trapped as small bubbles in the mud by its high gel strength.**

Well Killing Operations

- **The advantages of the wait-and-weight method over the driller's method are less important in a high angle or horizontal well. This is because the weighted mud will not reduce the surface and casing shoe pressures until it has passed the high angle or horizontal hole section. By then the gas influx may have entered into the casing or been out of the well.**

- **Do not wait for the mud being weighted up. Start to circulate using the driller's method once detecting a kick; change over to the wait-and-weight method once the kill weight mud is ready (circulate & weight method). This will minimise the time dealing with the kick and reduce the risks of stuck pipe and other hole problems.**

- **When pumping down the kill mud, use the kick sheet designed for high angle wells to work out the standpipe pressure schedule. Do not use the kill sheet designed for vertical wells, as it will result in excessive high well pressures and the possible consequence of fracturing the formation.**

- **During circulating out a gas kick, the free gas will slip through and travel faster than the mud, even in a horizontal hole section. Studies showed that the slip velocity is in the range of 60~180 ft/min, depending upon the mud rheology and hole angle, etc. Therefore the gas kick may arrive at surface much earlier then the mud.**

Free Gas Kicks in Inverted (>90°) Hole Section

- **If a gas kick occurs when drilling an inverted hole section, the free gas will be trapped at the bottom of the hole when circulation stops. Similar scenario may also occur in washouts or undulations of a horizontal hole section. Studies showed that, the free gas will remain being trapped unless the annular velocity exceeds about 100 ft/min, which is higher than that at a commonly used SCR during well killing operations. Therefore special well killing techniques may have to be considered.**

- **The trapped gas may be flushed out by gradually increasing the SCR to a corresponding annular velocity of about 100~150 ft/min for a short period of time (say 1/4 of bottom-up maximum). Then reduce to a normal SCR and proceed using a conventional well killing technique (driller's or wait-and-weight). Depending on the kick volume and the length of the hole section, the procedures may have to be repeated in order to remove the trapped gas completely. So prior to drilling the hole section, the pump pressure at a SCR corresponding to 100~150 ft/min should be recorded.**

- **If the above technique fails to remove the trapped gas, consider bullheading the gas back into the formation. As the trapped gas should be near the kicking formation, bullheading is more likely to succeed in an inverted hole section.**

For more information please contact:
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