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Research Article

Safety Management and risk in kill well with case study in Iran and the Other countries

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Abstract

We know that a kill well with drilling relief well is a one of prevalent process and all of company know a managing this work is a one of hard working. In this article, we try to study managing kind of relief wells and show relief well planning. Relief well planning was started as a contingency immediately after the blowout occurred with full resources directed to that effort after the second drill pipe kill attempt failed. These "design process" steps, in generic terms are the following: defining relief well objective, defining kill point(s), defining hydraulic communication method, evaluate position uncertainty, evaluate geology, define attack angle, develop an electromagnetic ranging strategy, determine surface location(s), develop relief well trajectory, define relief well casing program, define survey program, evaluate kill hydraulics, determine the number of relief wells, define kill equipment, and project refinement for drilling and kill. The team was broken into four primary units each with leader. We speak about criteria for evaluating kill options try to know about a principle relief well and relief well concentrations. In this paper we try to show you everything about managing it. This work can help companies for a best planning.

Key words: Safety Management; Kill well; Relief well; Hydraulic communication method; Well trajectory

Relief well teams

The team was broken into four primary units each with leader. Unit 1 was the drilling team which was further divided into the management and rig site crews for each drilling rig. This unit was responsible for the planning and execution of the normal drilling operations required for each relief well. Unit 2 was the well intersection team. This unit responsible for the planning and execution of directional drilling, surface and borehole surveying, and casing detection required to achieve a direct intersection in the blowout borehole. Unit 3 was the hydraulic kill team. This unit was responsible for the kill hydraulics; specifying, sourcing and testing of the kill equipment and kill fluids; developing the detailed kill procedures and supervising the final kill. Unit four, was the blowout specialists team, this unit was responsible for all work performed on the wellhead and inside the hot zone. (Fig 1 shown American company Planning Flowchart for a relief well)

Source Control – Relief Well Branch

The Relief Well Branch sub units are shown in more detail below. The routine drilling services are coordinated by a designated drilling rigs group leader. The logical choice for this position is a senior drilling engineer (supported by the drilling superintendent as required). This is a functional position and would be filled by the senior drilling engineer assigned initially to the Relief Well planning task force. In this position, he will be responsible for assisting the special services

