ADVANCED SUCKER ROD MATERIAL REDUCES WEAR IN UNCONVENTIONAL WELLS

Seth Silverman, Hess Corporation

Diane Nielsen and William Nielsen, Materion Corporation

ABSTRACT/SUMMARY

Tubing leaks have historically accounted for nearly half of the failures in the Hess Bakken wells. The root cause of these leaks is coupling on tubing wear; the non-metallic guides wear out, which results in spray metal couplings contacting the production tubing. To address this problem, the company installed ToughMet 3 (T3) TS95 sucker rod couplings in over 265 wells, significantly reducing the failure rate in the field. Individual case histories from the Bakken wells demonstrate the lifetime extension and reduced wear rates observed after the introduction of the new couplings.

Further study of the Bakken wells reveals additional benefits of using the new couplings. Wells with these couplings have increased fluid production, increased pump fillage, higher fluid loads, and lower gearbox loads.

INTRODUCTION

Sucker rod pumping in slightly deviated 10,000 ft unconventional wells presents unique challenges related to the side loading of rods. Rods can flex during the down stroke of the pumping unit, resulting in tubing and coupling wear, significant workover costs, and deferred production. In the North Dakota Bakken properties, this problem occurs so frequently in the lower 1,000 ft of some wells that it accounts for nearly half the failure rate in this region. The culprit behind the tubing wear is the spray metal coupling, made of a much harder material than the steel L-80 tubing. Over time, these couplings tend to wear the tubing down to the point of failure. The use of standard T couplings can also result in tubing wear by a galling mechanism.

In 2014, the operator of the Bakken wells decided to address the tubing leak problem with an alternate coupling material. The operator selected a CuNiSn high-strength spinodal alloy called T3 TS95. The alloy was designed for bearing applications and was an ideal match for sucker rod couplings because it resists abrasion in sliding applications and is compatible with the L-80 tubing. The hardness of the CuNiSn alloy is a maximum of HRC 32, compared to a hardness of HRC 23 for L-80 tubing. The alloy contains 15% Ni and 8% Sn, which improves the corrosion resistance compared to other bronze alloys.

PHASE 1: ONE INCH SLIMHOLE T3 COUPLINGS

In Phase 1 of the program, the operator replaced the spray metal couplings in troublesome wells with deep tubing leaks. Ten pilot wells were selected to receive 1-in. slimhole T3 couplings in the 1-in. rod string located above the pump. Table 1 shows that the pilot wells have achieved runtimes of anywhere from 700 to over 1,000 days after the installation of the new couplings. A typical well in the Bakken field runs at an average of 6 spm. This represents a service runtime of 9.365 million cyclic stress cycles. Of the over 265 wells in the Bakken that have now been completed with a range of 25-60 1-in. slimhole T3 couplings, no failure of the T3 couplings has been observed due to wear, corrosion, or fatigue.

For the original ten pilot wells, the mean time between failures has increased from 6-12 months to 18-30 months. The following sections detail case studies of three of the pilot wells.

EN-L Cvancara H3 Well

The EN-L Cvancara H3 Well experienced tubing wear and pitting in 24 joints at the bottom of the well. There were 303 joints in this well above the tubing anchor catcher. Joint 300 experienced 99% wall loss. The operator installed 31 new 1-in. guided rods with 1-in. slimhole T3 couplings and 24 new ¾-in. guided rods with ¾-in. full-size T3 couplings. The T3 couplings were placed in the part of the well experiencing the greatest side loading. The worn pump was also replaced.

Table 2 shows that, before the new couplings, this well had frequent workovers, averaging 3 to 8 months apart. The success of the couplings is demonstrated by the extended runtime between failures. By November of 2016, less wall loss was experienced over a longer runtime.

Strahan 15-22 H Well

Table 3 shows the history of Strahan 15-22 H. Although the well previously failed multiple times in only a few months, at the time of writing this well is active with 15 months of runtime. It should be noted that this well receives frequent fresh water treatments due to salt buildup issues. There have also been a few periods of downtime due mechanical issues with the surface pumping.

GO Braaten H1 Well

Table 4 shows that this well had an increase in runtime from 14 months to 20 months. Initially, this well had alternating spray metal and T3 couplings installed in the bottom 1-in. string. This was corrected 8 months later when the well was worked over for a pump change. All couplings in the 1-in. section above the pump were T3 couplings.

