API RP 96 & API BULLETIN 97: ESSENTIAL FOR DEEPWATER WELL DESIGN & CONSTRUCTION SUCCESS

Michael Gibson, PhD; IDEAS Singapore Pte Ltd

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ABSTRACT

This paper portrays the advantages of utilising API RP 96 & API Bulletin 97 for deepwater well design and construction through discussing and portraying those factors which are crucial for successful deepwater wells globally and particularly for offshore South East Asia.

Through discussing the reasons behind success (and failure) in terms of well design and construction, the lessons learned can be applied to future deepwater South East Asia wells thereby inducing both successful drilling and associated well cost (which is all-important in today's low oil price era). Furthermore, given the evolving content of well control certification programs and also the area of well integrity, API RP 96 is most useful with regard barriers and their testing once in place. This knowledge is extremely beneficial from both a planning and operational perspective for all those who are directly involved in deepwater wells.

Finally the paper addresses data which shows us that when costs over-run they are huge (typically of the order of $ several million). Also, well loss likelihood is very high when wells are not superlatively designed, there are no contingencies in place should things go awry, operational planning is less than optimal and risks have neither been adequately addressed nor assessed from a life-cycle well integrity perspective.

INTRODUCTION

With the world's energy companies struggling to make deepwater projects work with oil in the $40 - $50 range, it's vital that wells are both designed and constructed superlatively if they are to be a success. Having consulted on many projects, IDEAS has noticed that many Operators are finding that they do not have the requisite in-house experience or expertise to satisfactorily design, construct and manage contractors in the drilling, completion and production of such difficult and costly wells. Moreover, many do not have the time to learn the lessons learnt from other energy companies, particularly if there are no agreements in place regarding lessons learnt and data / information transfer. Many companies thus become reliant upon their service providers – whether drilling contractor, service company or capital equipment suppliers – to perform an optimal job. But is this ideal? Data shows us that cost over-runs are huge (as a minimum, $ several million), and well loss likelihood is very high when wells are not superlatively designed, there are no contingencies in place should things go awry, operational planning is less than optimal and risks have neither been adequately addressed nor assessed through detailed risk management.

For those Operators who do not have sufficiently expert experience in the areas of deepwater well design and construction, API RP 96 and API Bulletin 97 are vital starting points and cross-reference documents for both the design and construction phases of the well.

This paper portrays the advantages of using API RP 96 and API Bulletin 97 and, in particular, the use of "Well Activity Risk Management" as referenced in Section 5.7 of API Bulletin 97. Thorough risk management and associated impact analysis with respect to deepwater well design, contingency planning, operational planning and well construction are essential.

With deepwater semi-submersible rig and drill-ship operating rates approaching $1 million per day operating on existing contracts (half this on new contracts), the advantages of an extremely well-managed operation, where all risks and their impacts have been adequately addressed, are clearly seen. The disadvantages of not approaching deepwater projects in such a way are also clearly seen: well failures, huge cost over-runs and severe safety issues are also discussed.

Beginning with deepwater well objectives (i.e. maximum productivity and safety over a maximum period of time with minimum CAPEX and OPEX) the paper then discusses those key issues associated with the management of the well design and offshore operational processes which significantly impact productivity, efficiency and safety and where energy companies typically fail with regards to contingency planning. This massively impacts both short-term cost and long-term revenue. Risk impact methodology to mitigate or minimise such risks is discussed next. Then the paper discusses those key well planning and operational issues which typically befall the inexperienced energy company – and how, again, such risks can be mitigated / eliminated to the benefit of all concerned – energy company, drilling contractor, service company, supply company. In essence, if all conceivable risks are identified up-front – i.e. safety related, production related and cost related - then mechanisms can be put in place, through the appropriate management systems, to optimise ROI and minimise undesirable events – of which there are many around the world.

Finally the paper concludes by stating the key benefits associated with the utilisation of risk-based systems and the use of API RP 96 and API Bulletin 97, the conclusions being based upon experience gained on deepwater wells in a variety of locations. It is hoped that these conclusions will benefit South East Asian operators / energy companies with their deepwater projects.

