Relief Well Injection Spool (RWIS) – Enables single relief well contingency

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In December 2015, a change was implemented in the Activity Regulations relating to drilling and well activities in Norway. Section 86 was updated and now states: "In the event of a well control incident, it shall be possible to regain well control by intervening directly in or on the well or by drilling one (1) relief well. This applies to wells where planning of drilling activities has been decided on after 1 January 2016." This regulatory change emphasizes the importance of having an appropriate and feasible Blowout Contingency Plan in place in the event of a worst-case scenario.

Today, Blowout Contingency Planning is an integral part of the preparations for drilling operations. The primary purpose of a Blowout Contingency Plan is to minimize danger to life and protect the environment and valuable assets by minimizing response times and incorrect actions taken under stress. Questions like: "What if my primary barrier fails during our planned operation?" and "What if all barriers fail resulting in an uncontrolled blowout?" should be answered and mitigating options should be developed well in advance of the spud date.

The increased focus on planning for the worst has affected how wells are designed with the aim of reducing the consequences should a blowout occur. The overall goal with the planning will be to reduce potential errors and ultimately improve the response and limit the consequences should an incident occur.

Unfortunately, planning for the worst case might also unveil some disadvantages for an operation in general. For drilling activities, the result can typically be slimmer hole sizes, reduced kick tolerance, running more casing strings, longer lasting operations and increased overall cost. To reduce the consequences of a hypothetical worst-case scenario, one may in fact end up increasing the probability of an event.

A dynamic kill through a relief well is the safest and most likely successful method to stop a blowout. For many blowouts, it will also be the only alternative to regain control. Typically, relief wells are often referred to as the last line of defense in event of a well control incident. It is therefore vital that the operators address the feasibility of a relief well kill operation in their contingency plans.

For most wells, demonstrating a feasible relief well kill operation should be a manageable task considering the experience gained from several actual kill operations. Relief wells have been drilled regularly since 1933 when the first blowout was killed by directly intersecting the flowing wellbore (Gleason 1934). The dynamic kill method used for most relief wells today makes use of frictional forces caused by the mud pumped into the blowing well to increase the pressure in the wellbore and consequently stop the influx from the reservoir.

Sometimes the pump rate required at the intersection point might exceed the capacity of a single relief well rig. Limitations can be pump rate, pump pressures, pump power or fluid storage capacity. This will trigger options to increase the pumping capacity of the relief well or alternatively require planning for additional relief wells.

The history has shown that single relief well kill operations have had a high rate of success. On the other hand, a kill operation involving two or more relief wells is recognized as a very challenging operation. The only known incident where two relief wells have been used for a dynamic kill operation was during the El□Isba blowout in Syria in 1995. This operation was performed onshore in a controlled environment, something that cannot be compared to an offshore environment. Today, no experience exists on intersecting and coordinating a dynamic kill operation in an offshore environment using multiple relief wells.

Table 1: Advantages of the RWIS

Enables drilling of prolific reservoirs ensuring single relief well contingency
Increased pump rate and volume required for kill
Removes kill- and choke line bottleneck
Increases redundancy and flexibility of operations
Moves additional pumps and mud storage to remote vessels
No installation of additional pumps and mud storage on relief well rig
Enables off-bottom kills, faster and reduced spill volume
Removes the requirement for using mud weights above the fracture gradient
It is independent on the relief well rig
Enables larger and more cost-effective wells
Saves rig time and cost of casing
Increases production rate by larger completions
Improves safety
Limiting use of vessels in close proximity to the relief well rig
No need to challenge pump specifications on relief well rig

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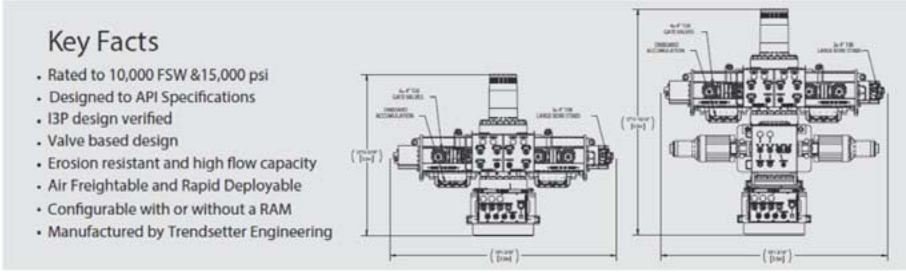

Table 2: RWIS key properties

Because of the limited experience and the obvious challenges involved in dual relief well kill operations, many of today's company standards as well as regulating agencies including the Petroleum Safety Authority Norway (PSA) now state that new well designs should have single relief well contingency.

To comply with the new regulations, while at the same time maintaining cost effective and safe well designs and operations, a patented Relief Well Injection Spool (RWIS) has been developed, manufactured, tested and delivered to the subsea oil and gas industry. Kill spools have been used on several onshore blowouts in the past. This field proven application is now ready for subsea use. The patented RWIS is manufactured using field proven conventional components that are utilized daily in deep-water environments.

The RWIS is designed to be installed on a relief well prior to intersecting the blowout well and would be positioned between the wellhead and the blowout preventer (BOP), effectively becoming a subsea injection manifold providing additional inlets for pumping kill mud. Each of these inlets is equipped with dual fail-safe barrier valves to provide the necessary means of pressure containment in the relief well. During the well kill operation, one or more high pressure pumping vessels or drilling rigs (typically the rig drilling the backup relief well) will be connected to the RWIS inlets using high pressure flexible lines to provide the additional flow of kill mud, see example in Figure 1.

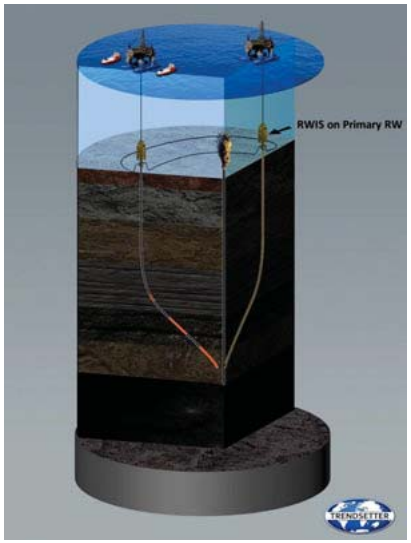

Figure 1: RWIS and connections to vessels

In the event of a blowout, drilling of a relief well will commence immediately as soon as a suitable rig has been identified and mobilized. As part of the preparations for the relief well, the RWIS will be transported to the location. The RWIS can be installed on the wellhead prior to the BOP or alternatively just before making the intersection, and it has the same bore (18 ¾") as the BOP and will not impact ongoing drilling activities.

Using downhole ranging techniques, the relief well task force locates the blowing wellbore and directionally steers the bit until it is finally aligned to intersect the blowing well at the planned depth. If the RWIS is not already installed, the relief well BOP must be disconnected from the wellhead and the RWIS installed on the wellhead via drill pipe or wireline rigging arrangements. Subsequently, the BOP is reconnected on top of the RWIS and the lines from the support vessels are attached to the RWIS flowline connectors using an ROV. After assembling the entire dynamic kill pumping system, the relief well can drill the final section and intersect the blowout well. Finally, a high rate dynamic kill is achieved by simultaneously pumping down the kill and choke lines from the relief well rig and from the dedicated support vessels connected to the RWIS.

Figure 2: RWIS ready for mobilization, configured without shear rams

The RWIS can be rapidly deployed by air, ground and marine freight to any region of the world. Because of the projected solution provided to drilling operations, the RWIS has already been contracted for several wells to be drilled in 2017 and 2018.