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SAFETY AND HEALTH HAZARDS DURING SERVICING WELLS: THE EXAMPLE OF SLICKLINE SERVICES

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Abstract: In the oil and gas industry there are many serious hazards. Possible aftereffects of accidents happening on wells producing gas or crude oil can have fatal consequences. Natural dangers such as high pressures, flammable and explosive fluids, H_2S content all make every project demanding and special care should be taken when planning works in harsh conditions. There are many precautions that could be done to ensure the long service life of the production wells and these can be achieved with slickline services. Slickline is usually a good first choice to conduct operations on live wells, and the potential risks during this work should be analysed since safety measures are crucial for both people and the environment. Only after assessing them correctly can work be done securely and in a timely manner.

Keywords: slickline, pressure control equipment, well servicing, oil and gas

1. Introduction

Nowadays the oil and gas industry, particularly the exploration and production branches, are starting to adapt to new market environments, with changes increasingly being made to make it both safer and more environmentally friendly. The long history of drilling has contributed to its safety but accidents still happen due to various reasons and their consequences are often significant. Accidents often affect only the economic aspects of the project, but sometimes they can affect the safety of people and the environment, thus it is crucial to prevent them from happening and minimize possible aftereffects.

The best known incident is probably the oil spill in Gulf of Mexico from the Deepwater Horizon platform, which happened on April 20th 2010. This accident caused 11 fatalities among the oil platform crew and severely impacted the marine and coastal environment. This blowout resulted in more than 110 000 km^2 of oil spill on the ocean surface and 2,100 km of shoreline being contaminated by hydrocarbons. This has negatively affected a wide range of organisms residing in contaminated habitats [1].

Serious accidents which have caused damage to the environment have also happened in Poland. An open blowout of reservoir fluid containing H_2S took place in Daszewo-1 wellsite near Karlino on 9th December 1980 during drilling. Fluid from the reservoir started to flow from the well and caught fire. Rescue operations took 33 days to contain the blowout. As a result of this blowout, an area in the radius of 600 m from the wellhead was degraded, 27 ha of soil was contaminated by hydrocarbons and the drilling rig was completely destroyed. However, after 30 years there are indicators that the environment was recultivated properly [2].

2. Hazards in the exploration and production industry

There are many hazards during drilling and servicing already producing wells. The most distinctive are probably hazards related to reservoirs: high pressures, flammable and explosive fluids, toxic fluids (mainly H_2S) and a risk of the reservoir fluid blowout. Geological conditions in Poland, particularly in the Polish Lowland, are unfavourable. From the abovementioned hazards, all occur at the same time.

The BMB (Barnówko-Mostno-Buszewo) field, is one of the mature fields with many deep wells drilled and it could be used as an example field in the Polish Lowlands. The BMB field produces both crude oil and natural gas. The reservoir pressure gradient was originally anomalously high, even 0.023 MPa/m, and there is also H_2S in the reservoir fluid produced. All these elements could be potentially harmful for people and for the environment [3].

Geological layers are heterogenous and their parameters can change in different places. This can mean that two identical wells could have different reservoir properties even though the wells are placed in the vicinity of one another. We can never be sure about exact parameters in the reservoir until the well is drilled. We could only use nearby wells as a reference and use geophysical methods to estimate them, but during the planning phase of the drilling project, all uncertainties should be taken into account.

Apart from natural hazards there is also a category of hazards associated with working with heavy equipment: heavy objects lifted to large heights, moving parts, high air and hydraulic pressures, electricity, and many others.

3. Well servicing

Well servicing is an important part of the life of the well. After completing the well, it starts production and through a long contact with a reservoir fluid, which could be corrosive, elements of the completion assembly start to deteriorate. Best practice shows that the condition of the well completion should be assessed regularly to ensure long service of the well.

Servicing wells is primarily conducted by coiled tubing services, wireline services (braided line and slickline), snubbing services or using a workover rig. In Poland, the first choice are primarily wireline services because the cost of their operation is significantly smaller than others.

Slickline is a part of the well servicing operations that are widely used, mainly being employed to obtain fluid samples from the wellbores, and measure pressure profiles in temporarily stopped production wells. The greatest benefits of slickline operations are: low cost of operations, an easy and quick mobilization, an ability to work on live and producing wells, short time of operations – wire could be pulled in and out safely with speeds exceeding 0.83 m/s (50 m/min).