PHASE 2: ¾ INCH T3 COUPLINGS

In Phase 2 of the program, the operator selected three pilot wells to test the hypothesis that using smaller couplings would reduce friction in the bottom portion of the well. Lower friction would enable increased net stroke length, thereby increasing production up to 3 bbls per day in each well. The operator purchased a number of ¾-in. full-size T3 couplings in 2015.

While the pilot was successfully performed, the three wells were completed in different configurations than planned. Additionally, some of the BHA configurations were changed such that good comparisons before and after the coupling change could not be made. Table 5 shows the production data before and after the installation of T3 1-in. and ¾-in. couplings. The data does not support a firm conclusion to the question of whether T3 coupling additions enhance production by reducing friction. Figure 1 and Figure 2 show a summary of well operating and production data related to Phase 2. The oil rate actual production history in Figure 2 illustrates the predicted production rate versus the actual oil production. The EN Leo Well has outperformed the predictive curve. The EN-L Cvancara Well cumulative oil production appears to be on track to catch up with the predicted rate. The Hodenfield Well is showing considerable improvement; however, this is largely due to an improved BHA configuration. Although it is difficult to make firm conclusions about the role of the smaller couplings based on the current data, all three wells have been producing for over a year without significant downtime caused by deep tubing leaks.

EN-L Cvancara H3 Well

Figure 3 and Figure 4 show that the well continued good performance after installation of the T3 couplings in November 2015. There was another pump change from 1.75 in. to a 1.5 in. pump in November 2016. It is not possible from this data to determine definitively whether there are significant improvements associated with the couplings. Figure 3 shows an improvement in the average fluid load, the gearbox was at or below the average target of 95%, and production remained steady. Figure 4 shows that for a time the unit ran at a slower speed and produced approximately the same volume of fluids. The rods are not overloaded.

To explore the question of friction reduction further, the operator plans to select a similar well and install an entire string of sucker rods with T3 couplings. A comparison of performance can then determine whether there is a measureable effect due to decreased friction. No changes to the BHA will be made so that data after the change will be comparable to data before the change.

SUMMARY AND CONCLUSIONS

The following observations were made about the use of T3 TS95 sucker rod couplings:

- In the original ten pilot wells, runtimes have increased from an average of 6-12 months to 18-30 months.
- Over 265 wells now have T3 couplings in the bottom 1-in. section of the rod string. In these wells:
    - Tubing wear has been reduced.
    - No failure of T3 couplings has been observed. Wear rates on the couplings have been minimal.
    - Service run times of up to 9.4 million stress cycles have been achieved.

Although the initial data is inconclusive about the role of the couplings in reducing friction on the rod string, further studies will equip wells with a complete rod string of T3 couplings and measure the effects. Accurate comparisons of friction will be achieved by preventing any changes to the bottom hole assembly.

Table 1 - Days of Runtime*

Pilot Well	Runtime
GO Biwer 157-98-2635 H1	1076 days
GO Braaten 156-07-3329 H1	992 days
Strahan 15-22 H	985 days
GO Elvin Garfield 156-97-1819 H1	1084 days
SC Tom 153-98-1514 H4	761 days
SC Tom 153-98-1514 H1	734 days
SC Tom LS153-98-1514 H1	754 days
GN Alice 158-97-1324 H3	723 days
GN EJ 158-97-0706 H1	705 days
GN-Ring-158-98-1522 H1	715 days

*As of January 30, 2017

Table 2 - EN-L Cvancara H3 Well History

Date	12-29-2014	8-7-2015	1-24-16	11-26-16
Runtime		8 month	3 month	11 month
Notes	AL Install	• Tubing leak • 22 red joints • Joint 304 had a split • Appears blue band/used tubing could have been run on bottom	• 24 red joints. Found collar leak when hydrotested • Installed 1” guided with TM and 24 new ¾” guided with TM • Joint 300 had 99% wall loss • 22 new joints were run on bottom	• No hole found with scan • Tubing bled off slowly, so either a collar leak or pump issue • Waiting on pump teardown • Hydrotested in hole – WV does not mention a hole being found • Longest runtime and max wall loss on bottom was 50-60% • Rerunning all 1” and ¾” TM couplings as all the rods look good

