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Experience, Role, and Limitations of Relief Wells

Introduction

This white paper has been developed and issued on behalf of the Joint Industry Task Force on Subsea Well Control and Containment. This group was formed to support policy inquiry and review after the Macondo blowout.

The utility and efficacy of relief wells as a 'solution of last resort' in well control incidents has been raised for discussion among industry and policy making groups. Relief wells can be technically challenging, and generally require longer implementation lead times than all other well control methods. Still, available records and anecdotal evidence show relief wells as 'consistently successful' for stopping uncontrolled flow from a well that could not be killed otherwise, through intervention methods at the wellhead.

It has been asserted that having a pre-drilled relief well available on 'standby' could conceivably reduce the consequences of a blowout event by shortening the time to intercept and kill the blowing well. Industry has been asked to assess the effectiveness and desirability of pre-drilling 'stand-by' relief wells. [… *Would having pre-drilled wells available for deep intercept and kill be an effective policy approach that would reduce the risk and consequence of a blowout?*]

This report examines recent history with relief wells and assesses the advantages and disadvantages of establishing a pre-drilled relief well as a policy alternative.

Conclusion

Relief well pre-drilling is neither resource friendly nor risk-free. Well risk can be reduced much more effectively by well design and operational procedures that include blowout prevention as a primary consideration. The Task Force concludes that requiring the pre-drilling of relief wells to a predetermined, intermediate depth in

advance of drilling an exploration well does not offer assurance of reducing environmental impacts from a potential blowout.

Relief Well Experience

Attachment 1 summarizes the insight compiled by one well control contractor relating to relief wells. This table suggests a 100% success rate for relief wells when implemented. It also illustrates that relief well plans often become unnecessary due to successful intervention at the wellhead, or natural 'bridging over' of the well prior to the relief well be completed. This experience is further corroborated by other sources [1, 4] (Danenberger, and Izon) which cover the cumulative history of well control incidents in US Gulf of Mexico waters from 1971 through 2006.

Anecdotal information pertaining to a recent successful relief well drilling operation offshore Western Australia suggests that drilling the relief well was complicated by restrictions over positioning of the rig for the relief well. Review of published accounts of this incident suggests that pre-planning of the relief well location in this instance might have shortened the duration of uncontrolled flow from that well by several days by eliminating decision time required to spot the surface location of the rig for the relief well. Similarly, pre-planning for relief well drilling in this instance might also have led to more rapid procurement of a rig to perform the relief well, as well as led to appreciably better efficiency and effectiveness in the drilling operations.

Owing to multiple operators having ready commercial access to rigs, it is possible to spud one or more relief wells on short notice in the Gulf of Mexico (GOM). Relief well drilling in the GOM will typically progress quickly, and target well detection is readily accomplished using proven technology, with ranging tools run within the relief well. Success with relief well drilling is due in part to the reliability of directional surveys taken in the original well that is blowing out. This directional control work is generally high quality in the GOM.

Regulatory Experience

Some advocates for mandatory pre-drilling of relief wells have asserted that Canadian regulations require advance, or simultaneous, drilling of relief wells. According to the Task Force's research this is incorrect. However, the Task Force found that regulatory approval for drilling in certain arctic locales (Canada, Greenland), requires that relief wells be pre-planned, and approval is granted only on condition that the relief well can be drilled during the same drilling season in which a blowout might occur. [3]

Establishing a 'Stand-by' Relief Well – Concerns

Some have asserted that partial pre-drilling a relief well for the purpose of supporting a prospective deep well intercept on the exploratory well could be a constructive policy. [… *If the relief well were already in place then we wouldn't be waiting so long to attempt a kill. So wouldn't pre-drilling a relief well make sense as a standard practice?*]

However, the foundation of this as a policy rests on flawed assumptions, and involves added technical risks that make it undesirable.

Flawed Assumptions:

That relief well drilling is risk free. Pre-drilling a relief well to a presumed intermediate depth is costly in terms of time and resources, and adds risk to a project in terms of environment, safety, and carbon impact. Any penetration of the seafloor establishes the potential for a well control incident, whether the flow involves oil (as in Macondo), or gas, or water, as typically encountered at shallower depths in deepwater. Beyond its first costs, a pre-drilled relief well creates a liability since it must eventually be removed through permanent plug and abandonment operations when not needed.

In drilling, there may be other hazards besides the penetration of the zone of interest (i.e. secondary targets, shallow hazards, lost circulation zones, etc.). These additional hazards will also be present in any pre-drill relief well. Since the actual need for a relief well is extremely unlikely, the wasted resources and the additional risks of multiple wells make the pre-drill of a relief well undesirable.

As mentioned, the fact that rigs and other resources are readily available in the GOM make the time for drilling a relief well comparatively short. This time can be further shortened by pre-planning.

Relief well pre-drilling is neither resource friendly nor risk-free. Well risk can be reduced much more effectively by well design and operational procedures that include blowout prevention as a primary consideration. If these primary methods fail then the risk of oil at the surface can be minimized by subsea containment equipment and methods.

That re-entering a Temporarily Abandoned predrilled relief well is risk free. Just as pre-drilling the relief well is not risk free, neither is re-entering and establishing operations at a temporarily abandoned well. Moving a rig back on the pre-drill location, testing of wellheads, blowout preventers and controls and removal of suspension barriers are all operations that may introduce higher risks than presented by the original well.