4. Risks during servicing live wells

When servicing the live well, we have one less barrier to contain the reservoir pressure. During drilling, mud exerts hydrostatic pressure on the reservoir which stops reservoir fluid from flowing into the borehole and to the surface. When working with a producing well, only there servoir fluid is in the completion string. It could be either gas or crude oil or a mixture of both. A reservoir fluid could be contaminated by H_2S and thus extremely toxic to people and it also could have significant pressure even on the surface. To prevent it from flowing out of the hole, pressure control equipment assembly is used. There are also hazards related to fire and explosion risk. When hydrocarbons make a mixture with air, they become combustible or can create an explosive atmosphere.

Before beginning a project, all hazards should be determined, especially natural hazards. Pressure control equipment should have pressure rating exceeding expected pressures increased by a risk factor. Moreover, if there is a possibility of H_2S occurrence, every piece of equipment should be able to cope with it.

Aggressive fluids could hasten the rate of corrosion, and weaken both elements of the pressure control equipment, tools and the wire in the wellbore during a lengthy exposure. It is crucial to control the rate of the corrosion of different elements of the tools and equipment and to clean them thoroughly and properly maintain them after exposure. Before the job, all equipment and tools should be visually inspected, particularly all elastomer O-rings and seals should be checked and changed if necessary.

In the presented Figure 1 there is a schematic of a typical pressure control assembly used during slickline operations on live wells. From the top, the first piece is a stuffing box, a part where the running or stationary wire is sealed. It consistsof a sheave to guide a wire and a series of packings which prevents reservoir fluid from leaking, and stuffing the box body. It could be also pressurized using hydraulic fluid to compress packings on the wire more tightly since packings will wear outduring long operations. The second is a liquid chamber connected to a pump located on the surface near the well with the check valve on the line. It enables liquid to be pumped to grease the running wire to minimize corrosion and drag on the stuffing box packings. The third section are lubricators, connected with quick union connections. Their length should be greater than the length of the whole tool string with some safety margin. When the operation assumes that some equipment or fish would be taken from the well the lubricator assembly length should be greater than the combined lengths of a tool string with a pulled object. On the lower part of the lubricator section there are ports with needle valves, they could be used to monitor pressure in a pressure control equipment or to bleed a pressure from it when the tool string is pulled out of the hole after operation. Number four is the blowout preventer, so called BOP, it functions as a valve to seal a wellbore from the surface and from the rest of the pressure control equipment. Depending on the type,it could be closed hydraulically and manually or only manually. It could close without anything between the rams or with the wire between them. A last part of the completion assembly is a flange adapter which connects pressure control equipment to the wellhead assembly. It contains a metal-metal seal to ensure tightness.

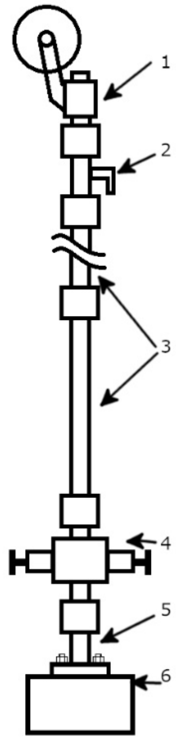

Fig. 1. Schematic of a typical pressure control equipment assembly during slickline operations:
1 – a stuffing box with a sheave, 2 – a liquid chamber,
3 – lubricators, 4 – a blowout preventer, 5 – a flange adapter,
6 – top of the wellhead

Another type of risk is a chance of the toolstring being stuck. In producing wells, there are many mechanisms which could potentially cause thesekinds of problems: corrosion, hydrates, a mineral precipitation, sand in producing fluid or mechanical damage. A used wire has a very small diameter so usually it is impossible to exert any significant force to the stuck tools. On the other hand jarring is a very good method to free a tool string, if it is possible. Jarring in a viscous fluid or in highly deviated wells is not very effective.

When long lasting operations do not yield any results, sometimes it is more beneficial to disconnect the wire from the tool string. When such operationsare done, the blowout preventer is closed and aspecial tool called a go-devil is fitted to the wire, then the blowout preventer is opened and the go-devil falls to the rope socket cutting the wire. Both the go-devil and toolstring have fishing necks, so they could be fished using another slickline tool string or a coiled tubing unit. A coiled tubing could use much greater forces compared to a slickline unit. If a slickline wire would break above the toolstring it would fall into the wellbore and be very difficult to fish it out. Such operations are very costly, and they take a lot of time.

