Case study: Critical well data go unanalyzed, leading to fatal shallow gas blowout on land

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A SHALLOW LAND well to be directionally drilled was planned utilizing offset well data. This information strongly suggested that a lost-circulation (LC) zone would be encountered a few hundred feet below the depth where surface casing would be set. This well was to be drilled on the same pad as another well that blew out in the 1950s during drilling operations; the blowout zone was the same approximate depth as the projected LC zone in the new well.

Consideration was given to drilling through this LC zone and running an intermediate casing string. After this casing string was set through the LC zone, drilling could commence without concern. However, doing so would considerably reduce the production tubing diameter. The operator decided to drill through the LC zone and monitor and control the mud's weight, making sure that the hole stayed full.

The use of an automatic driller (AD) was required by the operator to monitor penetration rate, hook load, standpipe pressure, pump strokes, rotary speed, torque and weight on bit. Controlling factors used by the AD were used to achieve an optimal rate of penetration.

Circumstances leading to a blowout were studied using the geometry of the BHA, including the open hole's configuration just before the occurrence.

The mud pressure was measured by a signaling device placed within the rig's standpipe and sent to the AD. Hook load was measured by another signaling device attached to the deadline anchor. Similarly, devices for torque and RPM were attached to the rig's rotary table. One or two of these parameters governed the drawwork's ROR by the AD and the drill string's downhole progress.

Before the bottomhole assembly (BHA), mud motor and bit were on bottom, the drilling contractor engaged the mud pump. Weight on bit (WOB) is difficult to measure in directional drilling operations and is not used as the AD's single governing parameter. While drilling non-vertically with a mud motor, its measured pressure differential becomes critical regarding achieving optimum output torque and revolutions per minute.

By manipulating pump stroke rates, the off-bottom circulating pressure was established. Pump strokes and hook loads were monitored and recorded using circulating pressure as a governing factor.

Surface hole was vertically drilled; 9 5/8-in. 36-lbs/ft K-55 surface casing was set and cemented to a depth of 209 ft. It was tested without difficulty.