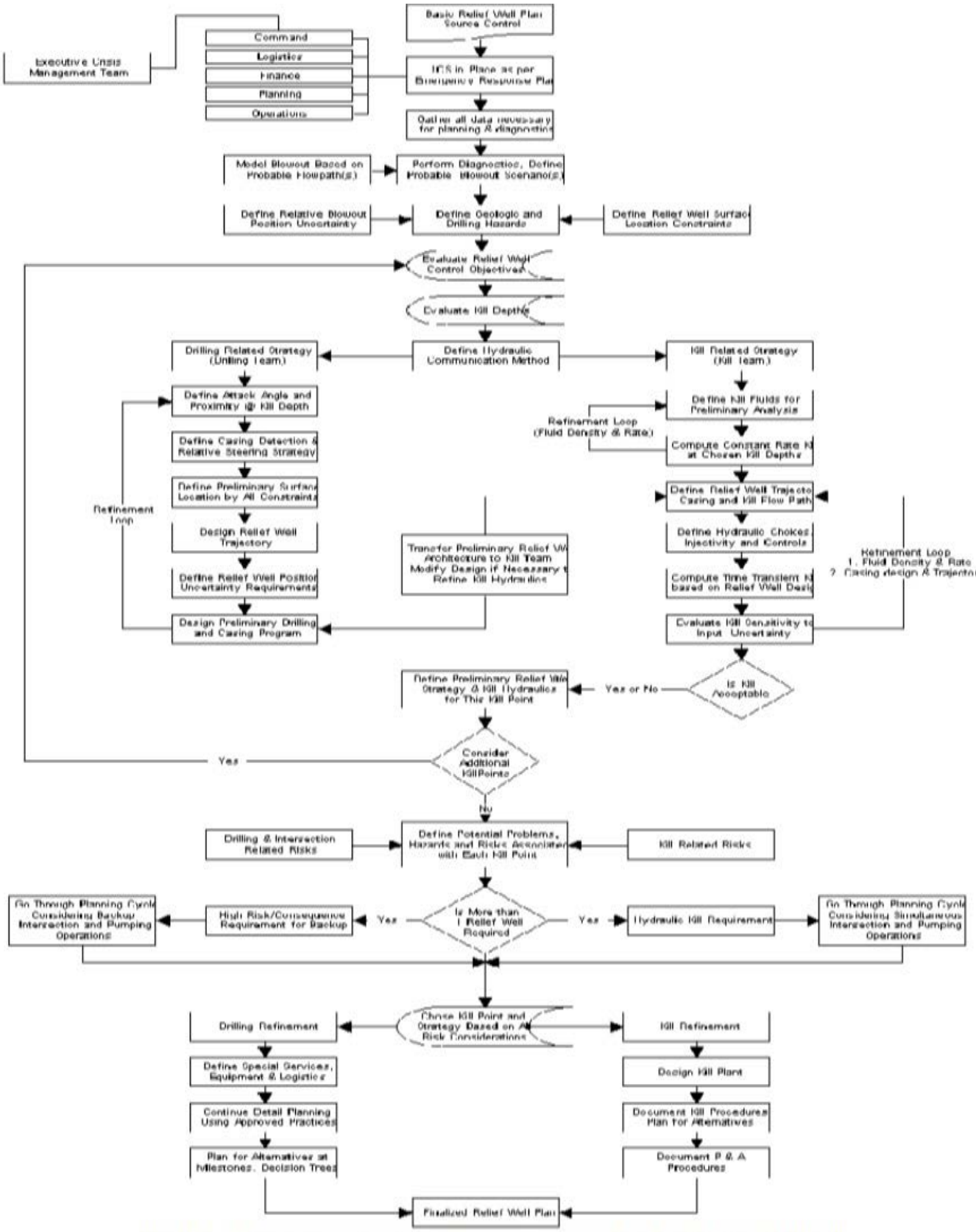

Figure 1. A shown success American company planning for a relief well.

group, initially in planning the relief well standard drilling program (e.g. casing design, wellheads, cement, drilling mud, bits, etc.). After the relief well is spudded he will coordinate all normal drilling activities between the relief well rig(s) and support the special services unit at the rig site. The drilling supervisor will be the unit leader for his rig. He will maintain most of his normal responsibilities during the drilling of the relief well. This will include all normal drilling operations, cementing, casing, logistics including well control and emergency response. If there is a well control emergency on the relief well it will be his responsibility to carry out appropriate response actions (the relief well special services unit leader will provide emergency response guidelines before drilling begins).

Special relief well services performed at the rig will be planned and supervised by either the kill unit leader or the intersection unit leader. The intersection unit leader will be responsible for making the intersection at the chosen kill point. He will supervise the directional drilling, surveying (surface and borehole), and the homing-in services. He will coordinate closely with the rig supervisor and the drilling rigs unit leader to minimize miscommunication (the intersection unit leader will have final decision on field procedures, for these services, if there are conflicts between service company personnel). The intersection unit leader has three functional task force positions under him. They are directional drilling task force leader, surveying task force leader and a homing-in task force leader. These positions may or may not all be filled depending on the scope and the number of the relief wells drilled.

The kill unit leader will plan, coordinate and supervise: (1) the high pressure pumping plant design; (2) low pressure kill mud pumping, storage and transfer; (3) kill fluid design including any reactive chemicals or polymers usage; (4) obtaining hydraulic communication between the relief well and the blowout; (5) the kill pumping operations; (6) kill monitoring and diagnostics during pumping; (6) plug and abandonment. The kill unit leader has five functional task forces under his supervision. These are high pressure pumping; low pressure pumping/mud storage and transfer; kill fluids; kill cementing; and kill modeling and diagnostics. These positions may or may not all be filled depending on the scope of the kill operations and the number of the relief wells drilled.

