Killing blowout caused by illegal oil bunkering involves more unknowns, special challenges

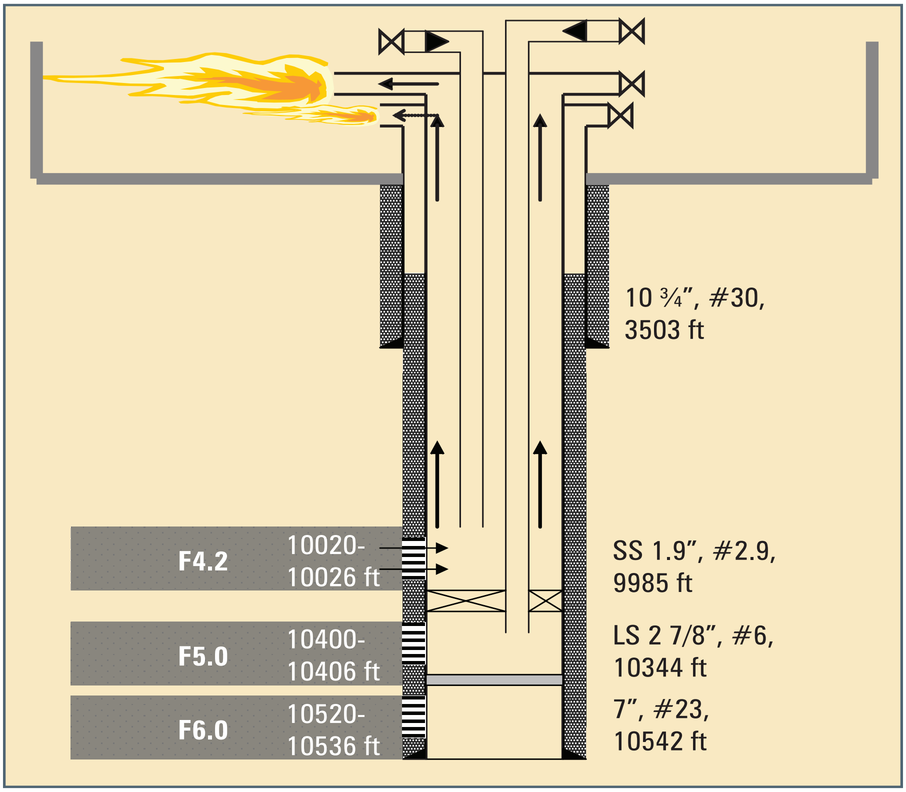
By Pieter Oudeman, Shell

ILLEGAL OIL BUNKERING, an euphemism for oil theft, has assumed considerable dimensions in the Niger Delta. Estimates range from 30,000 to 200,000 bbl/day. Apart from the substantial loss of income this constitutes for governments and oil-producing companies; the practice of illegal oil bunkering has numerous negative consequences, such as escalated violence and criminality due to the fight for control over bunkering opportunities, large-scale oil spills and disastrous accidents, often claiming many lives.

These accidents are, in most cases, related to reckless handling of the flowing well or pipeline effluents. Precautions are hardly taken to maintain control over the drainage points at all times and avoid ignition of the gas vented while stealing the liquids. This results in a highly explosive atmosphere around the drainage point and disaster when a source of ignition is introduced.

When this happens with a well, the crews charged with extinguishing the fire and killing the well face a difficult task. Typically when a well blows out, records have been kept of operations prior to the blowout, and survivors can provide additional information. When a well blows out due to illegal oil bunkering, no records on flow, pressure, produced fluids, etc., are available, and survivors will have fled the scene. This means that planning the killing operation can be based only on historic data, visual observations and rough estimates for current conditions in the well.

Since there will be considerable uncertainty in these rough estimates, the kill plan will have to take into account every possible scenario to ensure that the kill, once started, proceeds successfully. This case history demonstrates how such a kill plan was developed and executed.



This schematic shows the blowout situation after an illegal oil bunkering incident on the mainland of the eastern Niger Delta. In such bunkering cases, no records on flow, pressure, produced fluids, etc., are available. With considerable uncertainty, the kill design had to take into account any possible combination of critical factors to ensure that once the kill starts, it could be concluded successfully.

