EXPANDABLE REAMERS move from marginal to integrated components

While reamers have been in use for more than a century, reliability issues have kept them out of the spotlight... until now.

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The Troll field is one of Statoil's key gas assets on the Norwegian Continental Shelf, containing approximately 40% of total gas reserves in the area. The Troll C platform produces from oil-bearing layers in the Troll West reservoirs. First oil was produced in September 1995. (Photo by Øyvind Hagen, courtesy of Statoil)
deal of bit bounce, which often led to early shearing of the shear pin activating the tool within the casing. This meant an extra trip for the driller along with NPT for the operator.

**Reliability Today**

One example of the positive developments in under-reamer technology can be found in Baker Hughes' Hughes Christensen GaugePro XPR expandable reamer. Part of the GaugePro XPR success comes from extensive use in several landmark applications. "We have learned to see what the problems were and now we can overcome those problems by introducing new tools – better mousetraps, basically," Shale said.

Improvements in shear pins have been made by multiplying the number of shear pins. In some cases, reamer tools can have a pin that shears internally yet requires additional weight on the tool to push a sleeve out of the way before the tool can fully activate, using either hydraulics or mechanical means to activate the cutters for hole enlargement.

In the case of the GaugePro XPR, the system is ball drop-activated. "All the tools are ball drop-activated at the moment. This is the current generation of tools," Shale said. The GaugePro XPR has a direct operation so that it maintains a dead-head pressure acting on a ball, but rather than using pins, the system relies on set screws. "These set screws are an engineered set that uses materials with a known tensile strength, and that tensile strength will shear at a certain psi that is acting on that tool," Shale said.

Typically, the screws are made in batches from the same material, which is certified to a certain tensile strength. By testing each batch at a certain pressure, engineers can determine tensile strength within +/- 5%. With these engineered screws, the GaugePro XPR reamer shear screws work through a hydraulic method rather than mechanically. "This hydraulic method can be controlled much more accurately by allowing the pumps to stroke slowly so the pressure downhole builds up," Shale said. At activation, the pressure drops. This signals that the internals of the tool have been activated and the nozzles are open, allowing fluid to emit from the ID of the tool into the annulus of the wellbore, which provides proper cooling and cleaning functionality of the reamer.

**Approaching Integration**

As the industry has moved further offshore in recent years, the challenges have increased for under-reaming capacity. Where deep water once was considered to be 1,000 ft (305 m), common water depths for many drillers can reach 7,000 ft (2,134 m). In the southern Gulf of Mexico (GoM), Pemex has plans for several ultra-deepwater wells that could exceed 8,000 ft (2,438 m) between 2015 and 2020. The GaugePro XPR was successfully deployed in a world-record 31,400 ft (9,575-m) deepwater well in the GoM. As with most offshore operations today, the forces impacting on equipment is quite substantial.

One benchmark example of current reamer technology's improved role in the integrated drilling process took place in Norway's Troll field. Conventional drilling methods can be problematic in extended-reach horizontal wells. Known as one of the world's most difficult drilling environments, Troll field presents many challenges. Due to the changes in formation structure, increased vibration is a common problem for drilling these wells. As the formation produces vibrations, the associated harmonics often can cause damage to the drillstring, its components, and surface equipment. The operator was limited to how much drilling could be done. "It was possible to use two or three bits and several trips to get to a certain position within the wellbore because of the damage and the vibration to both the equipment and to the actual cutting structures of the drill bits and the reamers," Shales said.

The GaugePro XPR is not a standalone tool. "We designed the reamer to work as an integrated system first of all by synchronizing the reamer with a Baker Hughes bit so that both tools would have similar designed cutting structures that could support one another," Shales said. The bit is the most aggressive part of the drillstring; this was greatly improved through the integration of the GaugePro XPR. At Troll field, Baker Hughes' Hughes Christensen 14%-in. GaugePro XPR expandable reamer has been used in several landmark applications. (Images courtesy of Baker Hughes)
190 ft below the reamer — did not have compression on it, allowing lateral and torsional vibration, causing damage to the BHA, bit, and reamer cutters.

By designing the bit and the reamer to be synchronized, Baker Hughes matched the bit and reamer cutter technology so as the bit drilled off in the softer formation, the bit did not just drill away, allowing the BHA to remain in compression. Contrary to consensus within the industry, simply matching cutter size in the bit to cutter size in the reamer does not provide a "matched" system and mitigate vibration. "We have known this for a while because the multiblades on the bits are much more aggressive than the reamer," Shale said. The actual loading per cutter on the bit was removing much more material than the reamer, so the bit was more aggressive and could drill off faster than the reamer. The results in Troll field speak for themselves. The operator found savings through performance improvements of reduced stick/slip and whirl and improved wear on the reamer and other equipment.

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Looking ahead
The under-reaming world is dramatically changing. As clients become more demanding, reliability will continue to be a driving force for this technology. A variety of applications are generating tools that are rapidly becoming more sophisticated. Most tools are ball-drop activated and, in the beginning, consisted of a single ball. Tools now are designed for multiple balls. "In other words, you can drop more than one ball, so you can open and close the tool. Closing the tool allows you to perform different operations," Shale said.

Where reamers once were considered a stationary tool with a limited, but necessary application, they are rapidly being integrated into an ever advancing toolstring.

Editor's Note: A portion of the technology discussed in this article was sourced from SPE paper #138708, "First Worldwide Horizontal Run and Eastern Hemisphere Application of an Expandable Reamer and Stabilizer BHA on Troll Field, Norway," by Hugh D. Evans, SPE Baker Hughes, and Lydia E.B. Ulvedal, SPE, Statoil.