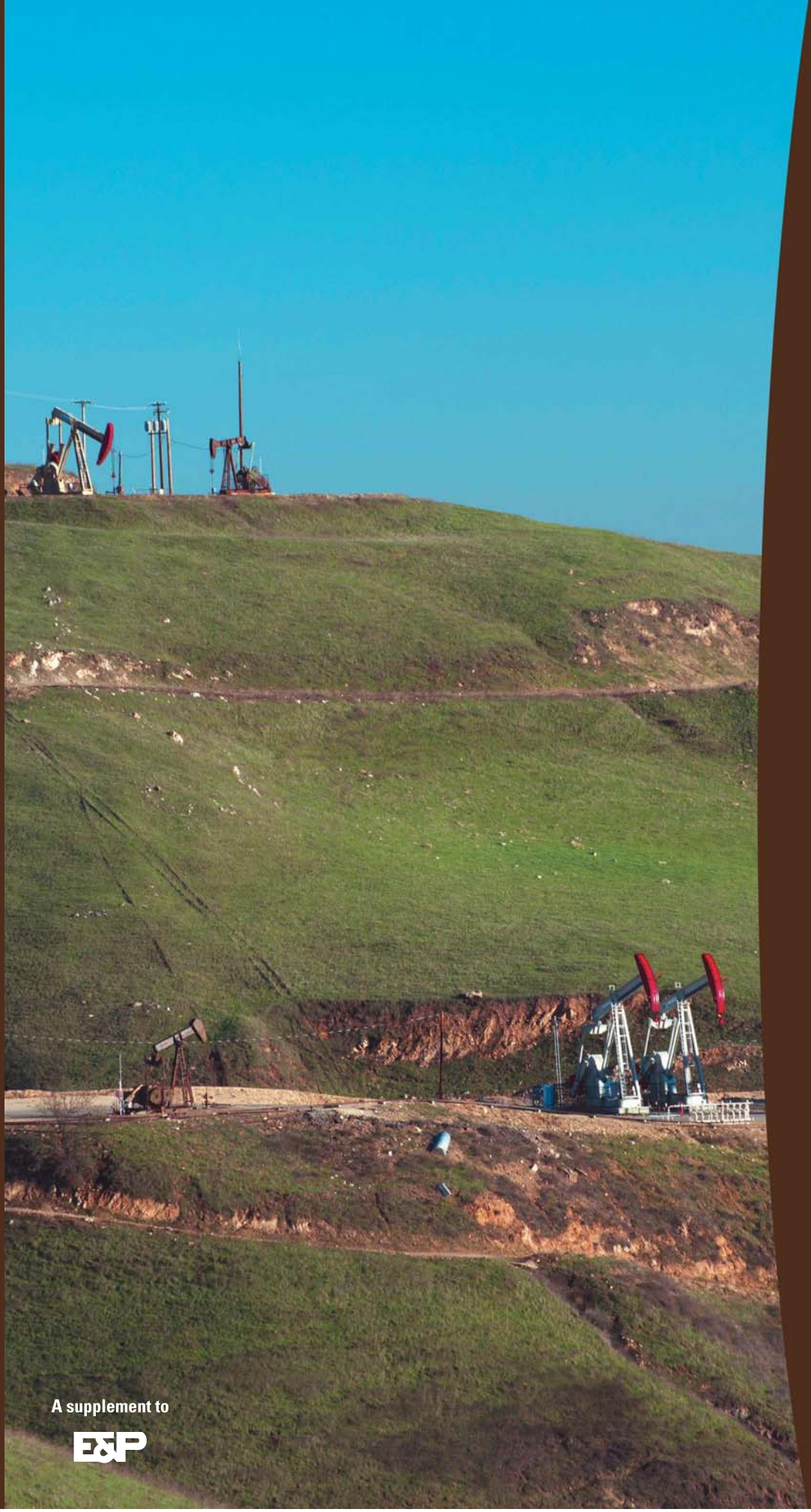

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A Simple Solution to Runlife Extension

Coupling alloy extends runlife of rod-pumped wells.

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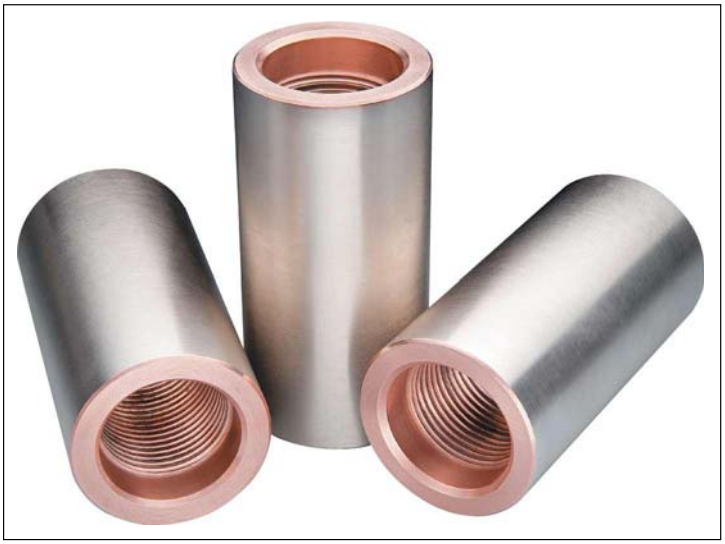
Nearly 50% of failures in deviated shale wells operating on artificial lift are attributed to metal-on-metal contact of sucker rod couplings and production tubing. Workovers and production losses can cost companies tens of thousands of dollars per well per year. Working with a large operator that was experiencing high failure rates in some of its Bakken wells, Materion Corp., which specializes in the supply of advanced materials, developed sucker rod couplings made of a new temper of its ToughMet 3 alloy, an advanced bearing material long-established in oil and gas drilling applications. It is notable for its high strength and anti-galling qualities.