Relief Well Branch- Special Services - Intersection Unit

The special services group leader acts as the special services project manager for the relief well. He will coordinate the daily planning cycle, incident action plans, the development of the general plan and supervise its execution through the intersection.

The kill unit leader and the intersection unit leader positions are functional. The special services unit leader may fill one, both or neither of these positions depending on the scope of the kill operations and the number of the relief wells drilled and his personal experience.

There are three functional task forces one for directional drilling, one for surveying and one for homing-in.

These units each have a unit leader positions. Someone must perform the functions but they may or may not be separate individuals (e.g. the intersection unit leader may also take on the survey and homing-in task force leader positions). The size and critical nature of the project will dictate the filling of these positions with dedicated individuals.

The directional task force leader is a specialist in precision directional drilling peculiar to well intersection and homing-in requirements. Responsible for well placement as per plan, he will coordinate the directional drilling activities of the service company. This is best done through the contractor's directional drilling coordinator. If he is not available on a full time basis, the task force leader will work directly with the DDS for each rig.

The Surveying Task Force Leader will coordinate all the surveying activities through the service company to include: MWD, drop magnetic multi shots and gyros. He is a specialist in borehole position uncertainty and QA/QC of the surveying instruments being used. He is responsible for survey accuracy in the blowout and all relief wells. The coordination is best done through the contractor's MWD and survey coordinator. If this person is not available full time he will coordinate directly with the operators.

The Homing-in Task Force Leader is a specialist in casing detection tools, their application and QA/QC of data. He will coordinate with the homing-in Service Company to design the ranging depths, procedures, relative well trajectories and uncertainty of calls. This position is again functional and might be filled by the Survey Task Force Leader or the Intersection Unit Leader if they are qualified.

Relief Well Branch- Special Services - Kill Unit

The Kill Unit Leader is an engineering specialist in planning, preparing for and directing the kill operation from either the surface or from a relief well. The Kill Unit is shown as a single group for both Surface Control and Relief Well as it is not common for both teams to work simultaneously on both (there generally is not enough resources, equipment or personnel, to set up kill spreads on two relief wells and a surface kill operation simultaneously). Kills are usually planned in sequences (e.g., if a surface kill is possible, several attempts may be tried before resorting to the relief wells). It may be necessary, however, in cases where drilling is fast, that separate task forces

may have to mounted.

The Kill Unit is further divided into specific functional Task Forces. These Task Forces may or may not require dedicated Leaders depending on the circumstances and scope of the kill job (i.e., the Kill Unit Leader may fill one or more of the Task Force Leader positions). The Task Force functions are:

- High pressure pumping Task Force: This group will be responsible for planning, assembling, testing and performing the high pressure kill pumping (based on simulated hhp requirements). This may require resources from more than one Service Company and they may have to be split between kill platforms or rigs. The Task Force Leader, if activated, must be a specialist in this field. If more than one Service Company is utilized he should be independent if possible.

- Low pressure pumping, mud storage, mud transfer, and mud plant design/construction (if necessary) Task Force: This group will be responsible for planning, assembling, testing and performing the low pressure kill fluid storage and pumping to feed the high pressure pumping plant. If liquid mud is not available then this team will also be responsible for design and construction of a suitable mud plant. This may require resources from more than one Service Company and they may have to be split between kill platforms or rigs. The Task Force Leader, if activated, must be a specialist in this field. If more than one Service Company is utilized he should be independent if possible.

- Kill Fluid Task Force: This group will be responsible for designing the kill fluid(s) and their recipes to be used. This will include: water, brines, mud, additives, LCM, special chemicals, polymers, and reactive chemicals (e.g., gunk). The Task Force Leader, if activated, must be a specialist in this field. If more than one Service Company is utilized he should be independent if possible. (fig 3 shown a kill hydraulic system for KGN 23 well that kill with two relief well)

- Kill Cementing Task Force: This group will be responsible for designing the kill cement(s) and their recipes to be used; equipment selection and testing and performing the kill cementing. This may require resources from more than one Service Company and they may have to be split between kill platforms or rigs. The Task Force Leader, if activated, must be a specialist in this field. If more than one Service Company is utilized he should be independent if possible.

