THE HOT ZONE

Fall 2017

THE HOT ZONE is a semi-annual newsletter from Blowout Engineers. Blowout Engineers is the well control division of Sierra Hamilton and provides the full scope of well control engineering, capping and well kill services to clients worldwide.

The newsletter is a compilation of technical well control information for Sierra Hamilton's clients and consultants. The focus of THE HOT ZONE is non-conventional well control topics.

This edition contains information on the following:

- Gas Migration
- Horizontal Considerations

Blowout Trivia

The Wild Mary Sudik well blew out in 1930 near Oklahoma City. The well blew approximately 200 mmscfd and an estimated 800,000 barrels of oil in 11 days before it was capped.

The cause of the blowout was failure to keep the hole full. There was no BOP on the well. The regulations requiring the use of a BOP were adopted as a result of this well.

This photo shows two blowouts in the Oklahoma City field in the 1930s.

New Sierra Hamilton Office

Sierra Hamilton has moved their Houston office. The new office is located at the following address:

Sierra Hamilton
900 Threadneedle, Suite #150
Houston, TX 77079

What's New?

Our recent projects include the following:

- Casing collapse investigation
- Failure analysis for Louisiana blowout
- Well control modeling for Marcellus operation
- Subsea BOP and wellbore failure in Arabian Sea
- Emergency response plan for Permian Basin operator
- Rig audits for BLM compliance
- Mud gas separator sizing for jackup
- SPE Young Professionals presentation
- Contingency planning for deepwater West Africa operator
- Emergency response drill for Gulf of Mexico operator

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Gas Migration

Gas migration occurs whenever there is a density difference between the gas and the fluid in the well. This is basically a gravity phenomenon. As such, a height difference is required. In a well that means there must be a TVD difference.

Gas migration rates vary widely and can be as much as 4000 ft/hr. The migration rate depends on several factors:

- The density difference between the gas and the fluid in the well (i.e. gas migrates faster in heavier fluids)
- The viscosity of the fluid in the well (i.e. gas migrates faster in water than thick mud)
- The migration path. A tortuous path will retard gas migration (liner top, packer leak etc.).

A common misconception is that there is no gas migration in oil base mud. A "free gas" bubble *will* migrate in oil base mud. Once the oil base mud becomes saturated with gas, the gas bubble migrates. However, as the bubble reaches unsaturated oil mud some of the gas goes into solution until the mud is gas saturated.

A large gas bubble in oil base mud will migrate similar to the same size bubble in water base mud with similar density and viscosity.

Gas Migration Formulas

The gas migration distance and rate can be calculated by observing the rise in casing pressure.

$$H_m = \frac{P_2 - P_1}{0.052 \times MW}$$

$$G_m = \frac{H_m}{\Delta t}$$

Where:

H_m = Height of migration, TVD ft

P_1 = Initial SICP, psi

P_2 = Final SICP, psi

G_m = Gas migration rate, ft/hr

Δt = Time interval from P_1 to P_2, hrs

MW = Fluid weight in the hole, ppg

Remember:

- The rise in casing pressure is equal to the hydrostatic pressure of the fluid that goes below the bubble.
- Gas migration can still occur after the gas has reached the surface. The rise in casing pressure at this time is due to the "bottom" of the gas bubble still moving up the hole.

Assumptions associated with the formulas are as follows:

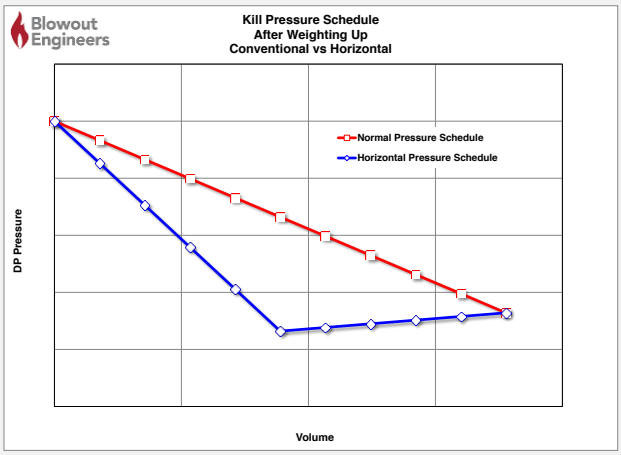
- No fluids are lost (closed wellbore system)
- No volume change in the gas bubble (no expansion through bleeding casing pressure)
  - No height change in the bubble (this requires consistent well geometry)
- The fluid through which the migration is occurring is incompressible
- No temperature change is considered

