Potential Approach to Future Gulf of Mexico Drilling – Preventing Blow-outs, Limiting any damage if a Blow-out still occurred

The overall goals of the approach outlined below are:

1. Eliminating all "preventable" blowouts. This would be achieved by establishing a fully independent "knowledge core", such that there would be no excuse for not fully understanding what could happen (and mitigation possibilities). The responsibility for the well design and operation would remain with the operator. This is similar to the "independent examiner" approach that is part of the UK Safety Case approach, but goes beyond this in scope while maintaining full liability with the well operator.
2. Putting in place an infrastructure such that if a blow-out accident were to occur, the impact would be limited and reduced by a fast and effective response. This response would not rely solely on the actions of the operator.

Phase 1: Well Design

The "root cause" of the Macondo disaster is most likely the well design. In particular, it is likely that if a different design were used, the disaster could have been avoided. Figure 1 shows the difference between the Macondo well geometry and that of a design that would be considered "Risk Minimized".

Attachment 1 ("System Based Well Design") has been summarized and submitted as an abstract for the 2011 SPE/IADC drilling conference. It addresses the heart of the problem. Two essential steps make up the well design process. These are:

A. Imagining what could possibly happen for the design chosen (i.e. identifying all possible load cases)
B. Determining the stress levels in the casing and other well components that result from the load cases

In this case, it would seem that the possibility of what actually happened was not recognized at the time of the design. If it was seen by some individuals within the operator (unknown if this were the case), their advice was overruled by a well management committee.

It is suggested that a significant focus be placed on ensuring that all potential load cases are recognized, such that the appropriate mitigation can be taken and disasters such as Macondo avoided in the future. In particular, the number of barriers and their effectiveness to deal with the identified load cases must be readily apparent to all concerned.

Phase 2: Operations/Execution

Evidence from the events of the 24 hours preceding the explosion and in particular the 1-2 hours prior to the explosion is not clear/public at this time. In looking at past incidents (for example, Ocean Odyssey and the work that followed from the UK HSE http://www.hse.gov.uk/research/rrpdf/rr264.pdf), the role of "Human Factors" is dominant. It would have been natural for the Horizon crew to have assumed that the well was "buttoned up". It would have been difficult to accept that a well control situation was occurring (despite a few signs) and then it may have been impossible to shut the primary line of defense (BOPs) if there were something inside the BOP (such as a seal assembly). As noted, the events that occurred during this time frame are still very unclear. However, in a general sense, if a "baseline" of "what should be observed" is established, it is much easier for a crew to accept that something that is other than this "baseline" is actually occurring. In many respects, the goal of eliminating the human factor is where we must aim.

Although, shutting the well in could have saved the lives of the 11 individuals and the rig itself, it is still quite possible that given the well design a blowout would have still occurred because of broaching of the 16" casing.

A second key focus of work that follows from this disaster should be the "Human Factors" and in particular ways and means of establishing "the baseline" such that there is agreement amongst the rig crew on (a) what is happening and (b) what to do about it (i.e. procedures). This activity must be rig and well specific.

The additional focus on BOP (and other key equipment) is merited. Work in this area will establish the requirement for appropriate enhancements. This discussion will not cover this area.

Phase 3: Intervention and Relief Well Drilling

The goal of activities in this phase is to safely regain control of the well in the shortest time frame possible. This can be achieved by re-entering the well at the top (a "top kill" of some sort), or utilizing a relief well.

For Macondo, the top kill was been made much more difficult because of the well design. In particular, the 16" casing was downgraded in weight/wall thickness (109 lb/ft to 96 lb/ft) and run as a liner. The original design would have allowed for higher pressures during the top kill and would have allowed for a "hard" shut-in, were the capabilities available to take such an action. Well design should also consider other possibilities, such as those that might be available if there were access to a 22" x 14" annulus (see "Alternative Design").

At the time of writing (July 3rd 2010) good progress is being reported for the 1st relief well (close to the reservoir).

