



Tiger Shark® II Pump Extends Run Life and Decreases Workover Costs

REVENUE INCREASE ON AVERAGE BY \$1.1 MILLION USD PER YEAR PER WELL

NORTH DAKOTA

CHALLENGES

- » Extreme temperature, abrasion and free gas shorten pump run life
- » Bearing system wear leads to pump inefficiency
- » Shortened run life decreases production potential

SOLUTIONS

- » Enhanced Tiger Shark® II pump design to increase run life and extend operating range in extreme environments
- » New bearing material and bushing retention system as a secondary mechanical locking system
- » Extensive testing to examine pump wear caused by fluid with highly abrasive content

RESULTS

The enhanced Tiger Shark® II pumps provided:

- » New bearings that are six times stronger than the previous generation
- » Approximately 87 percent improvement in bushing stability
- » Estimated 17 percent increase in pump run life, leading to a 25 percent reduction in rig time
- » Annual on average revenue and savings of USD 1.1 million per well

OVERVIEW

Abrasion, gas and high temperature all shorten the run life of downhole electric submersible pumps (ESPs). Individually, these elements are hard on equipment; together, they accelerate wear. The effect is particularly dramatic in highly deviated unconventional wells, where frac sand and pressure conspire to produce gas slugs and highly abrasive flows.

CHALLENGES

Operators need reliability and long run life from downhole pumping equipment to achieve optimal production. When pumping efficiency declines, production declines. ESP bearing systems and bushings, in particular, often show excessive wear and lead to shortened run life. In the Bakken region, one operator found that 90 percent of pulled ESP pumps in extremely harsh downhole environments had significant levels of bushing migration. Improving bearing system performance could improve overall run life.

SOLUTIONS

Summit ESP® – A Halliburton Service recently upgraded its popular Tiger Shark® pump line to better handle the challenges of attaining long ESP run life. The Tiger Shark® II pump was designed and tested to increase run life and extend operating range in harsh environments. Summit ESP conducted extensive tests at our Research and Technology Center in Tulsa, Oklahoma. A slurry loop was used to examine pump wear caused by fluid with high abrasive content and an industrial oven was separately used to examine temperature effects on bearing materials.

Bearings are subject to localized heat generation that can raise temperature considerably higher than at other locations within the pump. High friction coefficient, pump thrust, low lubricity, vibration, oscillation, dimensional changes, fretting and low flow rates can commonly cause these heat spikes. Excess heat can also strain bushings, which can migrate out of place as a result.

Factors affecting pump run life cannot be properly isolated and evaluated in the field, making laboratory



Slurry testing loop at Summit ESP® Research and Technology center in Tulsa, Oklahoma

testing invaluable for improving pump performance. Summit ESP ran four years of slurry testing on a flow loop specifically designed to manage fluid with high solids content.

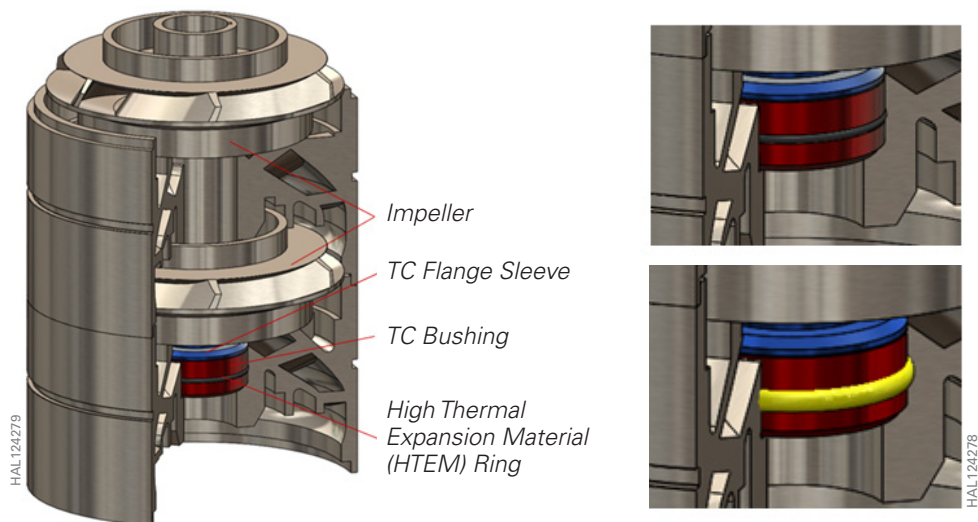
Focused tests used 15 different tungsten carbide (TC) formulations for bushings and sleeves, with continuous data collection. Each pump was disassembled, inspected, weighed, and measured before and after each test.

Based on test results, Summit ESP® changed bearing material and added a new bushing retention system as a secondary mechanical locking system. The new technology is patented by Summit ESP.

Left » New bearing system designed to expand when operating temperature rises, creating a mechanical lock to retain the bushing-diffuser connection.

Top right » Ring lock temperature size differential.

Bottom right » The enhanced Tiger Shark® II pump design is targeted to increase run life and extend operating range in extreme environments.



RESULTS

Thousands of Tiger Shark® II pumps have now been deployed by the operator and others. These pumps feature new bearings that are six times stronger than the previous generation. Significant bushing migration measured on pulled pumps has fallen 87 percent.

Pump improvement has resulted in an estimated 17 percent increase in pump run life, leading to a 25 percent reduction in rig time. Altogether, on average, these improvements represented annual revenue and savings of USD 1.1 million per well.

\$1.1
MILLION
ADDED VALUE



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