THE HOT ZONE

Spring 2018

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:

- Horizontal well control problems
- Relief well intervention for horizontal well blowouts

Tidbits

Coiled Tubing

A coiled tubing precursor was developed in England during WWII. The code name for the project was PLUTO (Pipe Lines Under The Ocean). Pipe was coiled on a spool that was laid on the bottom of the English Channel. The pipeline was used to supply diesel from England to Allied troops on mainland Europe.

Most of the lines laid were a layered lead- based product. There were only a few steel lines. The floating reels of steel pipe were towed by a tug during the pipe deployment. The 10' diameter reels of 3" pipe were called "CONUN drums".

Novel Diverting Technique

There were several well fires in the Los Angeles area in the 1920s. The main problem the blowout caused was intense heat damaging nearby wells and structures. Therefore the main goal of the intervention was to put the fire out. Handling the flow from the well was easily accomplished.

The intervention consisted of diverting the well so that the fire could be extinguished. To divert the well a tunnel was dug that intercepted the casing 60'-80' below the surface. The casing was "tapped" and a large funnel with a valve and chimney was placed over the fire. Once the cap was in place, the well was diverted through the tunnel and the valve on the chimney was closed. This method worked on several wells.

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What's New?

Some of our recent jobs and/or projects include the following:

- Relief Well/Dynamic kill modeling for offshore Australia
- Blowout in South Texas
- Well kill engineering for South Louisiana
- Well kill engineering for Eagleford operator
- Well control job in South Texas
- Blowout in Eastern US
- Rig audits for Permian operator
- SPE Petroleum Short Course presentation at Texas Tech University
- Intervention planning for leaking well offshore Australia

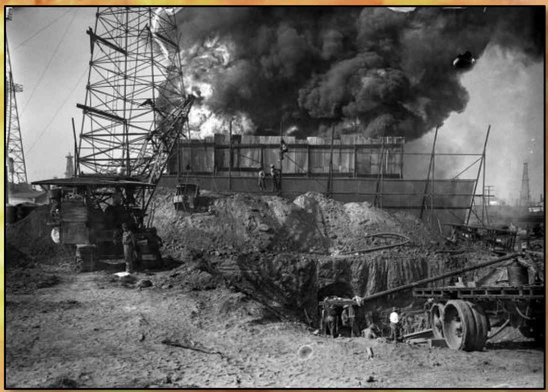

Photo from the LA Times

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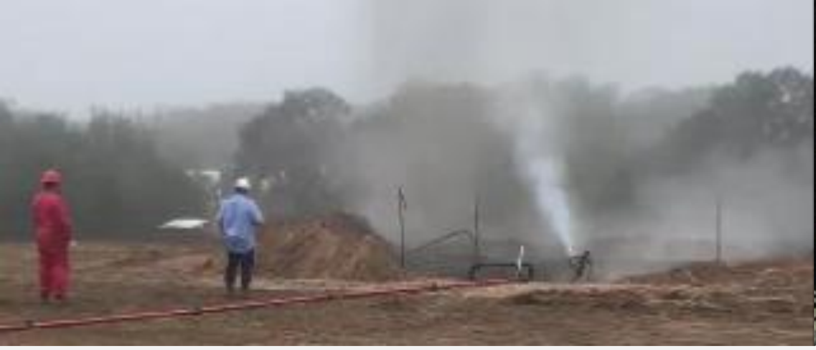
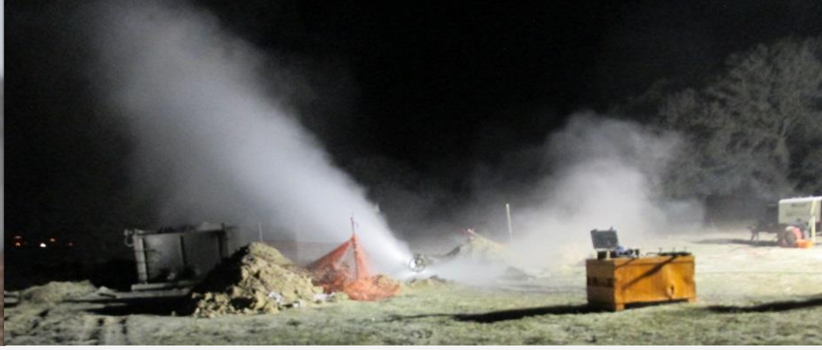



Well Control in Shale Plays

Oil and gas development on land in the US are now overwhelmingly shale plays. This has changed the nature of well control emergencies in the industry.