DEEPWATER WELL OBJECTIVES

For the Operator, the well's objectives relate to the category of well. It it's an exploration well the safe, cost-effective finding of hydrocarbons is considered the key objective. If it's an appraisal well, the safe, cost-effective likely reservoir reserves increment is considered key. If it's a development well the objectives go further – into the areas of successful reservoir drilling, completion and hook-up to production.

Implicit within the attainment of these exploration / appraisal / development objectives are two fundamental themes: cost effectiveness and safety.

All Operator’s want their wells to be either on-time and on-budget or under-time and under-budget. Yet many fail – due to a number / combination of reasons, many of which are discussed within this paper.

For the Drilling Contractor, the objectives relate to the type of contract negotiated. For example, if it’s a simple flat high day-rate contract (as is typically the case) then there is little incentive (depending upon the contractor) to improve performance through better understanding of downhole conditions / downhole drilling / completion systems for example. However, if a performance contract has been negotiated, then the opposite will be true.

For the Third Party Service Suppliers, their objectives are often more focused upon repeat business through their own performance – and whilst, for example, they can optimise the performance of their mud system (insofar as it’s the right mud system in the first place), they have little or no control over directional drilling performance for example (unless of course it’s a large Integrated Services contract for example).

For the Equipment Suppliers, well objectives might be as simple as “making a sale”.

Generally, from an overall project perspective, the key objectives are maximum productivity over maximum time with minimum associated cost (Capex & Opex). It is to be hoped that maximum safety is also an integral part of the overall project plan.

Latest Generation Drill Ship (Courtesy of Seadrill)

MANAGEMENT

Management excellence is crucial for these wells. This is an area with respect to which IDEAS personnel find to be remiss within many companies concerned with the drilling, testing, completion and hook-up of deepwater wells – whether Operator, Drilling Contractor, Service Provider or Equipment Supplier. Over-runs are usually in the order of $1.5 – $7 million. Final well costs in the Borneo arena can be as high as S100 million (2014, Reference 3).

Operating Philosophy

Excellence without compromise has to be the cornerstone to / of the company's operating philosophy – otherwise optimal performance will never be achieved. For example, an Operator is unlikely to enjoy absolute best performance from its contractors / equipment suppliers if its operating philosophy is always based upon lowest cost bid award. Similarly, if safety and personnel training is viewed as a cost as opposed to an investment again the Operator is unlikely to enjoy absolute best performance.

Beneath the big-picture umbrella of what should be "mission philosophy excellence" are several sub-set but inter-related areas which are all equally important within their own right:-

Management Systems

Typically, a company can only perform as well as its management systems allow. If these systems are deficient in any way then performance will suffer, particularly on deepwater wells. Why is it that, as an industry, we're still seeing, on deepwater wells, shallow gas blowouts, loss of BOPE and riser due to poor handling procedures, death due to poor anchor-handling to name but three examples? Poor management systems are synonymous with poor performance; however performance is measured (i.e. cost / time / accident frequency etc).

Engineering Systems / Standards

Do all Engineering Systems / Standards reference the appropriate sage / august / learned bodies of authority? For example, the Institute of Petroleum, the American Petroleum Institute, the International Association of Drilling Contractors, American Bureau of Shipping, the appropriate / relevant Design & Construction Regulations to name but a few examples. If Engineering Systems / Standards are poor, then the wells' design and construction cannot be expected to be optimal – however optimal is defined (e.g. cost-effective, life-cycle longevity, zero lost time accident frequency, objectives met etc).

Operating Systems / Standards

As with Engineering Systems / Standards, the same applies here, however pre-thought-out / rationalised Decision-Analysis Flowcharts are critical for offshore use to avert problems escalating from a "bad" situation to a "catastrophic" situation. Data from countries now heavily involved in deepwater drilling show that lack of good Operating Systems / Standards is highly contributory to untoward event escalation (i.e. from "bad" to "catastrophic").

Contract Strategy

Although the face to the public / investors is often one of "teamwork" and "co-operative spirit" and "synergy" etc, often relationships between Operator, Drilling Contractor, Service Company and Supply Company are fractious to say the least.