- Kill Simulation and Monitoring Task Force: This group is responsible for performing hydraulic simulations (using sophisticated software tools); assisting in blowout diagnostics; monitoring the kill during the job providing feedback as required to the Kill Unit Leader; performing diagnostics, if the kill attempt failed, for modifications to the next attempt.

Figure 2- A shown a kill hydraulic system for KGN 23 well that kill with two relief well.

Source Control - Planning Section

The Planning Section for Source Control operates slightly different from the ICS described Planning Section for say an oil spill or other disaster. In those cases the Planning Section plans what the Operations Section is going to do on a daily and long-range basis. This is done by setting objectives but not tactics on how to accomplish those objectives.

Due to the rare occurrence of blowout source control operations and the requirement to utilize both blowout specialists and local personnel in much of the planning as well as operations, this format needs to be modified. The Planning Section, in reality, turns out to be more of an engineering/technical support section. The blowout engineering specialists will develop a control strategy for both surface and relief well options and the Planning Section will provide local engineering technical support to turn the strategy into an acceptable design and then assist in the daily planning and implementation cycle as required. Most of the support engineering staff will only be required during the initial planning cycle and will not be full time members of the Source Control Team.

The Engineering/Technical Support Unit Leader is logically a Qualified Individual from Drilling Engineering, e.g., the department supervisor. Under his direction (supported by blowout engineering specialists) will be five functional Task Forces as required by the circumstances: (1) Surface Engineering Support; (2) Relief Well Engineering Support; (3) Situation, Status and Documentation Support; (4) Blowout Diagnostics and Kill Engineering Support; (5) Risk Assessment and Management Support.

The Surface Engineering Support Task Force Leader would be a Senior Drilling Engineer if the blowout was on a MODU or a Production Operations Manager for the affected platform if a platform blowout. He would be responsible for coordinating engineering personnel as required to support the Surface Control Operations. He would be advised by the blowout engineering specialists and liaison closely with operations.

The Relief Well Engineering Support Task Force Leader would be a Senior Drilling Engineer. He would be responsible for coordinating engineering personnel as required to plan and support the relief well. He would be advised by the blowout engineering specialists and would take over as the MODU Group Leader after the relief wells are spudded.

The Blowout Diagnostics and Kill Engineering Support Task Force Leader would logically be a Petroleum Engineering Manager in the area where the blowout is located. He will work with the blowout specialists to determine the blowout characteristics (e.g., flow rate, flow path, pressures, GOR, IPR, chokes, uncertainties, sensitivities, geologic constraints, kill hydraulics, etc.).

The Situation, Status and Documentation Task Force Leader may be a Qualified Individual from data management or perhaps a drilling engineer. He would be responsible for supplying personnel with documentation skills to provide daily situation and status reports, document collection and archival, and documentation support for the functional groups as required.

The Risk Assessment/Management Task Force Leader would logically be the Loss Prevention Manager. He would be responsible for responder's health and safety, evaluating risk based on safety, environment, asset damage, and operations/economics. He may activate specialists in risk assessment (e.g., hydrocarbon ignition specialists, environmental impact specialists, etc.).

All positions are functional and would be activated only if required and deactivated when no longer needed.

Relief Well Constraints

For drilling relief well we should know about some constraints this is very important for planning. We should speak about this constraints with the other teams, this constraints is:
1. Surface Constraints to Rig Placement.
2. Geologic Considerations.
3. Position uncertainty of well.
4. Primary and contingent relief well kills objectives.
5. Kill point(s).

Number of relief wells.

Based on the assumptions of this blowout scenario, the assumed kill hydraulics and position uncertainty of the well, only 1 relief well is required for control.