However, it is probably possible to significantly reduce the time taken to drill such a relief well in deepwater if the objectives of such a well are focused on. In particular, it should be possible to run the conductor pipe (22" typically) to a greater depth using "pump and dump" techniques. At that point a BOP should be run (along with the conductor) and operations resumed using "pump and dump", but with a much increased mud weight. This would allow 2, 3 or 4 casing strings to be eliminated, along with many days. Prior to reaching the reservoir, casing would be run and the riser attached, such that the final interception can be made. This approach is effectively a radical form of "Dual Gradient" drilling. It can be implemented in this manner because the formation pressures between the seabed and the reservoir are well known because of the drilling of the original well.

The conventional approach to relief well drilling (as being carried out) should be considered to be the "base case".

Suggested Areas of Focus to Enable Going Forwards

A. Intervention & Relief Well

The lessons learned from Macondo must be taken forwards. Perhaps it would be appropriate to charge a fee for each deepwater/challenging well drilled such that a fund of (potentially) $100mm per year would be available to ensure that was a single "ready to go" intervention team. The "intervention team" may involve elements from the leading companies in this area. If Company A drills 10 of 100 deepwater/challenging wells, then the cost to this company would be $10mm. Most importantly, there are no economic decisions to be taken by an individual company as to the value of this up-front activity.

B. Load Case Identification and Establishment of "Base Lines"

A similar approach to that given above in A. can be used. In this case, the goals (on an industry-wide basis) are:

i. Identify load cases (or what can happen) to a well design
ii. Identify the "baseline" of what can happen and potential procedures that can then be followed to provide a solution.

Whereas in A (above) the intent is to provide "The Resource", the objective for this activity is not to provide a full resource for an operating company, but is to set the standard by which operations should be conducted. It could be viewed as a totally independent open consultancy with transparent 2-way communication. The goal is to eliminate the possibility of what actually could happen not being recognized (at the time of the design). This is achieved by having a core of knowledge against which individual operating companies and outside assessors can assess designs and approaches. Communication between the operator and the "knowledge core" would be confidential as long as a well control incident did not occur. The format of this "knowledge core" is such that it eliminates the "committee think" within an operating company where a dissenting individual (who is actually knowledgeable) can be overruled by a committee vote. The approach here is that the operating company could overrule the advice of the "knowledge core", but if a problem then occurred, the actions of the operating company (and individuals within it) could not be construed to be "an innocent mistake due to ignorance". The liability remains firmly with the operating company.

The role of the "knowledge core" is twofold: (A) provide public examples of what should be looked at and how designs/procedures can be formulated and (B) provide a 2 way discussion with the operator, such that appropriate decisions are made by the operator. It is somewhat academic, but it is most important that it be carried out by very experienced professionals – it is not suited to a university environment. It recognizes that it is best to leave the core activity of well design with the individual operating company, but it ensures that the appropriate level of knowledge and understanding is available to all.

This activity supplements the underlying industry standards laid out by API, IADC etc.. It provides an additional path for updating of these standards.

In some respects 3rd party certification by a PE aims to produce the same result. But it is likely that the PE will only be required to confirm that the design made by the operator conforms to industry standards and norms. By contrast, the goal of this effort is to substantially increase the understanding and articulation of what these "standards and norms" should be, recognizing that it is very difficult (if not impossible) to provide prescriptive approach for these complex deepwater wells. Questions of how to handle the (implied legal) liabilities placed on an individual PE (or a PE within a (small) independent company) are not discussed here. Absolving the operator of liabilities with a PE stamp is not appropriate.

The same comment as for the PE certification applies to the UK "Safety Case" approach and the requirement for a well design to be examined by an independent (competent) examiner. It is assumed here that a 3rd party carrying out this activity must have equal (or even superior) resources to those of an operating company and this is exactly what it is intended to provide.

An annual budget of perhaps $20mm, funded in a similar way to A. (above) might be appropriate for this "knowledge core".

C. Review and Enhancement of BOP and other key equipment

This activity is essential – it is simply not commented upon here.

Release of Information

It is appropriate that during normal operations, information regarding the well should be the confidential property of the operator. This would include any information or discussions between the operator and the groups noted in focus areas A. and B. above. However, if a blowout occurs the impact is owned or felt by everybody. It therefore should be the case that following a blowout, information with respect to the well should be made public without the need for a congressional enquiry.