Horizontal Well Considerations

Horizontal wells are a significant portion of wells drilled on land in the US. With many wells having a lateral section that is 40% or greater of the total well depth, it is important to recognize when gas is in the lateral and how to handle each situation.

Drillpipe Schedule

Scheduling kill mud weight (KMW) to the bit for the Engineer's Method or second circulation of the Driller's Method must account for killing wells with horizontal sections. The conventional pressure reduction schedule is assumed to be a straight line from the surface to the bit. The value calculated for the Final Circulating Pressure (FCP) is still valid but following a conventional straight line schedule from the surface to the bit will not result in a constant bottom-hole pressure.



The graph shows how the actual drillpipe pressure should be handled versus the conventional schedule that is used in vertical and directional wells.

Casing Pressure

Horizontal wells that experience kicks have certain characteristics regarding the casing pressure. The most significant of these characteristics are:

- When a kick is taken, a portion of the casing pressure is due to the U-tube between the fluid in the drillstring and the lighter fluid (gas) in the annulus. When the gas is in the lateral, the differential pressure due to the U-tube does not exist. In theory, it is possible to have a lateral filled with gas and 0 psi on the casing pressure gauge. A kick swabbed into the lateral may not be detected, as there is no casing pressure when the well is shut in.
- Another characteristic of the lack of the U-tube effect is that when a kick is taken in the lateral, the SIDPP and SICP may be very close. This can lead to a misdiagnosis of the kick fluid being assumed to be water (or "dead oil").
- Expansion of the gas while circulating out the kick is a vital element in maintaining a constant bottom-hole pressure. This expansion occurs when the kick is moving up the hole (change in TVD) and therefore the casing pressure will show little change until the gas is circulated into the vertical section of the well

Gas in the Lateral

Trapped gas in the lateral section of a horizontal well may be present after kill circulations, or trips. Tips to remember that are associated with gas in the lateral are:

- Gas migration is due to gas buoyancy in the wellbore fluid. The gas migration rate in the lateral can be extremely low or non-existent.
- Gas in the lateral near the "heel" can be displaced into the vertical portion of the hole while tripping into the lateral. This type of kick can go unnoticed if pipe displacement volumes while tripping into the well are not monitored.
- Gas in the lateral can be solubilized in oil or synthetic base mud. Once the gas/mud mixture pressure goes below its bubble point the gas can break out of solution very quickly. This is usually in the upper part of the hole. This unloading phenomenon can have severe consequences.

CONTACTS

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These contacts act as First Responders to a well control event and can be reached 24 hr/day for any type of well control emergency.

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BLOWOUT ENGINEERS

Blowout Engineers provides operators the full complement of well control engineering and services.

- Blowout Control
- Well Control Project Management
- Relief Well Design and Execution
- Underground Blowouts
- Pressure Control
- Special Services
- Well Integrity Assessments
- Dynamic Kill Modeling and Execution
- Kick and Kill Modeling
- Emergency Response Plans
- Rig Well Control System Audits
- Expert Witness

Blowout Engineers personnel have worked in over 40 countries and have a wide range of experience in addition to blowout control operations.

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In the last five years, we have provided consultants for more than 15,000 drilling and completion jobs and more than 3,000 hydraulic fracturing jobs. We work with most of the large multinational oil & gas corporations and independent E&P firms and specialize in helping them reduce their fixed operating costs. We do this by leveraging the most highly skilled and experienced independent consultants in the industry.

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