One of the components of the relief well planning process is the evaluation of the required number of relief wells. The process for making this evaluation is to first define the technical requirements for multiple relief wells. If it is determined that one relief well is technically capably of controlling the well the next step is a risk management exercise which evaluates the probability of success, over given time periods, verses economic and HSE consequences if the single relief well fails or is substantially delayed due to mechanical problems or changes in the blowout situation. This is an iterative process, which next evaluates the probability of success, over a given time period, if two relief wells are started verses the addition cost and resources required for an additional well, traded-off against reduced economic and HSE consequences for a single relief well failure or delay.

Technical Requirements:

The technical requirements for multiple relief wells are primarily controlled by kill hydraulic requirements at the chosen kill point. Can the blowout be controlled with the selected casing design and pumping equipment using a single well? The required hydraulics calculated to regain control of the blowout may require more than one relief well. Consideration must be given to worst case scenarios using a single relief well, and include: maximum required hydraulic horsepower, maximum injection pressure, mud volumes and mud density, mud storage and transfer, loss of circulation after or during the kill, plug and abandonment options, super charging of shallow zones, multiple flow paths in the blowout wellbore and reservoir depletion while drilling the relief well.

Technical Risks to Evaluate

Kill Risk

Uncertainty in achieving a successful kill (or being substantially delayed) can be caused by various factors including:

- Initial assumptions in designing the kill are inaccurate e.g., flow rates, pressures, reservoir inflow performance, reservoir depletion, flow path, fluid/gas properties, etc.

- Changes in conditions during the drilling of the relief well e.g., changes in flow path (drill pipe), reduced back pressure, changes in open hole size, shallow formation gas supercharging, poor hydraulic communication, etc.

- Potential problems after intersection e.g., massive loss

of kill mud into fracture system, inability to kill both drill pipe and annulus, inability to set cement plug for permanent P&A, equipment problems, etc.

Intersection Risk

Uncertainty in achieving a direct intersection (or being substantially delayed) can be caused by the following:

- Relative Borehole Position Uncertainty. The blowout wellbore and the relief wellbore both have inherent uncertainties in their respective subsurface positions. The magnitude of this uncertainty is based on a number of factors including; the survey instruments used, wellbore trajectory, latitude, QA/QC of instruments and running procedures, surface uncertainty, and other factors. The position uncertainty at the ranging zone must be low enough to be within the search radius of the ranging instruments being utilized to locate the steel casing.

- Ranging Instrument Uncertainty. The electromagnetic ranging instruments being utilized have an effective range which is controlled by the ability to flow electricity on the target pipe adjacent to the sensor package. Under ideal conditions this range can be +/- 200â€™ or even greater. Factors which can affect the range are; electrical contact to the formation of the target, conductivity of the formation between the relief well and target, relative approach angle, conductivity of the mud in the relief well, etc. Once the tool is within range of the target there is additionally uncertainty in the relative distance and direction given from the sensor to the target. This uncertainty is a factor of; relative distance away from the target, approach angle, dog-leg severity of the relief well, non-homogeneous conductivity of the formations, fracture systems, steeply dipping beds, other fish within the effective range of the tool, relief well mud system, etc.

- Directional drilling limitations. To make a direct intersection into an 8-1/2" open hole, thousands of feet away, requires precise directional control. After the uncertainties of the surveying and ranging tools are taken into consideration, the intersection must be evaluated for probability of problems that would result in high dog-legs, deeper intersection points, or plug backs to achieve the intersection, e.g., inability to hold precise tool face, sliding problems, temperature problems on motors and MWD, unexpected dogleg rates, etc.

- Potential for Drilling and Operational Problems. The probability of drilling or other problems should be evaluated during the course of drilling the relief well. This might be the result of shallow gas, high temperatures, lost circulation, stuck pipe, hole collapse, well control, bad weather, rig equipment, crew mistakes, down hole tool failures, etc.

Consequences to Evaluate
HSE Consequences

This risk must be weighed against HSE hazards that are posed by the blowout every hour it is out of control that include e.g., ignition hazards, sour gas, pollution, health hazards, etc.