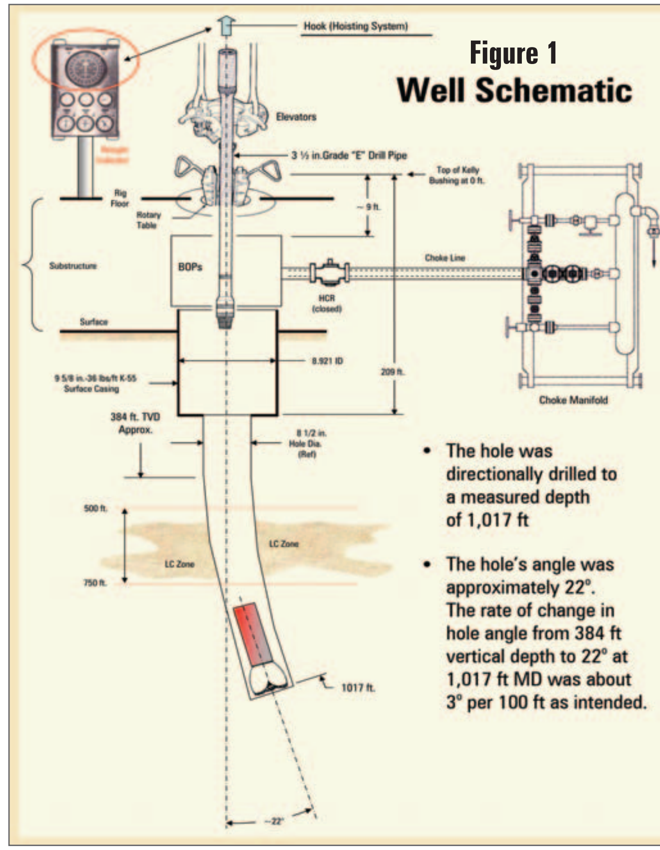


Figure 1
Well Schematic

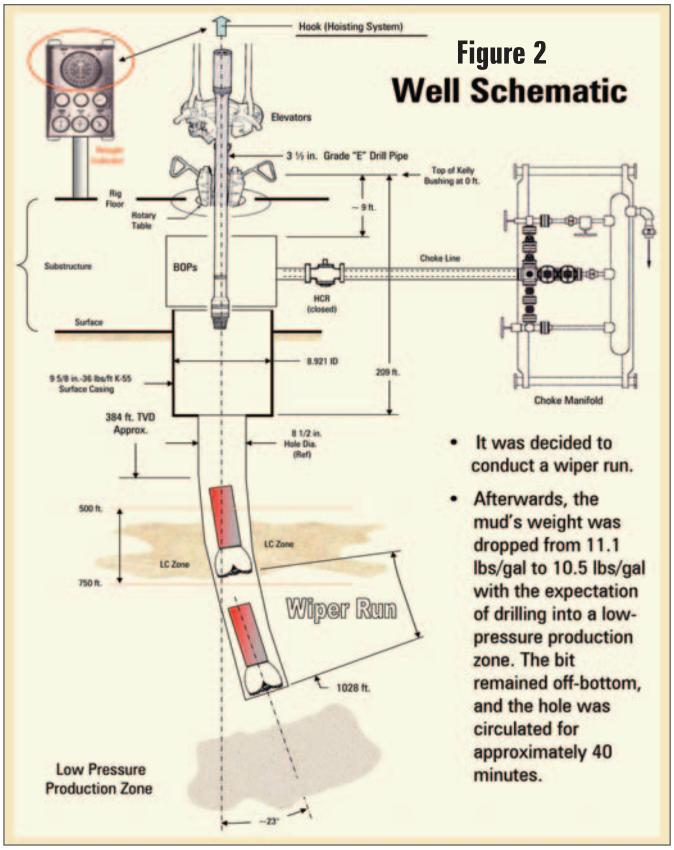
Next, the BHA accommodated a build rate of 3°/100 ft, and 3 ½-in. drill pipe was used. The bit was 8 ½ in., and the BHA utilized a mud motor and a backpressure valve. The OD of the BHA was 6 ½ in., and its overall length was approximately 119 ft.

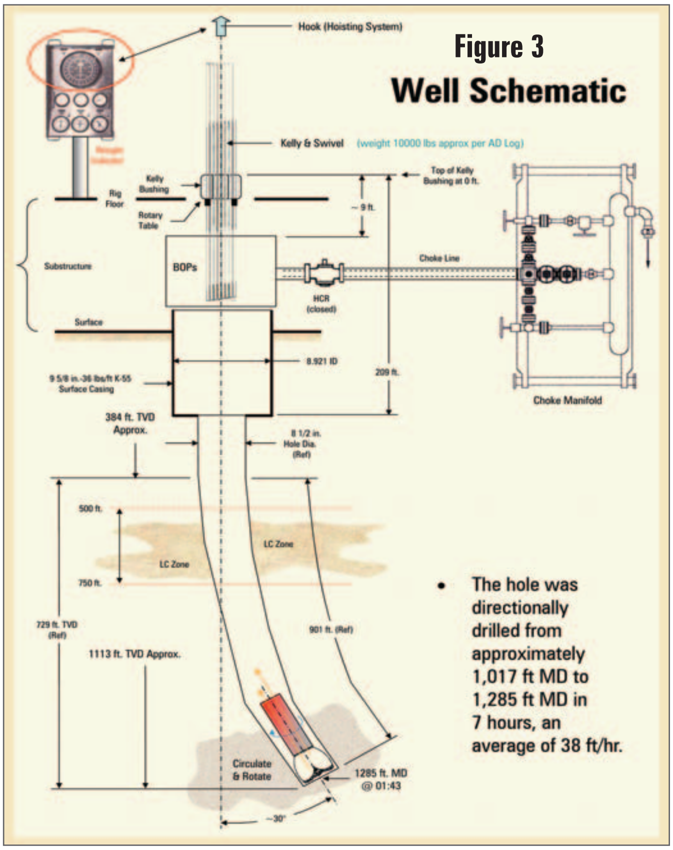
The rig used a kelly, and the 8 ½-in. hole was drilled vertically to a depth of 384 ft. It was believed that the anticipated LC zone would be encountered between 500 ft and 750 ft total vertical depth (VD).

