

# WELL CONTROL

## Ultra-deepwater blowouts - how could one happen

**Options are limited, so prevention and fast action are critical**

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A sustained ultra-deepwater (300 meters) blowout has not been experienced by the global petroleum industry. Is a deepwater blowout possible? If so, what are the prevention steps? With sustained controlled oil flow rates of over 13,000 b/d and plans for individual well rates nearing 30,000 b/d, the consequences of a sustained deepwater blowout would be severe. Drilling is proceeding into ever deeper water world wide. A major deepwater drilling boom is underway in the US Gulf of Mexico. Current exploration is underway in over 2,300 meters of water in taking place. Also, field development work is underway on several deepwater projects. Is there a blowout risk? If so, how can it be prevented.

### **Risks and scenarios**

Ultra-deepwater blowout risk is mitigated by low formation strength. Natural well bridging would shut off most blowouts. One concern is the high well productivity has been seen in ultra-deepwater. High flowing bottom hole pressures could limit bridging. What types of blowouts may occur: Underground blowout risk is substantial in ultra deepwater wells. Low **kick tolerance** and minimal differential between pore pressure and fracture extension pressure heighten this risk. Underground blowouts have been experienced in ultra deepwater, but have not sustained. Natural well bridging has shut off flow. Bridging resulted in stuck pipe and wellbore side-track. Surface blowouts while drilling would not likely sustain, unless the flow path was very restricted or up the drillstring. Broached blowouts could happen with casing failure. Recently, an ultra-deepwater operator swabbed in a kick resulting in over 9,000 psi on the subsea BOPs. Fortunately, the casing was sound and set just on top of the sand. This allowed safe kick bullheading. Gas hydrate plugging of ultra-deepwater choke lines is possible. Trouble areas are kicks without methanol injection or other hydrate suppression methods (mud formulation or heat). Choke line plugging could induce an underground blowout. Large kicks in long choke lines may form hydrate plugs even with some current prevention steps. The effect of water depth on an ultra-deepwater blowout could be significant. Shearing drill pipe suddenly removes a significant hydrostatic column. The impact of seawater hydrostatic at the mud line would add a significant back-pressure to broached blowout flow. This increases flowing bottom hole pressure and reduces formation draw-down and flow rate. Unfortunately, bridging tendencies would also

be reduced. Most sustained blowouts in the US Gulf Coast region occur during completion or workover operations. The primary causes are the positive potential for pressurised hydrocarbons and limited bridging tendency with flow through perforations or gravel pack. This risk is mitigated greatly in ultra-deepwater work because of the excellent well control equipment used on these wells by knowledgeable people. Common causes are instances where only a single pressure barrier was present and there was a subsequent mechanical failure. A few likely sustained drilling blowout scenarios in ultra-deepwater wells based on actual blowout examples follow:

### **Blowout No. 1**

A kick up the drill string fish during fishing operations can lead to an underground blowout. With the top of fish up in the casing, flow can come up the drill string and back down the annulus to the casing shoe or out through a casing rupture. The flow path up the parted drill string has been common to many sustained blowouts. Bridging is less likely as flowing pressure is high and limited formation exposure to the flow path. Drill string restrictions and fracture pressure at the flow exit depth control flowing pressure. Similar blowouts have occurred in the past onshore and offshore, but not as of yet in ultra-deepwater. The key is always plugging the bottom hole assembly prior to a drill string back-off. Blowouts are possible when cement is over-displaced out the bit in an attempt to plug only a limited portion of the drill string. The operator mistakenly treats well as if drill string is plugged. One solution is to inject materials that would plug the bit with cement or place a wiper plug behind the cement that sets up on some restricted ID to control cement over-displacement.