Economic Consequences

The economic consequences of the blowout must be evaluated every day it is out of control e.g., loss of hydrocarbon, reservoir damage, reservoir depletion, ignition damage, adjacent asset damage (surface property, wells, etc.), evacuation of third parties and control of exclusion zone (including roadways, railroads, etc.), shutdown of adjacent production, loss of resources for other budgeted projects (human, equipment, rig, etc.), hydrocarbon contracts, pollution control and clean-up, adverse public reaction (stock price, partners, environmental groups, future business effects), lawsuits, regulatory fines, other knock-on economic effects both direct and indirect.

Evaluate Available Resources to Drill Multiple Relief Wells

If multiple relief wells are to be drilled the resources that are available to achieve the objectives must be carefully evaluated. This will require additional personnel, supervision, planning, and equipment that if in limited supply, may actually reduce the probability of success of a single relief well that could be efficiently managed alone.

Evaluate the Cost to Drill Multiple Relief Wells

The cost to drill a second (or more) relief wells must then be evaluated against HSE and Economic Consequences. This is generally an economic risk decision. Will the increased cost of a second well outweigh the risk of possible long delays or loosing completely a single well? Historically, two redundant intervention projects going simultaneously and independently has generally proved sufficient. If a surface intervention is undertaken, and has a reasonable chance of success, then a single relief well may be adequate. If serious pollution or other environmental damage is being caused by the blowout, two relief wells might be considered regardless of the surface intervention plans. Risk analysis and risk management methods should be considered as a systematic approach to help make this decision.

In more recent years (last 12) most gas blowouts that were successfully controlled by relief wells were done with only a single relief well being started. This change from previous procedure of automatically starting two relief wells is primarily due to technology improvements in ranging, surveying and directional drilling. If two relief wells are to be started, the entire intervention strategy will change depending on how the second well is to be used (e.g., as an integral part of the kill, as a backup, or as a replacement for the blowout well. If it is possible to use the relief well as a replacement (a secondary objective) a different design may be necessary and should be

investigated beforehand.

Kill equipment

Based on the hydraulic calculations, kill equipment requirements vary with respect to the blowout scenario: The critical factors are: (1) maximum pump rate; (2) maximum pump pressure; (3) pumping time at peak loads; (4) maximum hydraulic horsepower (hhp) at peak loads; (5) various kill mud densities required; (6) total mud volume of each density including reserves; (7) location of high pressure pumping plant; (8) location of mud supplies; (9) mud transfer requirements to feed high pressure pumps; (10) contingency equipment for reactive plug storage and displacement, (11) cement volume and displacement rate requirements.

Criteria for Evaluating Kill Options

The Source Control Team had determined the safest method with the highest probability of success for controlling the blowout at this point was with relief wells. Additional surface control methods were evaluated however. The criteria for evaluating those options were as follows:

1. Safety: Any operation that has a high or unknown risk of injuring the intervention team should not be attempted.

2. Deterioration of current well integrity: Any operation that has a high or unknown risk of causing further well deterioration (e.g. destabilizing crater, damage to wellhead or BOP, damage to drill pipe), should not be attempted.

3. Jeopardize relief well success: Any operation that would jeopardize the relief well success (e.g. removing drill string electromagnetic target, losing ability to pump down drill pipe of blowing well), should not be attempted. Any operation that does not have a high probability of success (e.g. 70% or higher) should not be attempted.

Conclusions

For drilling relief well at first we should start with a managing unit that everyone do work for a one purpose “kill well”

1- When there is a blow out to a well, it leads to some damage (reservoir damage, loss of hydrocarbon, reservoir depletion, ignition damage …) therefore every four units with all their members should be present and work fast to prevent blow out as soon as possible.

2- While a well is blowing and all efforts are focused to it, it’s better to be a synergy between four units leaders and members.

3- To make a relief well the most vital unit is the well intersection team. This unit’s leader should be a specialist and their equipments should be updated as soon as possible.

4- To battle with a blow out one relief well is more economical and also more correspondent to HSE but if serious pollution or other environmental damage is being caused by the blow out , two relief wells might be considered regardless the restrictions .

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