The mud's weight was closely watched. No significant problems were encountered as drilling progressed through the noted LC zone. Based on offset well data from the 1950s, a mud weight of 11.1 lbs/gal was selected, due to the afore mentioned blowout.

After drilling through the LC zone without any well control problems, the mud's weight was reduced to accommodate a low-pressure production zone at the bottom of the hole. As drilling progressed, the hole was routinely circulated. Hole and pit levels were monitored, and several wiper runs were made by partially pulling out of the hole (POOH).

After the hole was directionally drilled to a measured depth (MD) of 1,017 ft, its angle was approximately 22°. The rate of change in hole angle from 384 ft vertical depth to 22° at 1,017 ft MD; about 3°/100 ft (Figure 1). Next, it was decided to conduct a wiper run (Figure 2). Prior to this run, WOB was 12,000 lbs. The bit drilled off to 0 lbs while circulating, taking about 3 minutes.





With 0 lbs WOB, the pump running and the BPV open, the hook load recorded by the AD was 30,000 lbs. When the pump was shut down, the BPV closed. The BHA and drill stem were now buoyed by hydrostatic pressure, and the hook load should have reduced to 6,000 lbs.

After the kelly was set back, the drill string was POOH. The hook load reported by the AD was 28,000 lbs. It was important to note that while the AD was not being used for controlling ROP, it continued to receive and record signals.

The rig pulled doubles; 8 stands were pulled in 20 minutes. Recorded hook loads remained considerable but went unnoticed by the driller and the operator's company representative.

The pumps remained on during the pulling of Stands 1 through 5, continuously filling the hole. After Stand 5 was set back, the pumps were turned off and remained off while the next 2 stands were pulled. A trip tank and/or pit volume monitor was not used.

The 8th stand was pulled and remained suspended in the elevators. The pumps were turned on for about 2 minutes; then off. The wiper run ended with the bit in the vicinity of the LC zone.

Over the next 15 minutes, all 8 stands were run back into the hole, at approximately 1 stand every 2 minutes. The kelly was replaced, and drilling operations resumed.

As these activities occurred, a recorded series of events went unheeded and unnoticed. Notably, the rig crew was working quickly while POOH and recorded hook loads were substantial.

With the bit back on bottom, the mud's weight was dropped from 11.1 lbs/gal to 10.5 lbs/gal with the expectation of drilling into the low-pressure production zone. It appears the prior blowout in the 1950s well was not considered. The bit remained off-bottom, and the hole was circulated for approximately 40 minutes.

The hole was directionally drilled from 1,017 ft MD to 1,285 ft MD in 7 hrs, an average of 38 ft/hr. The hole angle was 30°, and its TVD was 1,113 ft (Figure 3).

Next, POOH operations commenced to facilitate logging. The hole was circulated. The kelly was intermittently raised and lowered as the drill stem rotated. The pump was turned off, and four stands were quickly POOH:

Stand 1: AD hook load 37,000 lbs; calculated hook load was 16,700 lbs.

Stand 2: AD hook load 39,000 lbs; calculated hook load was 16,200 lbs.

Stand 3: AD hook load 38,000 lbs; calculated hook load was 15,700 lbs.

Stand 4: AD hook load 36,000 lbs; calculated hook load was 15,200 lbs.

After the first four DP stands were POOH and set back, the pump was turned on. After pulling the 5th stand, the pump was turned off before the 6th stand was hoisted. The pump ran for 2 minutes.

Stand 5: AD hook load 32,000 lbs; calculated hook load was 14,700 lbs.

Stand 6: AD hook load 34,000 lbs; calculated hook load was 14,200 lbs.

The 7th and 8th stands were rapidly POOH. Recorded hook loads were high — higher than they should have been.

Stand 7: AD hook load 30,000 lbs; calculated hook load was 13,900 lbs.