This information should include, but not be limited to:

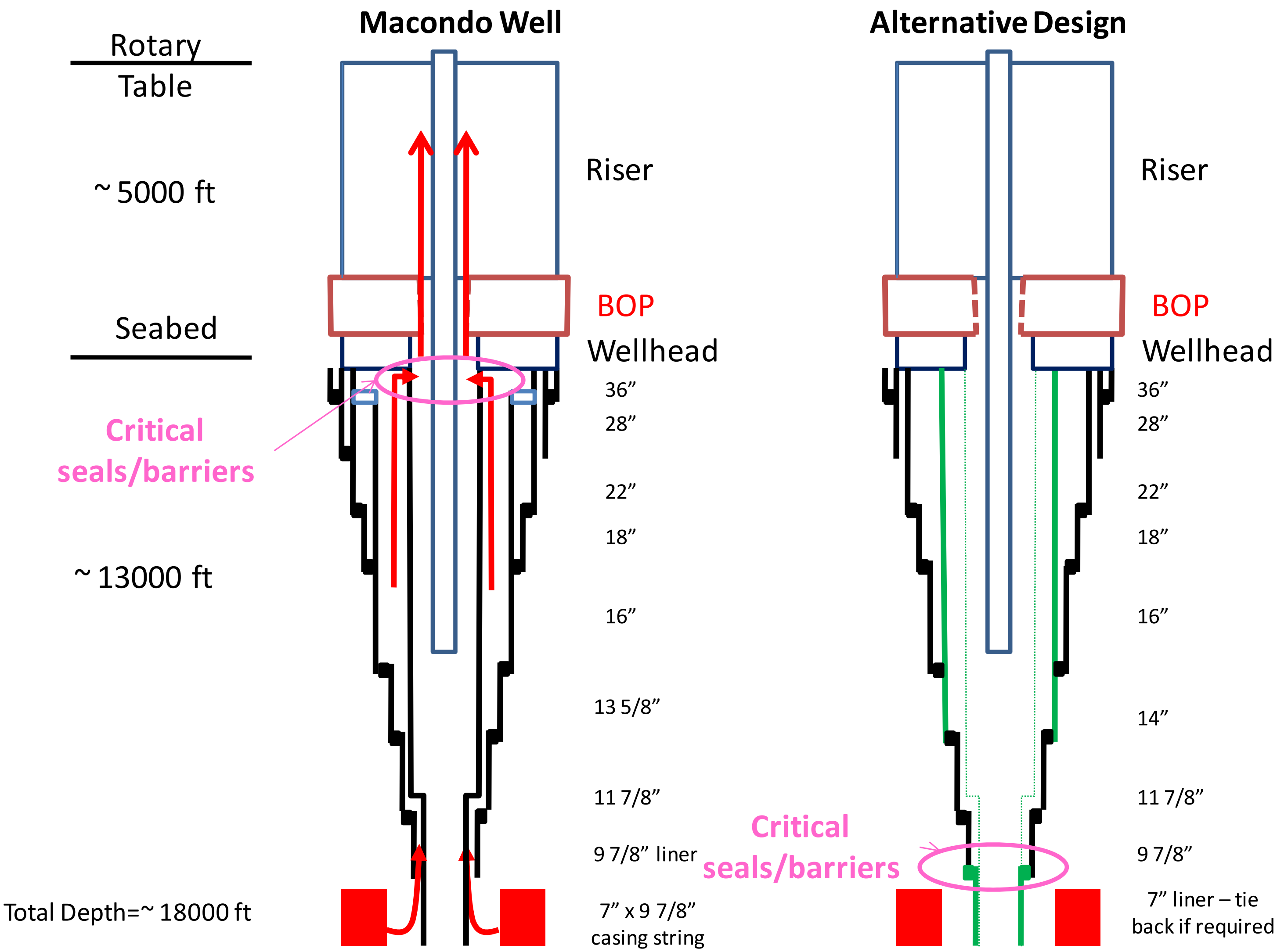
- Well (and seabed) geometry
- Well logs
- Mud weights and pressures

- Gas and oil flow-rates and potential
- Intervention and kill plans

Release of such information would allow some input to the solution by parties not directly contracted to the event. It would also potentially remove the uncertainty with respect to the extent of the problem (particularly flow rate from the well). It would certainly allow the community at large to see the logic of the go forwards strategy.