Table 3 - Strahan 15-22 H Well History

Date	6-2-2012	4-29-2013	5-22-2014	12-7-2015
Runtime	6 month	9 month	12 month	18 month
Notes	• Parted rod coupling four feet above pump • Lay down 10 joints of tubing, extreme wear noted	• Lay down 26 joints, guided 1" section of rods above pump	• Jt. 314 split due to rod wear • Installed alternating T3 / T couplings on bottom 26 rods	• Scan found 6 red joints but no hole • Pump report indicates leaks in SV/TV • T3 couplings in "new" condition • T couplings showed wear. Replaced T couplings with T3 • Production target is 60 boepd with average daily production of 45 bopd, 57 bwpd, 110 mcfd

Table 4 - GO Braaten H1 Well History

Date	3-2-2013	5-24-2014	2-28-2016	11-23-2016	2-10-2017
Runtime	15 month	14 month	20 month	8 month	3 month
Notes	• Runtime from AL installation • Tubing leak	• Split in tubing in joint above the TK800 • Laid down joints 287-306 due to excessive wear • Ran T3 couplings alternated with Spray Metal in this section. 36 1" guided rods in this section	• Hole in tubing due to rod wear, 2 joints above the seating nipple (1 joint above the TK 800) • Re-ran T3	• Worn pump TV leak • No bad tubing found	• Parted rod-7/8 in pin in Rod #162 from surface with shoulder looking up • Laid down 2 1" guided rods with broken guides • Production on this well is targeted at 33 boepd; average daily production has been 29 bopd, 67 bwpd, 108 mcfd • Fresh water treatments are common, about 30 bbls once a month

Table 5 - Production Trends Before and After T3 Installation

Well	Install Date	Pump Size	Number of T3 couplings	Production 90 day	Production 180 day	Runtime since install	Comments
EN Leo H3	2/15/2016	1.75	• 123 0.75" couplings • 24 1.0" slimhole couplings • 28 1.0" slimhole couplings on guided rods	Before Install: 13765 After Install: 12980	27420 22482	357 days	• Faster decline rate • Still exceeds predicted prod. rate
EN-L Cvancara H3	11/26/2015	1.5	• 31 1.0" couplings on guided rods • 24 0.75" couplings on guided rods	Before Install: 6985 After Install: 8388	15046 15310	393 days	• Cum. production improved
Hodenfield 1533-H	2/9/2016	1.5	• 120 0.75" couplings alternate SM • 1.0" couplings on guided rods	Before Install: 3769 After Install: 6524	7570 10244	353 days	• Cum. production improved above target since install