THE WELL

The well, located on the mainland of the eastern Niger Delta, was drilled in 1966 to a total depth of 10,542 ft and completed with a 7-in. (23 lbs/ft) production casing to produce 3 sands. It was re-completed as a dual parallel string producer (without a top dual packer) in 1970. The 2 7/8-in. long string produced the middle sand, and the 1.9-in. short string produced the top sand. The water-producing bottom sands were isolated with a bridge plug. The F4 sands started producing 500 bbl/day at a GOR of 2,800 scf/bbl. This GOR gradually increased to 4,700 scf/bbl in 1974, when the well was beaned back to 360 bbl/day to control the GOR. This continued until 1983, when the well was closed in due to the high GOR. The well was killed, backpressure valves were installed in both tubing strings, and disconnected, pending redevelopment of the area.

EVENTS LEADING TO THE BLOWOUT

Obviously an exact account of the events leading to the blowout is not available. The thieves must have found out or were tipped that the well could be produced through the A-annulus by cracking open one of the 2 1/16-in. casing valves. The oil collecting in the cellar was pumped into a tanker truck. The gas was vented off. Due to the fairly high density of this gas, an explosive cloud must have formed rapidly around the well. According to a local source, 2 tanker trucks had already been loaded that morning and left, when the explosion occurred, killing several (estimates range from 15-29) in the vicinity of the well and setting the well and nearby tanker truck on fire. The cause for the explosion is uncertain. Some sources suggest disagreement over the "sharing formula for the royalties" among the 3 communities contesting ownership of the land on which the wellhead is located, led to the fire. This left the well burning at the casing valves on one side of the wellhead with a long horizontal flame bouncing into the cellar.

FIRST EMERGENCY RESPONSE

Emergency response teams arrived

shortly after the incident. First, the burnt-out tanker truck was removed since it deflected the flames towards the well, making any work near the well impossible. Next, attempts were made to close the casing valve. Special tools to close the valve from a distance were fabricated on site for this purpose, but the valve could not be operated. Hence it was decided to divert the flames away from the well by breaking away part of the cellar wall and directing the flow to a flare pit by placing pipes over the casing valves.

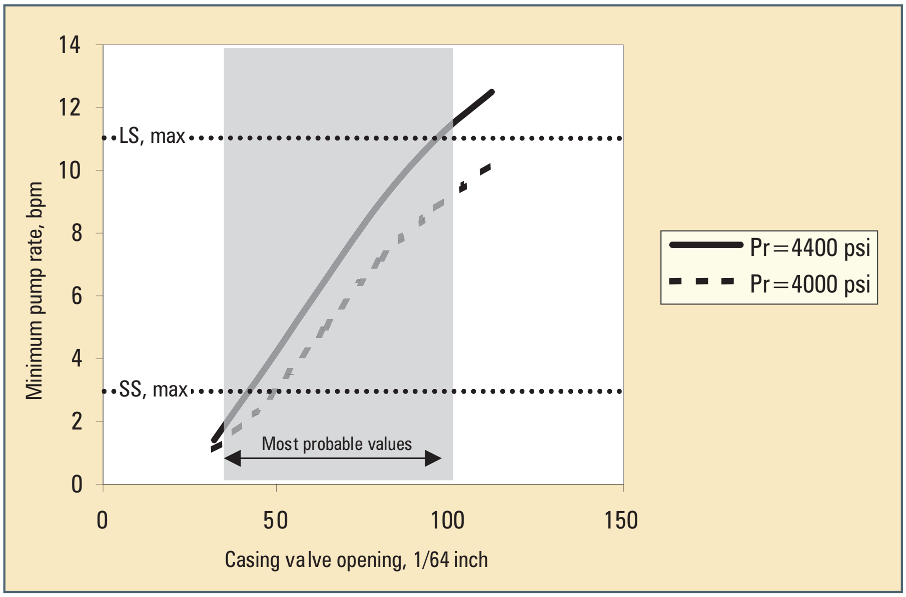
This made it possible to work on the wellhead. Non-operable valves on the long and short string were replaced. Since it was clear by now that closing the casing valve could not shut the well in, the alternatives were replacing the well head or killing the well hydraulically. Replacing the wellhead would, at least temporarily, give rise to a large uncontrolled flow at surface. This was considered unacceptable, which left the hydraulic kill as the only option to control the well.

THE HYDRAULIC KILL

To load the blowing well with liquid, kill fluids could be injected into the annulus at bottom either by pumping down the short string, the long string (after perforation above the packer), both strings or down a relief well. The pump rate required to kill the well determined which route would be selected, i.e. obviously a considerably higher rate can be pumped down a 9 ⅝-in. relief well than 1.9-in. tubing string. Hence the required pump rate had to be estimated first. The main factors determining the pump rate are the blowout path, formation pressure, depth of the well, pressure against which the well blows out and kill fluid density.