That the relief well is re-useable, either to respond to future wells in the same field area, or as a development well later in the field lifetime, thus its costs and risks can be justified. Whether this assumption is true will depend on the relative geometry of the relief well in relation to other potential future wells in a field, as well as to its placement within the reservoir. By definition, these considerations will not be fully understood until after the relief well is drilled to a particular target in a particular location. In fact, historical references 1 and 4 confirm that most of the

GOM blowout incidents occur at depths much shallower than the Macondo incident, further complicating directional plans and alternatives.

More recently, - during the blowout and relief well incident offshore Western Australia, accomplishing a successful intercept of the well was made difficult due to the approach angle of the relief well. The relief well required multiple attempts before succeeding[2]. The approach angle was made difficult by surface restrictions on the relief well drilling location. Obviously this would make the relief well unsuitable for a development well or replacement well. This is a good example of the difficulty in designing a multi-use well.

Furthermore, in exploration wells there is a large likelihood of a dry hole. Thus no additional wells would be required. A pre-drilled relief well in the vast majority of cases will finally represent a disproportionately large cost of resources, and a large addition to risk.

The resources expended on a pre-drilled relief well cannot reliably be recovered in secondary use of that well. Requiring pre-drilled relief wells will undoubtedly reduce the number of economically viable exploration wells drilled in the Gulf of Mexico; that will result in lost oil and gas production which in turn means increased tanker traffic and imported oil and reduction in employment for the Gulf Coast region.

Added Technical Risks:

How deep would a pre-drilled relief well be required to go? The depth to which to pre-drill a relief well involves a trade-off between drilling time savings and the accuracy of intercept operations. On the one hand, the deeper that intermediate casing can be set, the less time it will take to complete the relief well from a depth stand-point. On the other hand, successfully accomplishing the intercept is dependent on flexibility in the final intercept plan and trajectory for the relief well. The deeper the pre-drilled well is drilled, the less flexibility will be available for accomplishing an intercept.

The success of the relief well is dependent on intersecting the blowing well at the right depth. This necessitates a detailed understanding of the blowing wells actual, not just planned, trajectory. Having a predrilled relief well does not thus guarantee an increased capability to deliver a well interception or less well drilling time. A relief well could end up in a poor location or poor depth choice when the actual path and blowout depth of the blowout well is known. This may make the pre-drilled relief well useless, or result in slow drilling or multiple attempts to intercept as was experienced on the Montara blowout. [2]

How would the Casing Program be "pre-designed" for the pre-drilled relief well? Exploration wells are predominantly vertical wells and have a casing design that is appropriate for a "theoretical" pore pressure and fracture gradient. During the course of drilling the exploration well, the casing program may have to change to add additional casings due to actual drilling conditions and pore pressures and fracture gradients encountered.

Consequently the pre-drilled relief well cannot benefit from the increased understanding of the pore pressures and frac gradients and borehole stability issues that were determined by the exploration well. For this reason it is not possible to install an optimum casing design in the pre-drill. The casing pre-installed could make it impossible to use the pre-drilled well for relief well purposes, or could even cause the well to have to be side-tracked and additional casing strings installed. In other words, the correct casing design for a relief well cannot always be "pre-designed" until the actual drilling conditions in the original well are known.

Conclusion

The risk of a blowout while drilling any given well is very low, but actually pre-drilling a relief well increases those risks, potentially doubling them. On the other hand, a policy of pre-planning of relief wells, especially for special projects with potentially 'high risk', or 'high consequence', should be considered.

The Task Force will study this along with the potential benefits that may be associated with further research into relief well practices. Research would necessarily begin with integrating lessons from Macondo.

Bibliography

1. Danenberger, E.P., *Outer Continental Shelf Drilling Blowouts, 1971-1991*. 1993.
2. Danenberger, E.P., *Submission to Commission of Inquiry, Montara Uncontrolled Hydrocarbon Release*. 2010.
3. Overby, P., *Canada's Policy on Relief Wells.* NPR, 2010: p. 3.
4. Izon, D., Danenberger, E. P., Maynes, Melinda, *MMS study of OCS blowout incidents 1992-2006.* Drilling Contractor, 2007(July/August, 2007).

Attachment 1 – Selected Experience with Relief Wells

Type	Location	Successful Intercept?	Comment
Offshore	Mediterranean	**Yes (3)**	Three wells drilled to three separate targets. All were Designed and Executed. Three (3) successful intercepts.
Deepwater	Indonesia	**Yes**	Designed, Executed Successful Intercept.
Inland Waters	Gulf Coast	Not req'd.	Designed. Surface intervention succeeded.
Deepwater	GoM	Not req'd	Designed. Surface intervention succeeded.
Offshore	Bay of Bengal	Not req'd	Designed. Surface intervention succeeded.
Offshore	GoM	Not req'd	Designed. Surface intervention succeeded.
Offshore	Persian Gulf	Not req'd.	Designed. Surface intervention succeeded.
Onshore	Middle East	Not req'd.	Designed, Executed Surface Intervention succeeded.
Offshore	GoM	**Yes**	Designed, Executed Successful Intercept.
Offshore	Western Australia	**Yes**	Designed, Executed Successful Intercept.
Deepwater	GoM		Macondo (work in progress). Two wells designed and being executed.

Due to long lead times for well construction, relief wells are ordinarily planned and execution begun while surface intervention activities proceed simultaneously - interception at depth becoming unnecessary whenever surface intervention activities succeed.