Risks associated with poorly-planned deepwater wells are high – thus, why would a Drilling Contractor want anything other than a (high) day-rate for his deepwater latest generation semi or drill ship? Answer is – he doesn't. If the well exceeds the budget allocation by a significant amount (5-10%) the Operator can become “annoyed” with the Drilling Contractors / Service / Supply Company’s performance, particularly if there are failures of equipment for whatever reason.

One of the most optimal ways forward is to move away from the typical day-rate model and move toward a performance model – and reward all those concerned for performance excellence. It’s essentially a question of being completely fair as regards risk and reward; rewarding those who contribute to success – again, however this is measured – financial savings, zero lost time accident rate etc.

Interfacing
Many Operators are notoriously poor at interfacing – not just with their peers (who are often seen as “competitors”) but with their service providers / suppliers (who have enormous worldwide experience) and sometime in-house too! Thus, it is not surprising to the outside observer that the same mistakes keep being made – repeatedly.

Given the huge cost of deepwater wells and their associated potential for untoward event risk escalation, great gains can be made through interfacing or “alliancing”, particularly if data acquisition and its interpretation is independent, impartial and objective. If companies, as a result of their Operating Philosophy / Philosophies choose not to interface or seek alliances, then they face a very steep learning curve – and all that goes with it – for example:- high cost over-runs, safety issues, project failure and, in some cases, loss of reputation, increased insurance cost and loss of operating license.

This very important subject area must also include full embrace of Government and Industry Standards.

Time
Unfortunately, many oil-related companies, due to their structure, how they’re run (accountants) and their views, perceive time as a cost rather than as an investment (which Six-Sigma companies do). Within these companies, particularly insofar as deepwater operations are concerned, difficult times at best and awful times at worst are prevalent, since, simply, there’s no short-cut to doing things properly.

Those companies which do view time as an investment as opposed to a cost reap the attendant benefits almost immediately. They achieve their objectives; they have no safety issues; they are on-time and on-budget without drama and without incident. There is, simply, no substitute for time well-spent on all aspects of deepwater planning and associated deepwater operations.

Peer Review
Unfortunately, many operators, drilling contractors and virtually all third-party service and equipment supply companies do not utilise the many excellent independent peer reviewers available to them. Peer reviewers; because they are independent, un-biased and “fresh to the scene” often see things, particularly in terms of performance and efficiency, which people who have become entrenched within things do not. Even the smallest thing on paper can impact things significantly on deepwater offshore operations.

Well Examination – Design & Construction
As a result of previous offshore tragedies occurring within their waters, and simply because it’s the right thing to do, many Governments around the world have now introduced Well

Examination Schemes whereby independent, competent and experienced examiners check the well's design with regard to risk and safety (not performance per Peer Review). Concerns regarding design, risk and safety have to be addressed before the drilling / testing / completion programme can be approved. Then, assuming the design has been approved, checking of the daily drilling reports by the Well Examiner ensures that the well has been constructed per its design.

Such a well examination scheme prevents both unsafe design in the first place and unsafe drilling practices during the construction phase. Typically also Operator – Drilling Contractor Bridging Documents are also reviewed. This further aids safety.

Training

Do your staff have all the necessary (which is not the same as the minimum) training? This is critical since deepwater wells are expensive – and even more expensive if untoward events occur. This can be embarrassing for Operator, Drilling Contractor, Service Provider and Equipment Supplier alike – particularly if the untoward event was found to have been preventable through training.

Training should be viewed as an investment – not a cost. Well trained people are motivated people, and motivated people are efficient people – which significantly impacts bottom-line performance.

Deepwater Semi-submersible (Courtesy of Ocean Rig)

DWOP (Drill Well On Paper)
Drilling the well on paper is an opportunity for all companies involved in the well to come together in an informal environment to discuss everything from spud to TD (Target Depth) – and what the objectives are once the well has reached TD. This is a great opportunity to maximise / optimise planning / engineering and operations.