5. Slickline services

Slickline is a type of service where a string of the tools is lowered into a wellbore on a single strand of a solid wire. This wire is typically made from a low carbon steel for a standard service or an alloy for H_2S service. Wire diameters canvary from 1.57 mm (0.062″) to 4.78 mm (0.188″), with the most commonly used in Poland is 2.74 mm (0.108″) diameter wire. On the other hand, a tool string has typically a much larger diameter – about 38 mm (1.5″) and parts of the tool string are screwed together or connected using quick connectors. A typical slickline tool string includes (from top):

- a rope socket – used to securely connect the wire with the tool string,
- stem weight bars (roller stem bars with knuckle joints for deviated wells) – used to exert weight to properly run wire into the wellbore against a well pressure,
- mechanical jars – used to enable upward and downward jarring,
- a slickline tool or gauges – could perform different functions.

The slickline wire diameter is significantly smaller than the diameter of a work string, so a wire is a crucial part of the assembly, its good shape could determine safety of the operations.

With the use of specialized tools, a slickline service could perform various functions:

- checking if there are no obstructions in the production tubing and if it is safe to run another tool using gauge cutters,
- locating the depth of the tubing shoe,
- running downhole pressure and temperature gauges,
- running in PVT samplers, or bailers to obtain fluids and solid samples from the wellbore,
- running and locking downhole pressure and temperature gauges during well testing,
- opening and closing circulation sleeves,
- running and using downhole mechanical perforators to perforate tubing,
- running and locking plugs in landing nipples,
- running and locking downhole chokes in production wells,
- cleaning well from debris using bailers like sand-bailer or hydrostatic bailer,
- cleaning deposits from the inside wall of landing nipples using scratchers,
- mechanical activation of perforators run on drilling string or tubing,
- fishing and other intervention works.

6. Possible aftereffects of accidents

The aftereffects of accidents depend on the scope of the accident. Usually, only time is compromised, resulting in solely economic consequences – another trip, wasted time etc. More serious accidents can result in crew injuries and significant losses to equipment and the environment. The most serious ones could even end in people's death and environmental disaster caused from a blowout. Safety precautions and measures are used to minimize the risk of accidents and to limit their aftereffects.

7. Safety measures

There are many safety measures to minimize the risks, and they apply to both the working crew and equipment use. Firstly, the crew is acquainted with safety manuals and instructed to the correct way of working and how to react indifferent situations. Before starting a job, a safety meeting is conducted where the following issues are discussed: scope of work, safety rules and possible hazards, crew responsibilities, etc. Personal protective equipment suitable for a given situation is used, safety gloves, safety googles and safety glasses, protective shoes, hard hats, gas detectors, etc. When there is possibility of H_2S occurrence, appropriately trained and equipped well mining rescue service oversee and monitor work.

To minimize the risk of fire or explosion, hazardous zones according to ATEX are marked. In these zones a risk of explosion is likely to occur. All the equipment used in these zones is made to minimize the risk of fire and explosion, and it is certified according to ATEX.

Pressure control equipment is controlled visually every time before the start of a job with particular attention to any wear and damages. If necessary, seals and O-rings are replaced. Every connection is checked if it is screwed securely. Hydraulic fittings are inspected if they work properly, and if they are clear from debris to ensure proper operation of BOP, stuffing box and liquid chamber. Before the start of the job, a pressure test with the test pressure equal or above the expected pressure is conducted. Moreover, all pressure control equipment is pressure tested at regular intervals with manufacturers specification and NDT tests are conducted. From time to time, pressure control assembly is disassembled, inspected and replaceable parts are changed.

During hoisting operations, only certified shackles and slings are used. A crane operator or a derrick man is acquainted with the scope and specifics of the job at the safety meeting, where communication such as hand signals are discussed. When lifting the equipment, crew stay away from hoisted equipment and use the attached string to help with positioning.

8. Concluding remarks

Despite many hazards and risks, operations during drilling and on live wells prove to be both safe and environmentally friendly. Great attention is paid to appropriate preparation – both the crew and equipment. People are trained, a safety meeting is conducted and safety always discussed as a top priority during works. Internal regulation manuals contain a comprehensive approach to further minimize unexpected situations and tips how to react to them. Such serious effort to prevent and minimize risk brings good results where people's safety is crucial. Also, environmental aspects are not omitted, because all leaks and other accidents, even if they don't harm working people, might do so to the environment.

Good condition of the slickline wire and its proper maintenance is crucial, because it limits available parameters and ensures that all operations could be performed safely and in a timely manner.

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