The latter 3 can be considered known. Estimates for the formation pressure were questionable; initially the well was hydrostatically pressured, but during production, pressure had dropped by ca. 1,000 psi. It was considered probable, however, that during the long closed-in period, the well had partially re-pressurized. Therefore it was decided to study scenarios with full hydrostatic pressure and 400 psi depletion.

The main uncertainty in the blowout path was the opening of the casing valve. Since the opening also determines the blowout rate, hopes were that from the observable jet fire, the blowout rate and the casing valve opening could be



It was estimated that the casing valve opening was between ½ in. and 1 ¾ in. For the range of formation pressure and casing valve openings, required pump rates to kill the well were determined to range from less than 2 bpm for the smallest opening of the casing valve and reduced formation pressure to as much as 12 bpm for a 1 ¾-in. open casing valve and full hydrostatic pressure.

derived. Pyrotechnic experts estimated that the well was blowing some 8,500 bbl/day but indicated 50% uncertainty in this estimate. This corresponded to an opening of the valve between 1 and 1 ¾ in. The most optimistic estimate was based on the fact that the bunkerers were loading some 100 bbl into a tanker truck every hour. This gives a valve opening of ½ in. It was decided to study all scenarios between ½ and 1 ¾ in. For the range of formation pressure and casing valve openings, required pump rates were determined, assuming the kill fluid is water, the only fluid available at short notice. Since the well would be at most hydrostatically pressured, the density of water would suffice to kill the well.

The kill plan will have to take into account every possible scenario to ensure that the kill, once started, proceeds successfully.

Calculated pump rates required to kill the well ranged from less than 2 bpm for the smallest opening of the casing valve and reduced formation pressure to as much as 12 bpm for a 1 ¾-in. open casing valve and full hydrostatic pressure.

Although pumping down the short string with direct access to the annulus would be feasible right away, calculations indicated that, given pressure limitations, at most 3 bpm could be pumped down this string. This was insufficient in most scenarios. Eleven bpm could be pumped down the 2 ⅞-in. long string, which covered the vast majority of scenarios. As a last resort, pumping down both strings simultaneously would cover all scenarios. Hence it was decided to focus initially on the long string. A kill line was connected to this string, and the string was killed by bullheading. This did not visibly change the well fire, indicating that there was no communication between the long string and the annulus. A plug was set below the packer, and a gyro-survey was run in the long string to ensure that the well trajectory was accurately known in case events take a turn for the worse and a relief well was required.

Next, a perforation tool containing 14 shots of ½-in. diameter was run in the hole and fired just above the packer. To keep the long string filled, ¼ bpm was pumped while pulling out. In order not to exceed the pressure at which the equipment was tested, pumping commenced at 3 bpm and increased to 8 bpm after ca. ½ hour. The highest pressure observed was 2,000 psi. After pumping 465 bbl, the flames from the A as well as the B-annulus were fully extinguished, and the pumps were slowed to 4 bpm, which reduced the pump pressure to

300 psi. Reducing the pump rate to 2 bpm reduced the pump pressure to zero. Following the kill, all valves were replaced, and 60 bbl of cement were pumped into the well. The next day, cement was tagged at 7,840 ft and the well was dead.

POST-KILL

A simple observation after the kill was that the casing valve of the A-annulus was ca. ½-in. open. According to the calculations on blowout rate as a function of valve opening, this corresponded to a blowout rate of ca. 2,000 bbl/d, i.e. at the lowest side of the range of estimates, suggesting that logistics were indeed the limiting factor in producing the well for illegal bunkering.

In hindsight, it also meant that the well could have been killed pumping down the short string or even bullheading the annulus, but as discussed, there was no way to assess this prior to the kill. Analysis of the pressures observed during and after the kill indicated that the formation pressure was ca. 4,200 psi, i.e. close to hydrostatic, confirming the assumption that during the long closed-in period the well had re-pressurized.

Furthermore, a comparison between the observed and predicted progress of the kill indicated that the calculations gave a reliable picture of the sequence of events during a hydraulic kill. This is important for validation of such calculations and maintains confidence in such calculations for future events.

CONCLUDING REMARKS

Designing a hydraulic kill for a well blown out due to illegal bunkering is challenging since any records of well performance and operations prior to the blowout are missing, and those responsible will not come forward to discuss their observations. Hence the kill design will have to take into account any possible combination of critical factors to ensure that once the kill has started, it can be concluded successfully. The price for this robustness is over-design, but a single successful kill attempt is considered preferable over a series of failed attempts with the risk of further aggravation of the situation.

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