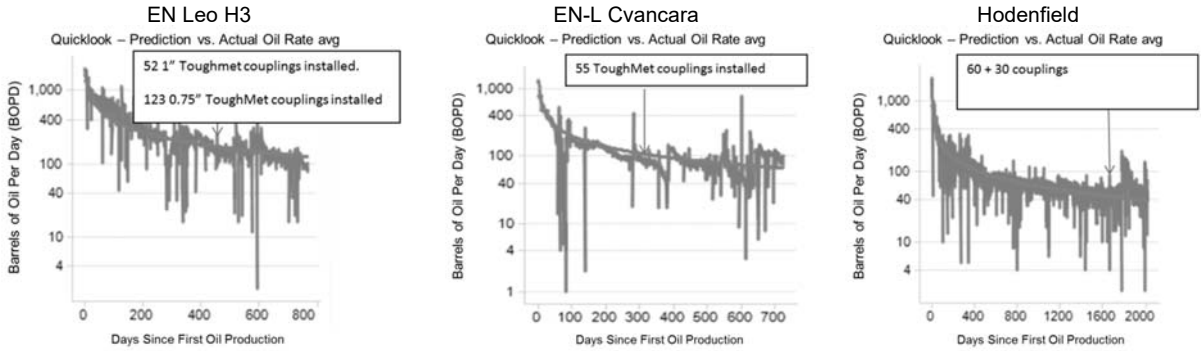

Figure 1 - Production, Prediction vs Actual Oil Rate

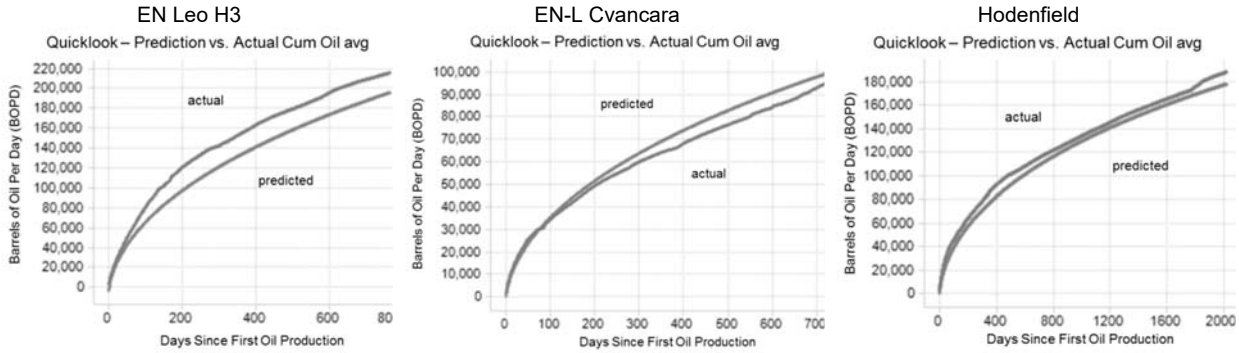

Figure 2 - Production, Prediction