Drilling Kicks

The permeability of the shale is extremely low. Even though there is a large effective wellbore radius due to the long lateral, the deliverability of the shale is subsequently low. As a result, drilling kicks as taught in well control training schools are uncommon. Major well control events while drilling are rare and many can be contributed to exposed formations above the lateral.

For shale drilling, trip gas is the major concern. There can be a large amount of core volume gas due to the length of shale drilled. Gas can collect in high spots in the lateral. This gas can be problematic once it is circulated to the surface. Flow after cementing the production casing string is observed when the gas is swept into the vertical section of the well. For the most part, modern rigs utilize good rotating heads and good mud gas separators. This usually allows the trip gas to be removed from the well without major complications.

Frac Bashing

Frac bashing (or well bashing) is not uncommon in shale drilling. There are many cases about old vertical producers and new horizontal wells that have experienced communication between wellbores. This is usually attributed to the frac job on a new horizontal. The most common reason that is the frac job was not "contained" as expected. There has been a lot of work done to explain why the frac created communication to a nearby well. The industry has expended significant time and money resources to frac modeling, observation wells, formation stress studies etc.

For laterals that experience communication from an adjacent well one likely cause may be due to laterals that are closer together than planned. The survey method for laterals is mostly limited to MWD. High accuracy surveying such as a gyro are rarely run due to the cost of deployment in the horizontal section. The accuracy of the MWD can be questioned. Independent directional companies can purchase or rent MWD tools "off the shelf". The accuracy and calibration of these tools is dependent on many factors that the operator does not control.

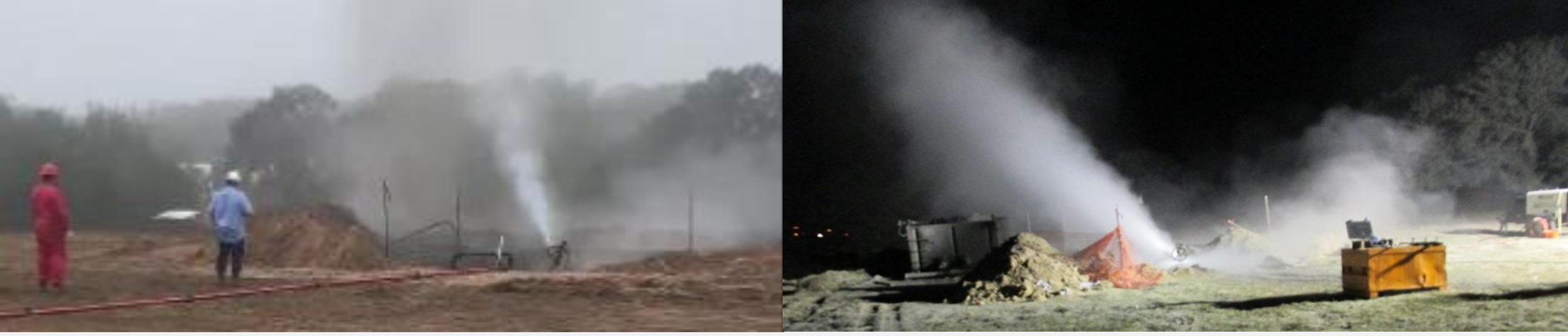
It is not inconceivable that the two sigma error in the MWD surveys can be as high as 300'-400' at the end of a two mile lateral. Even if the error is half of the two sigma value when the error is applied to two wells it is possible that the wellbores are within the one-half frac length. If this is the case then inter-well communication could even be expected during frac operations. This communication has resulted in a number of well control events that do not conform to conventional well control theory. One well in the Northeast US experienced a frac bash that resulted in the drilling well experiencing >30 ppg EMW at the intermediate casing shoe *without leak off*. The event was resolved by bleeding the pressure on the drilling well but it illustrates challenges that can be presented due to communication between wells.