### **Blowout No. 2**

A bridged underground blowout can result in a severe drill pipe kick. A surface pressure chart of an deep high temperature, high pressure (HTHP) underground blowout can be seen. Note that 408 bbl of 17.4 ppg oil mud were pumped into the drill pipe at zero pressure when the well was flowing underground. After the well bridged in about 230 minutes, drill pipe pressure suddenly increased by over 4,000 psi in seven minutes and ultimately to a recorded maximum of 6,300 psi while blowing out the mud pump pop-off valve. The drill pipe kick experienced in this well is not uncommon in drill string blowouts. The kick and drill pipe blowout are caused by the following circumstances: Drill string hydrostatic pressure balances with underground flowing bottom hole pressure which drops mud level in drill pipe. Well bridges shutting off underground flow. Bottom hole pressure at the bit builds-up to the pore pressure of the zone at the bit that originally kicked. The drill pipe then kicks. The greater the differential between flowing and static bottom hole pressure, the worse the drill pipe kick. Successfully closing surface safety valves and/or standpipe gate valves in near sonic high density mud flow fails. The kelly cock valves cannot be closed in high flow. Valve seats cut-out from high velocity mud solids. The kelly hose fails. Leaks in the pressure-isolated top drive can occur at elevated pressure. In some circumstances, severe hydraulic hammer occurs at surface when the column of mud that

remained in the drill pipe is rapidly pushed to surface by the kick. In the example well blowout, the upper and lower kelly cock valves and standpipe gate valves either could not be closed or cut-out.

### **Blowout No. 3**

A sheared drill pipe blowout may result in a follow-on blowout. The drill pipe may drop or may still be landed within the subsea blowout preventers (BOP). Flow can sustain up the drillstring and then down to rupture casing or the casing shoe. With sheared drill string in the subsea BOP, flow can continue through closed lower pipe rams. These floating rams seal pressure only from below. BOP erosion can occur at the top of the sheared drill pipe, followed by dropping pipe through eroded rams. Annulus pressure builds up, then the casing or shoe fails. A costly North Sea subsea blowout resulted after shearing drill pipe (multiple casing ruptures).

### **Blowout No. 4**

A drill pipe blowout is the most likely flow path of a sustained blowout while drilling. Based on US Gulf of Mexico continental shelf and onshore examples, this is the most common of all surface drilling blowouts. Flow is through the bit and bottom hole assembly to surface. The well does not bridge as easily, since the bit may be within the reservoir and flowing pressure is high. Pressure drops through the bit nozzles, and the bottom hole assembly and drill string limit formation draw-down. High shut-in pressures and rapid pressure build-up could lead to pipe rupture. Drill pipe does not seal against gas very well and leaks could lead to quick pipe failure. It can be impossible to close a valve against high velocity dense mud flow (the valve jams partially open or cuts out). Kelly hose can fail, if the well was isolated at the standpipe. The kelly hose or standpipe can rupture, or the well can blow out at the mud pump pop-off valve. All of these failures have occurred recently in onshore and offshore shelf water blowouts. Nothing is so unique about ultra-deepwater that would reduce this risk. The common answer is "that is why we have shear rams." Though this may solve an immediate problem, an even larger one now is at hand.

## Conclusions

Blowouts are possible in ultra-deepwater wells. Blowouts seen in shallower water floating drilling operations could happen again if similar circumstances are experienced in ultra-deepwater.

The greatest drilling risk would involve a kick up the drill pipe. This risk is easily mitigated by use of an effective drillstring float valve. The major problem is the current generation of float valves have limited useful life in the typical ultra-deepwater environment of high mud weights and high circulation rates. The flapper type valves with a latch that allow automatic pipe filling on the trip in are the most useful. There is no need to port this flapper as drill pipe pressure is easily obtained by rolling the pumps to open the check valve. A better float valve is needed.

Thought must be given to the reaction steps to be taken after shearing a drill pipe in a blowout. Severe follow-on complications can occur and may have greater consequences than the original problem. Are drill pipe rams needed that effectively seal from above and below located below the shear rams? Can this ram be designed to also better support the sheared drill pipe (slip ram)? Is there a way to limit pressure build-up on sheared drill pipe isolated by such a specially designed ram so that burst failure is limited. How will casing pressure be limited after shearing drill pipe?

Serious effort must be given to limit kick size as much as possible on ultra deepwater wells. Factors of limited **kick tolerance** and severe pressure drops in choke lines exist. These are complicated by hydrate plugging in choke lines and rapid gas migration. Well control training, specific for the well, the rig, and the on-location drilling team is needed.

When is bullheading an option on such wells?

When is the driller at greatest risk of an underground blowout?

How do we strip into a well through the subsea BOP, while maintaining volumetric well control to account for rapid kick migration?

Blowout control options in ultra-deepwater are very limited.

Blowout prevention is of paramount importance