Ideally, a few days completely outwith the normal working environment should be invested in a setting conducive to "no barriers" discussion, communication and viewpoint gathering. All personnel must be involved, otherwise the team is incomplete. This means the full spectrum of people from Operator, Drilling Contractor, Service Company and Supply Company (including the Peer Reviewer and Well Examiner) and, if employed, the Technical Limit coaches.
The drilling / testing / completion / hook-up programme(s) can then be optimised in light of the contributions made.

Technical Limit
If Technical Limit hasn't been built-into the programme(s), this is the last time that it can be discussed / built-in.

Arising as a result of poor performance offshore to West Australia in the early – mid 1990's, Technical Limit is now referred to by several names, but essentially the ethos is one of "performance optimisation" through highly detailed planning and operational organisation. It is suggested that all deepwater wells, in view of their cost and propensity for massive cost overrun, be planned on a Technical Limit basis.

Programme Sign-off
In many cases, it's a rush to "get the programme out to the rig / drill ship" and so senior (e.g. Drilling Manager) sign-off personnel do not typically spend sufficient time reviewing / improving the planning operations. Thus, the programme reaches the rig / drill ship in a hurried manner, which is not optimal. Sufficient time should be dedicated to this task – it is very, very important. After all, the Drilling Manager is the final signatory – and sign-off should never be rushed.

Operational Interfacing
Again, time must be taken here – to allow the rig / drill ship crew (who did not attend the DWOP) to become completely acquainted with the programme(s).

Senior Drilling Contractor / Service Personnel should have attended the DWOP. However, only rarely do the drill crew attend, and so it is vital that they have the time necessary offshore to understand what's required in terms of safety and performance in advance of the operation – as opposed to "on the fly" – which is typically the case.

RISK MANAGEMENT
If all of the above – and all associated / related issues – are subject to Risk Impact Methodology, then risks can be either eliminated or at the very least mitigated. And not only does performance improve, but safety improves enormously too.

Each hazard within an activity is considered as having two risk parameters associated with it:-

1. The probability of occurrence of the hazard (P_{occ})

2. The consequences to the operation if the hazard were to occur (specifically, tolerability)

The meaning of the first parameter is self evident, namely the probability of occurrence of the hazard. The second parameter can also be interpreted as a probability – ***the probability of occurrence that would be considered acceptable for that hazard.***

Safety Factor
A Safety Factor (SF) can be calculated for the ratio of the tolerable probability of occurrence of the hazard to the probability of occurrence of the hazard. The definition and meaning are as follows:-

Safety factor SF is given by: $SF = P_{tol} / P_{occ}$

Where:- P_{tol} is the tolerable probability of occurrence of the hazard and P_{occ} is the probability of occurrence of the hazard

In terms of SF, a variety of plots / schematics can be used to portray the data / information. For typical oil & gas studies, bar charts are utilised since they are readily interpreted by well designers, operator staff and drilling contractor staff.

Overall Safety Factor
The safety factor described above gives a risk assessment at the hazard level, where one or more hazards can affect an activity. However, as there can be many activities, it is useful to distil the information into a summarising graphical representation. This is achieved by calculating an Overall Safety Factor (OSF) for each activity.
The OSF for an activity is obtained by multiplying the individual SF values together. This is subject to the constraint that SF values that are greater than 1 are set to 1 prior to the multiplication. This prevents activities with one or more, high, SF values from artificially skewing the OSF in the direction of safety.
The maximum possible value of the OSF is 1. A value of 1 implies that all individual hazards are considered to be at least as safe as that which is considered tolerable. An OSF value of 0 implies that one or more hazards are in the category of being considered **highly dangerous**.
An easy way to see this is through the use of Overall Safety Factor Bar Graphs.

Safety Factor Bar Graph
In terms of SF, a variety of plots / schematics can be used to portray the data / information.
A SF of 1 means that the risk is acceptable as it is less likely, or as likely to occur as that which is considered to be tolerable. Conversely, a SF of less than 1 means that the risk is more likely to occur than that which is considered to be tolerable.
The safety factor bar graph displays the safety factor for each risk as calculated using:-

$SF = P_{tol} / P_{occ}$

If all of the areas below are subjected to Risk Impact Analysis then, simply, risks are either eliminated or, at the very least, mitigated.