vs. Actual Cumulative Oil Average

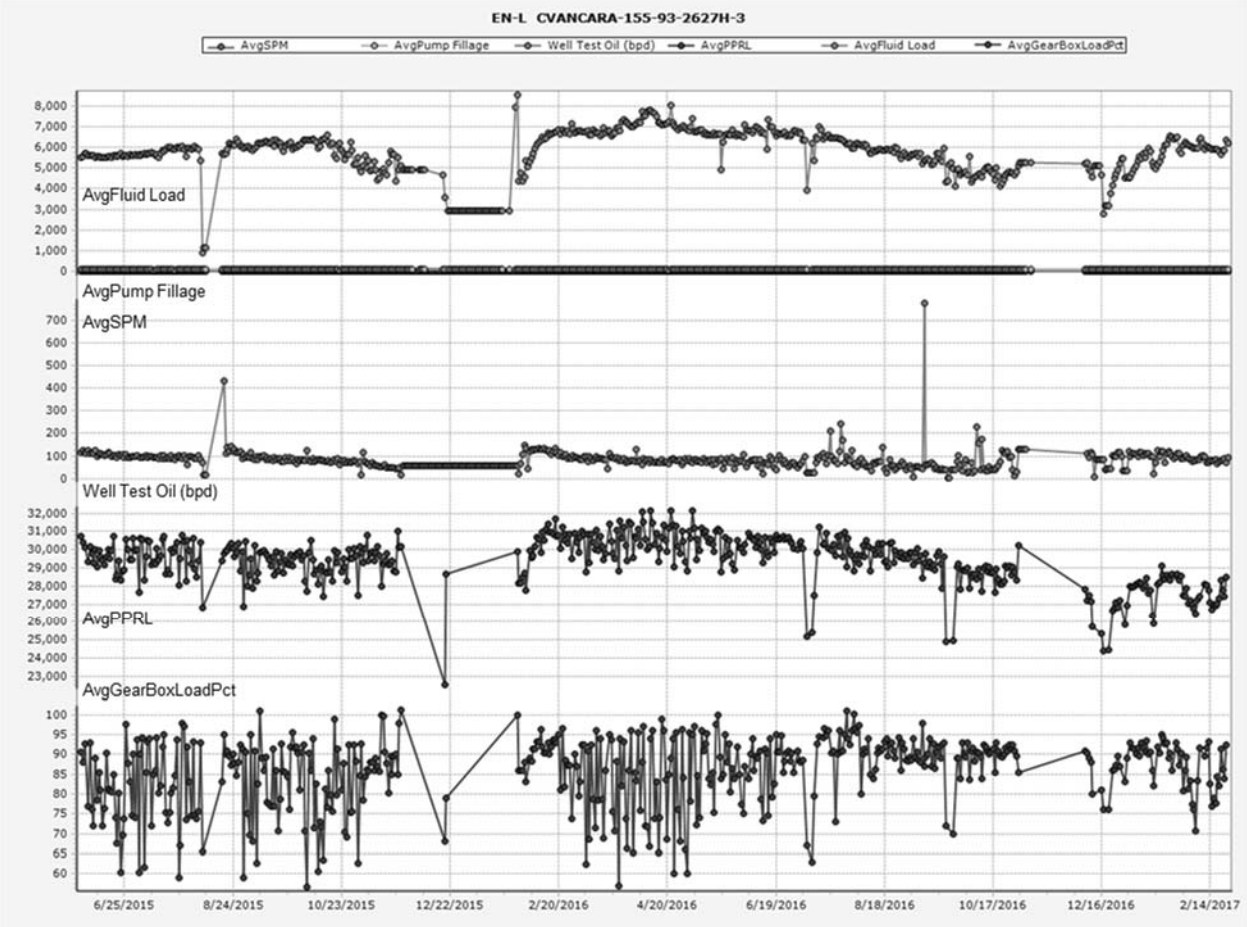

Figure 3 - EN-L Cvancara H3

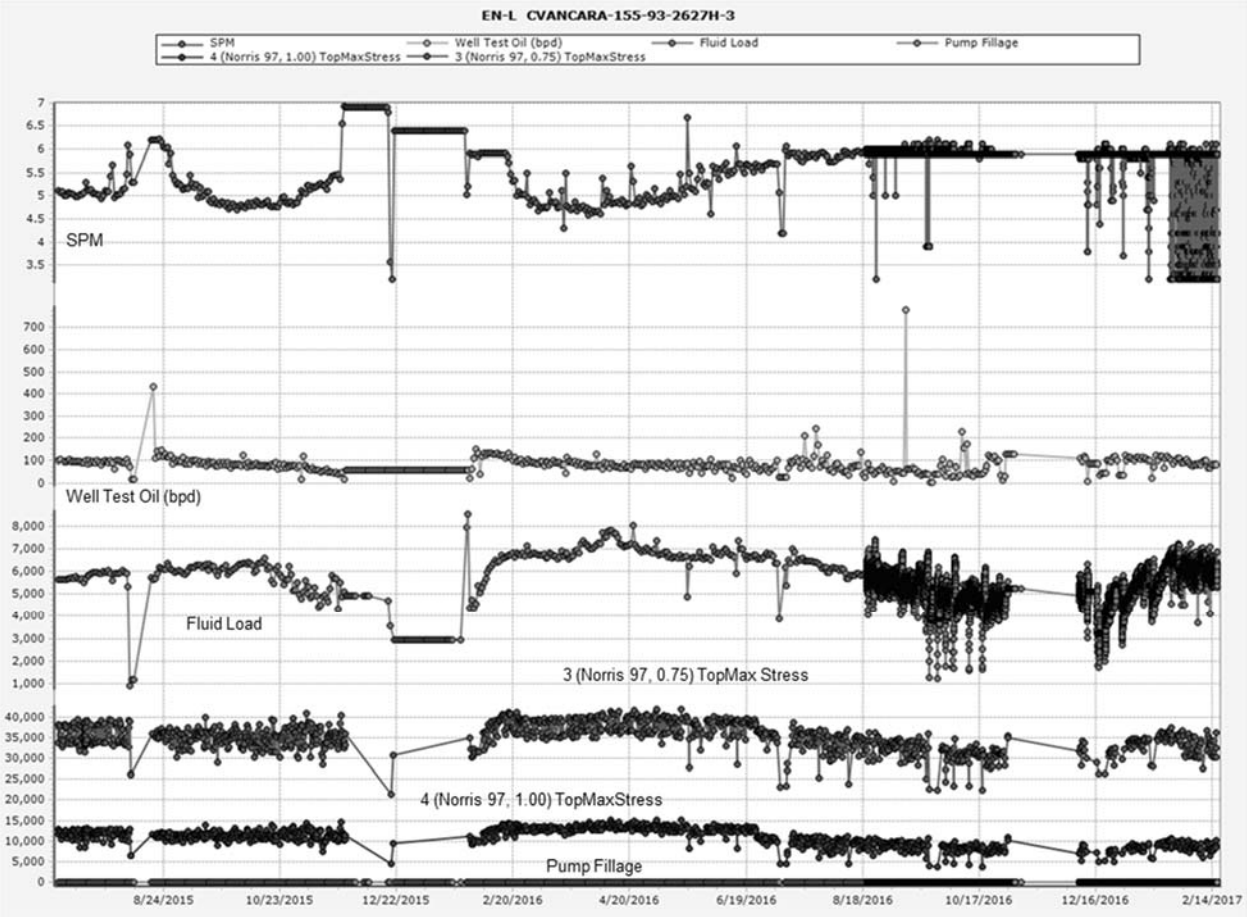

Figure 4 - EN-L Cvancara H3