MEASURED ROD COUPLING ON TUBING WEAR

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ABSTRACT

The Petroleum Industry is becoming more aware of the significance of rod string side loading and associated tubing wear. This wear is due to rod string buckling resulting from downstroke compression and/or wellbore deviation.

Rod string couplings are an integral part of rod string design. Proper selection and installation is critical since these couplings connect every design element in a rod string and can dictate well performance and economics. During lift operations, rod couplings can experience compression and side loading. The result is contact with the interior surface of production tubing and coupling on tubing wear.

Results from this paper will provide the Petroleum Industry with a more accurate understanding of reciprocating rod coupling on tubing wear. This wear test utilized the following parameters:

* 2-7/8", J-55, ERW tubing
* 7/8" Spraymetal and Class "T" rod couplings
* Water/glycol fluid media
* Side load of 57 lbs.

A better understanding of rod coupling on tubing wear will provide the Industry with improved sucker rod string design guidelines. Use of these guidelines will reduce costly coupling on tubing wear and resultant failures that impact the ability of the Petroleum Industry to economically produce oil and gas.

PURPOSE

There is a long standing debate in the Petroleum Industry concerning the use of spraymetal rod couplings in rod pumped wells. The two basic schools of thought are:

1. The harder spraymetal overlay wears the tubing at an accelerated rate as compared to a softer Class "T" coupling. Therefore, rod coupling wear is minimized at the expense of increased tubing wear.

2. Since the spraymetal overlay is a hard and polished surface, it does not accelerate tubing wear as compared a softer Class "T" coupling. Therefore, both rod coupling and tubing life are improved.

The purpose of this test was to measure the amount of wear and better understand the character of wear for Class "T" and Spraymetal couplings on J-55 tubing in a non-lubricated (water/glycol) environment. The glycol was used to minimize the amount of oxygen corrosion in the open test system.

TEST EQUIPMENT

The designed test equipment for this experiment simulated vertical sucker rod and tubing wear in a horizontal configuration. The tubing reciprocated in a horizontal plane, while the couplings were loaded during the full stroke with a 57 lbs. static load. This static load was selected to best simulate side loads acting on the interior wall of production tubing during lift operations. This test equipment was designed to handle four (4) separate test configurations of couplings in tubing. All four (4) test configurations were submerged in two (2) separate containment vessels to simulate rod coupling on tubing wear in a water wet (non-lubricated) fluid environment.

TEST PARAMETERS

The test parameters for this experiment were selected to simulate as close as possible rod coupling on tubing wear experienced by rod strings operating in compression or deviation in production tubing. The selected test parameters are listed as follows;

1.	Tubing:	2-7/8" OD, 6.50 #/ft., J-55, 0.217" Wall API Full Body Normalized, Electric Resistance Welded (ERW)	
2.	Couplings:	7/8", Full Size, Class "T" coupling (FST) 7/8", Full Size, Spraymetal coupling (FSSM) 7/8", Proprietary coupling - **Test Data not part of this paper** 7/8", Slim Hole, Spraymetal coupling (SHSM)	
3.	Average Tubing Velocity:	1,044 Inches / Minute	
		Stokes per Minute;	43.5 SPM
		Stroke Length;	12.0 Inch.
4.	Side Load:	57 lbs. (25 lbs. dead weight + 27 lbs. assembly weight)	
5.	Test Fluid:	Fresh Water (Odessa, Texas) with 10% glycol	
6.	Testing Period:	0 - 2,500,000 Cycles	

MEASUREMENT EQUIPMENT

1.	Wall and Diameter:	Micrometer Caliper, 0 - 4 Inch. with 0.200 Inch. ball point for curvature measurements L.S. Starrett, +/- 0.001 Inch.
2.	Weight:	Electronic Scale, 0 - 10,000 Gram Ohaus Manufacturing, +/- 0.1 Gram

TEST PROCEDURE

1. All production tubes were internally bead blasted to remove mill scale.

2. Interior surface hardness values were measured for all production tubes.

3. Tubing wall thickness was measured at five (5) points along the bottom of the four (4) longitudinally half cut samples of 2-7/8" tubing. These measurements were averaged to establish initial wall thickness.

   Following these initial measurements, the number of measurement points was increased to nine (9), to include one (1) additional point at the end of each tube. This non-wear area acted as a reference point for future wall thickness measurements.

4. Coupling diameters were measured at three (3) points and averaged to establish average coupling diameter. Coupling surface profile and hardness values were also measured.

5. Tubing and coupling weights were measured to substantiate wall thickness and diameter measurements.

6. Measurements were recorded at interval points of 192,200 cycles; 441,000 cycles; 703,200 cycles; 865,851 cycles; 1,500,000 cycles and 2,500,000 cycles.