KEY WELL PLANNING & OPERATIONAL ISSUES

Based upon deepwater experience in the Atlantic, West Africa and the Gulf of Mexico, if the following areas referenced below are poorly planned and executed then the well will exhibit massive cost over-run, poor safety performance or both. It thus makes sense to subject each area to rigorous Risk Impact.

- Operating Philosophy
- Management Systems
- Engineering Systems / Standards
- Operating Systems / Standards
- Contract Strategy
- Interfacing
- Time
- Peer Review
- Well Examination
- Training
- DWOP
- Technical Limit
- Programme Sign-off
- Operational Interfacing
- Deepwater Drilling Vessel Selection
- Environmental Considerations (Wind, Wave, Storm Force Loadings, Emergency Disconnect)
- Wellheads & Pack-off Problems
- Hydrates
- Well Control
- Riser Issues (Forces, Buoyancy, Gas Expansion, Margin, Boosting, Vortex Shedding)
- Jetting versus drilling the conductor
- Overburden, Pore Pressure, Fracture Gradient
- Managed Pressure Drilling
- Shallow Gas
- Shallow Water Flow
- Losses
- Drilling Fluids
- Pump / Standpipe Flow Rates
- Bulk Volumes & VDL
- Cementing
- Stuck Pipe
- Drill-string vibration and twist-off
- Weak / Incompetent reservoirs
- Geo-pressure

This last sub-section needs, particularly for South East Asia (Borneo region), deserves its own section, which we will look at now

GEO-PRESSURE

First-rate G&G data is essential if both pore and fracture pressure is to be estimated correctly thereby allowing sufficient kick tolerance to be attained at each casing shoe in order for the exploration well to reach target depth. (Many deepwater exploration wells have failed to reach target depth simply because of insufficient kick tolerance). It's also essential for the optimal drilling and completion of development wells too. In Asia, great gains can be made from the use of geo-pressure prediction. Reference 3 covers this area in excellent detail.

RISK MITIGATION / ELIMINATION

In a nutshell, if all of the above referenced points had been studied in detail and Risk Impact Analysis used, then it is most unlikely that the problems pertaining to these events (which are readily available through the Industry's forums) would have occurred.

CONCLUSIONS

Deepwater operations are expensive and, due to the environments (oceanographic, meteorological and sub-surface [particularly with respect to pore pressure and fracture pressure]) what seems to be an "ordinary / routine" risk very quickly escalates into an expensive "non-routine" risk. This can significantly impact safety, efficiency, cost and the maximisation of oil production.

All who are involved in deepwater drilling should reference API RP 96 and API Bulletin 97; not just at the beginning of the well design phase but throughout the construction phase too.
Finally, it's vital that the greatest attention be paid to the "Well Activity Risk Management" statement in API Bulletin 97, i.e. "the risks associated with the planned well construction activities must be identified and mitigated to as low as reasonably practical". If they aren't then the well may not be drilled under budget – and it may not reach its objective.

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AUTHOR'S BIOGRAPHY

Michael Gibson PhD has 35 years international oilfield experience working in a wide variety of disciplines ranging from drilling engineering through to drilling operations and, latterly, drilling consultancy and training.

A champion of lateral thinking, new technology, risk analysis and inter-disciplinary teamwork, he studied at The Robert Gordon University in Scotland. He holds Master's Degrees in Offshore Engineering and Engineering Technology and a PhD in High Pressure High Temperature Drilling.

He currently advises and teaches a wide-range of clients worldwide and is based in Singapore.

FOOTNOTE

IDEAS Singapore Pte Ltd was established in Singapore in order to transfer its North Sea, Atlantic and Gulf of Mexico experience to South East Asian operators, drilling contractors and service companies. Focusing upon well performance, risk reduction, efficiency and cost-effectiveness, IDEAS Singapore Pte Ltd advises a number of clients, including deepwater operators and drilling contractors, ranging throughout South East Asia. IDEAS also teaches a great deal throughout South East Asia, and this Abstract refers to a very large drilling company based here in South East Asia.