After successful field tests in 10 problematic Bakken wells, between 12 and 60 ToughMet couplings were installed in 50 deviated well sections by operators throughout the Bakken, Permian and Eagle Ford basins. In this pilot program, known as "Solution 1," a 62% average increase in tubing runtime was observed after ToughMet couplings were installed in the bottom of rod strings. Throughout the trial, it was noted that there were two instances in which the wellbore was so severely deviated that nothing could be done to improve the wells' performance.



Materion's ToughMet alloy couplings have been deployed in the Bakken, Eagle Ford and Permian basins. *(Source: Materion Corp.)*

Expanding the program

During the Solution 1 pilot runs it was noticed that placing an increased number of couplings in the well, spanning a larger area than just the deviated sections, could give rise to significant benefits. Namely, the overall frictional loss of the machine could be significantly reduced, along with the mechanical loads on all the surface equipment and the energy consumption of the system—ultimately increasing the output of the well. Solution 2 was subsequently launched as a program to investigate cases in the Permian and Bakken where much longer portions of the sucker rod string were outfitted with the couplings.

A broad sample size was acquired in order to mitigate for any operating practice variations among operators. The goal was to perform a statistical analysis on the results as a whole population, not on a case-by-case basis, to understand if, in fact, the "before" and "after" were statistically different operations and what type of distribution the results conformed to. By drawing results from such a large data-

Component	% of Wells	
	Improved	Did Not Improve
Oil Production	73%	27%
System Efficiency	78%	22%
Downhole Stroke	86%	14%
Pump Fillage	73%	27%
PPRL	91%	9%
Load Range- Pol Rod	91%	9%
Gearbox Loading	94%	6%
Fluid Level AP	83%	17%

Figure 1. This chart depicts the Solution 2 trial results to date for average changes in efficiencies for the different measured components. *(Source: Materion Corp.)*

set, potential clients can be better reassured that the deployment of multiple couplings in this fashion will result in performance improvements unachievable with a more conventional approach.

Analyzing Solution 2

In addition to all the benefits afforded by Solution 1 (wear reduction, mitigation of holes in tubing, etc.), Solution 2 offers more than 100 ToughMet couplings in a large section of the rod string to reduce sliding friction on the rod string and loading. When these large numbers of couplings are deployed, the operator starts to observe positive changes in their wells.

Solution 2 trials: performance analysis. Twenty-two full strings and five large partials were being monitored across 14 major operators in the Permian, Bakken and West Coast. Materion collaborated with the operators to analyze various metrics on these wells. The ToughMet couplings were observed and monitored to assess how they affected the performance of the wells.

Observations. A number of the wells were pulled out of the data set due to the concern that special causes such as nearby fracking, for example, may distort fluid production data. Data from 16 of the wells that were considered to be reliable data sources by the production engineers was retrieved.

It was observed that overall system friction was reduced, resulting in a range of benefits in production performance (Figures 1 and 2). The effects that the couplings demonstrated in the wellbore include an improvement in sucker rod string movement, decrease in mechanical loads on the polished rod and gear box, better pump fillage, increased overall system efficiency and increased fluid production. About 73% of the wells in the sample set have seen improved oil production with the average change of at least 12.6% increase in oil production. Of those tested, 78% have shown system efficiency increases and 86% of the wells demonstrated downhole stroke increase.

The most notable result observed was in load reductions; 94% of wells experienced reduced gearbox loading with an average reduction of 12.5%. Regarding changes to load on the polished rod, 91% of wells experienced a smaller range between peak and minimum load with an average reduction of 12.1%. By shortening the load range (or alternating stress) in these instances, fatigue is reduced.

Statistical significance. In almost every case, the before-and-after data pairs followed a normal distribution. Paired sample t-test analyses confirmed statistically different results for all of the important measured performance parameters following the installation of a full, or nearly full, string of ToughMet couplings. The statistical analysis provides the operator with confidence about the likelihood of realizing benefits and the degree thereof.

Component	Average Change	
Oil Production	12.6%	⬆
System Efficiency	20.6%	⬆
Downhole Stroke	16.0%	⬆
Pump Fillage	6.4%	⬆
PPRL	-13.1%	⬇
Load Range- Pol Rod	-12.1%	⬇
Gearbox Loading	-12.5%	⬇
Fluid Level AP	-23.8%	⬇

Figure 2. This chart depicts Solution 2 trial results to date by measured improvement percentage for the different measured components. *(Source: Materion Corp.)*

Conclusion

The Solution 2 trials have proved to deliver friction reductions down to one-third of what the system was losing in the way of lifting power due to frictional losses. The stroke length of the piston inside the pump has significantly increased, the overall system efficiency, which is an overall measure of the hydraulic work that is done by the system relative to the amount of energy input, has significantly increased and there have been increases in production, in some cases to up to 30%. In addition, the mechanical loads on the surface equipment—the gearbox, the polish rod, etc.—have been brought down substantially.

The results reported to date continue to be compelling; Solution 2 enhances both the runlife and the performance of rod-pumped wells. ■