Completion/Production Operations

Frac jobs, drill-outs and flowback operations are likely the highest exposure for well control events in shale development. Stored energy after fracking can be very high and the use of 15K WP equipment is common in gas shale completions. This type of equipment was traditionally rare on land in the US.

Live well completions are common where once live well work was often limited to rigless workover. Tubingless and live annulus completions are common and remove the packer/annulus fluid barrier common in conventional wells. As a result, the surface pressure control equipment is subjected to robust operating conditions at all times. Sand production can lead to equipment failure during drill-out, flow back and completion operations.

Frac bashing has also occurred during production operations. This is less troublesome in a well control sense if a full Xmas tree is on the bashed well but blowouts on wells with a pump jack are not uncommon due to inter-well communication.



Relief Wells for Horizontals

Relief well planning that has been done for horizontal well blowouts is predominantly for completion or production events. Some well kills have been accomplished this way but the majority of horizontal blowouts have been controlled through direct intervention. However, the need for a relief well should not be discounted as downhole problems that prevent shutting the well in, bullheading or snubbing to pump a kill are always a possibility during a blowout.

Intercept

The objective of the relief well should be to control the blowout in the shortest time possible. The shortest drilling distance is usually a straight relief well that targets the toe of the horizontal. However, drilling straight down into the toe can be problematic due to the survey error at the toe. Proximity ranging in this scenario is limited to passive ranging with an MWD or wireline deployed tool. However, this ranging method has a limited detection range (usually <5 meters). Locating this target is difficult and sidetracking the relief well is almost guaranteed. Active ranging has a much larger detection range but cannot be used when the incidence angle between the wells is high ($>\pm 25^o$).

The intercept type most commonly involves milling into the target well casing. This provides the best communication channel between the wells and is essentially required for high blowout flow rates. Using the fractures created in the horizontal can be considered but this channel can limit the pump rate due to the fracture geometry and the fact that the perforations in the target can provide significant restrictions.

Drilling Challenges

Shales are routinely drilled underbalance. This is advantageous as it keeps mud costs lower and penetration rate higher. However, once the well has been fracked, the near wellbore pressure in the shale changes drastically. Stored energy in the target well fractures dissipates with time but the stimulated reservoir can make underbalance drilling a high risk.

Intercepting the blowout in the portion of the hole that has been fracked can lead to lost circulation into fractures. This is especially true when the distance between the wells is within the small detection distance of passive ranging. Lost circulation also affects directional drilling operations and can lead to stuck pipe. The flowing bottom hole pressure on blowout wells is usually low if the exit point is not restricted. This low pressure regime can lead to hole stability issues when the relief well approaches the target well.

Well Kill After Intercept

The first step in designing a relief well revolves around the well kill. Dynamic kill calculations are highly dependent on the TVD at the intercept. As a general rule of thumb, most blowouts can be killed if this depth is 90% of the total TVD of the blowout well. This is usually valid for intercepts at or near the heel of the horizontal well.

One of the difficulties in intercepting a blowout at the heel is that long pump times can be required to fill the lateral with mud. The kill mud must fall (slip) during the kill and replace the gas that is in the lateral. The result is that gas in the returns is observed for an extended period of time. The result is a large volume of mud needed to completely fill the blowout well with kill mud. Handling a large volume of mud returns at the surface requires preplanning so that contingencies are put in place to minimize pollution.

If the lateral path is "uphill" ($>90^o$ inclination) displacing the gas can be difficult. High spots in the lateral can also make filling the lateral more difficult. Fortunately, the blowout is usually hydrostatically controlled when the mud/gas mixture density in the vertical part of the well overcomes the flowing bottom hole pressure and sweeping the gas from the lateral does not result in a kick that can restart the blowout.

Computer simulations can accurately predict the volume of mud needed to kill the well and fill the lateral. The simulations can be used to determine the optimum kill fluid density and pump rate to accomplish both tasks. Simulations show that the volume of mud required to fill the lateral and sweep the gas from the hole can be as much as four times the hole capacity.

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BLOWOUT ENGINEERS

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