Stand 8: AD hook load 28,000 lbs; calculated hook load was 13,100 lbs.

During the pulling of the 9th stand, the pump was turned on for 2 minutes, then off.

Stand 9: AD hook load 28,000 lbs.; calculated hook load was 12,600 lbs.

Lines of communication between the company representative and the drilling contractor proved horribly inadequate prior to the blowout event.

The 10th-13th stands were POOH. All was accomplished in 25 minutes, or 1 stand every 2 minutes.

Stand 10: AD hook load 28,000 lbs; calculated hook load was 12,100 lbs.

Stand 11: AD hook load 28,000 lbs; calculated hook load was 11,600 lbs.

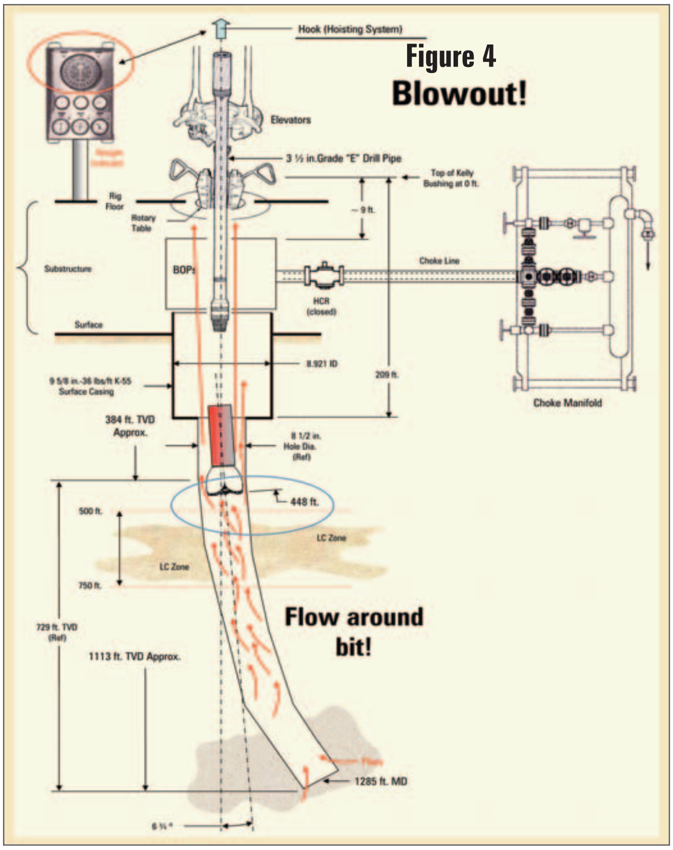
Stand 12: AD hook load 28,000 lbs; calculated hook load was 11,100 lbs.

While the 13th stand was being POOH, the AD hook load dropped to 7,000 lbs while the calculated hook load was 10,500 lbs. The well then began flowing through the annulus (Figure 4).

Instead of closing the BOPs, the driller tried to put the kelly back on. He and his crew attempted to stab it but could not make it up. Then, discharged gas from the well ignited.

The driller yelled for everyone to run while he exited the floor. As the flames grew larger, the derrickman was in peril; he could not climb down. His only means of escape was his "Geronimo Line." This line was a 1-in. diameter hemp rope and did not have a riding belt. The rope was consumed, and the derrickman was lost.

After this incident, printouts from the AD were available. Notably, after drilling ceased, data such as hook load, pump strokes and RPMs were continually recorded when the drill string was POOH and when it was tripped into the hole (TIH) (Figure 5). The firefighters who were engaged to fight the fire confirmed that the rig's BOPs had never been closed.