It would of course highlight the potential liability of the operator. However, that is not necessarily all bad.

Figure 1: Alternative Well Designs



Attachment 1: SYSTEM BASED WELL DESIGN

Well design tools currently used by industry are both mature and very sophisticated in the treatment of stresses and loads on the casings and other well components. Despite these tools there must be improvements and advances in the understanding of the relationship between the abstract design process and the real world loads and conditions imposed on the design. This is of particular concern in deepwater high pressure wells, where extreme conditions push technologies to the limits. Recent disasters point out that revisions to the process are essential if we wish to continue drilling and completing wells with acceptable results.

For deepwater, HPHT and other challenging wells, it is well understood that there is a need to make compromises, weighing risks and consequence in order to arrive at a balanced well design that works for all situations. While it is not possible to generate a design that will provide 100% assurance that all situations can be handled using design margins currently in use, we need to ensure that we fully understand the failure modes of the design and can assure that all cases including the failure of one or more components does not result in total loss of well control.

The design by its nature must cover the entire well from spud to abandonment as a dynamic interactive system. It must be an iterative process considering both the impact of a situation on the design chosen and the properties and characteristics of well components (casing etc) that are available, or could be made available if required. Simply, there is no "standard" approach that can be applied for all wells, though there are many guidelines and standards that must be considered and included within the design process.

The goal of a design must be to provide a well that has integrity over its lifespan and to allow primary, secondary and if possible tertiary operational approaches to be implemented to provide a high probability that the well can be safely secured and avoid an environmental disaster, even if “less than perfect” choices are made during the execution phase. This may be called a "risk minimized design”. The aircraft industry has demonstrated that no design can guarantee failure will not occur. The well design must however always make success the highest possible outcome if it to be considered “Risk Minimized”. It is most important that the unknowns are fully recognized and allowed for and that some allowance is left in for those unknowns that we absolutely do not know. If it is easy to include extra margin, perhaps we should, even if we cannot identify the specific need.

Typically the methodology of design used today is:

A. Identify a well configuration to suit both knowns and unknowns

B. Determine what could possibly happen to the well, given the identified configuration. This must include dialogue from the operations team as to their understanding of what would be imposed on the well. It is most important to understand what has happened to wells of the type being designed in the past. It is also most important to think through what could happen, but which has never happened before. A key component of this step is a thorough and realistic understanding of well control events including the events leading up to (termed preventative well control) and details of catastrophic events.

C. Calculate the stresses and other conditions that will occur given the well configuration and the identified load cases

D. Iterate through many loops to arrive at a safe and effective well design

Input (and buy-in) from the operations team is essential during this design phase.

In all cases, the number and effectiveness of the available barriers must be readily apparent to all parties. It would be well worthwhile to provide an approach that enables the designer to identify each and every barrier and the related strength/effectiveness and then the operations team to identify the condition of each barrier, such that effective feedback can be provided throughout the overall design/operation team.

The Focus must be on:

1. The methodology of well design, but in particular steps A, B and D (above), which could be improved within the industry. Note that in some cases, more stringent component specifications will be required (for example very specific additional barriers), but in some cases, it will be perfectly acceptable and appropriate to lessen such specifications such that there is then the proper safety level available for when it is really needed. Discussion of Step C is excluded from this discussion.

2. The absolute necessity for the designer to provide the operations team with a crystal clear understanding of the limits of the design. It is essential that timely and appropriate feedback is relayed from the operations team to the designer during the execution of the well, such that the designer can identify if his or her thinking did not include the conditions which the well is being subjected to and plans or approaches modified accordingly. If changes are to be made, a strong "Management of Change" program must drive the process.

3. A reflection on costs of well components and fully understanding the difference between a calculated risk, and a foolish chance

4. Development of newer approaches and better use of existing technology which can be used to ensure the integrity of challenging wells. In some cases, use of this new technology reverses the approach that has been taken to date.

The goal is to provide a path forwards such that we can safely and effectively drill and complete the most challenging of wells if we choose to do so.