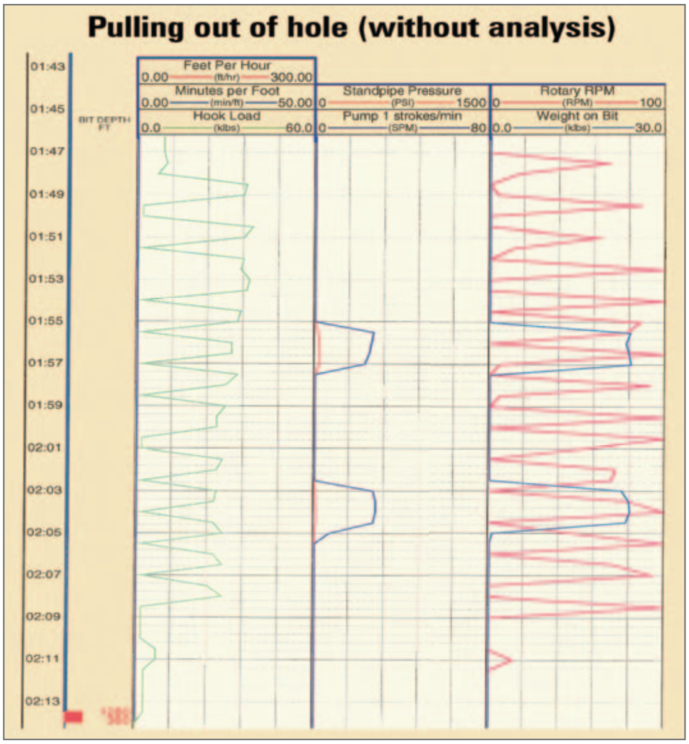


Figure 5 (above): After drilling ceased upon the blowout, data such as hook load, pump strokes and RPMs continued to be recorded when the drill string was pulled out of hole.

Clearly, well control problems had been developing from the rapid extraction of the drill stem during the wiper run. AD recorded and calculated hook loads while drilling and circulating generally agreed. As POOH operations were under way, there were significant discrepancies between recorded AD hook loads and calculated hook loads.

Furthermore, the drilling contractor's efforts to monitor fluid volumes while the drill stem was extracted were absent. The mud pumps were simply turned on until mud spilled out of the hole and then turned off.

As the driller and his crew POOH, the well swabbed-in. As the bit and the BHA approached the LC zone, hook loads were not what they should have been.

The drilling contractor's policy required that hoisting speeds be done at controlled rates so as not to induce an influx of formation fluids from the effects of swabbing nor cause a loss of drilling fluid and corresponding hydrostatic pressure decrease from surging. If there was ever any indication of swabbing and/or an influx of formation fluids, measures should immediately be taken by the driller to control the well. Furthermore, that mud would be circulated and conditioned, on or near the bottom of the hole, unless conditions prevented lowering the BHA back to the bottom.

Prior to this incident, concerns existed relative to the integrity of the 9 ⁵/8-in. 36-lbs/ft K-55 surface casing's shoe. In the event of a well control situation, a hard shut-in may have compromised its integrity. It later became apparent that confusion existed between the driller, tool pusher and the operator. During a well control event, the driller believed that he was to perform a soft shut-in. On the other hand, his employer trained him to shut-in the well during any well control emergency. The driller did neither.

The AD data provided crucial information to the drilling contractor and the operator's representative but went unheeded by both. The company's representative had the AD data available to him. The drilling contractor should have known to monitor mud volumes and keep the hole properly full during POOH and TIH operations. Competent rig and operations managers should have recognized what the hook loads should have been during POOH operations. Based upon the AD data alone, the drilling contractor and operator's representative should have been alerted. The well should have been shut-in and competently dealt with.

Clearly, any derrickman working up in a mast or derrick would be in peril should the well blow out and catch fire. The derrickman had no reliable means of escape as this event developed. Also, lines of communication between the company representative and the drilling contractor proved horribly inadequate.

Critical data provided by the AD during POOH and TIH operations, which spawned this shallow gas blowout tragedy, were completely ignored by both the drilling contractor and the operator's representative, including the drilling contractor's implementing their own crucial well control policies. This was not the first time a preventable well control event like this has occurred.

Poor communication and misunderstandings between the operator and drilling contractor, efforts to work too quickly, the use of improper safety equipment and improper supervision and conduct of responsible employees are all too often the reasons.

This article is based on a presentation scheduled for the IADC Well Control Conference of the Americas, 28-29 August 2007, Galveston, Texas.