7. A validation test was conducted with a 57 lb. side load on each of the four (4) independent test arms. Tubing wall loss (utilizing flat steel plate) and coupling diameter loss (utilizing 1.5" Sinkerbars) were measured on each test arm. (Refer to Figure 5 for validation data)

8. Independent, third party engineering laboratories were utilized to measure and record all data gathered throughout this test procedure.

OBSERVATIONS

1. All tubing and the Class "T" coupling experienced wear characterized as "mild galling", which is typical for many wells. The Spraymetal couplings experienced very slight diameter loss (Refer to Figure 2) and no galling.

2. The wear width for the Slim Hole Spraymetal coupling was more narrow than the wear width for the Full Size Spraymetal Coupling. (Refer to Table 1, Column 6)

TEST RESULTS

The primary purpose of this test was to measure the amount of wear and better understand the character of wear for Class "T" and Spraymetal couplings on J-55 tubing in a non-lubricated environment. Tubes 1 and 2 compared very well during the validation test (Refer to Figure 5); therefore, these tubes were used for the following tubing wear comparisons. (Refer to Table 1)

1. The tubing wear depth for the Spraymetal coupling was 15.3% greater than the Class "T" coupling.

2. The tubing wear width for the Spraymetal coupling was 28.5% less than the Class "T" coupling.

3. The tubing "material loss" for the Spraymetal coupling was 6.3% greater than the Class "T" coupling. (Material loss is defined as weight loss per square inch per million cycles)

4. The tubing weight loss for the Spraymetal coupling was 24.8% less than the Class "T" coupling.

CONCLUSIONS

1. Spraymetal couplings exhibited a very slight diameter loss. However, the Spraymetal couplings created a deeper cut into the tubing wall than the Class "T" coupling. The use of Spraymetal couplings to reduce rod coupling wear, may result in accelerated tubing wall loss.

2. The tubing wear width of the Spraymetal couplings was narrower and deeper than the Full Size, Class "T" Coupling. Therefore, even though the weight loss was less for the Spraymetal, the damage to the tubing was greater.

3. The Full Size, Class "T" coupling wore in a manner to conform to the internal radius of the tubing. The Spraymetal couplings did not experience significant wear and therefore, did not conform to the internal radius of the tubing.

QUESTIONS THAT MERIT FURTHER INVESTIGATION

What are the effects of the following items concerning rod coupling on tubing wear:

* Coupling manufacturer, metallurgy, surface hardness, surface profile and radius of curvature.
* Tubing interior wall hardness and uniformity.
* Fluid lubricity.
* Tubing and coupling coatings

REFERENCES

SWPSC - "Solving Rod Buckling" - Gregory L. Mendenhall, and Russ Ott

SWPSC - "Downhole Dynamometer Update" - Glenn Albert

SPE #35214 - "Euler Loads and Measured Sucker Rod Buckling"
Scott W. Long, P.E., and Donald W. Bennett

SPE #37502 - "Measured Rodstring / Tubing Wear and Associated Side Loading"
Scott W. Long, P.E., and Donald W. Bennett

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Table 1
Tubing Weight Loss and Dimensional Data
Summary For
2,500,000 Cycles

Tube #	Coupling Information: Type	Hardness (BHN)	Profile (micro in. AA)	A.P.I., 2-7/8" Production Tubing: Interior Hardness (BHN)	Wear Width (Inches)	Wear Depth (In. / 1000)	Weight Loss (Grams)	Material Loss (Gm/SqIn/MMcycles)
1	Full Size-T	195	63	157	0.925	8.5	11.3	0.31
2	Full Size Spraymetal	>700	4	156	0.661	9.8	8.5	0.33
3	Proprietary Coupling	Data Not Included As Part of This Paper						
4	Slim Hole Spraymetal	>700	12	147	0.604	9.8	7.7	0.32

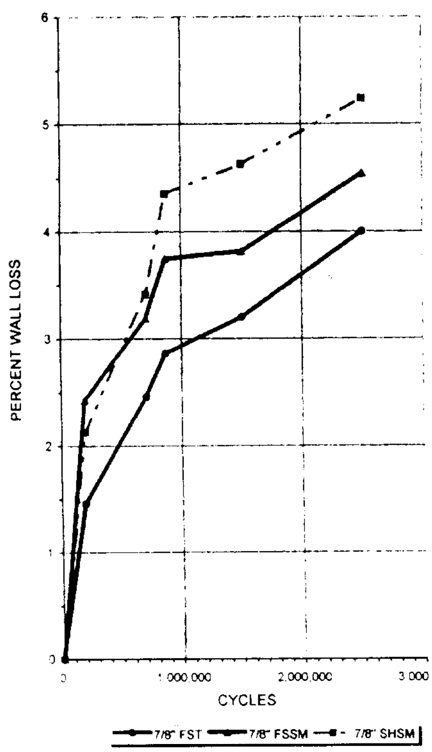

Figure 1 - Percent 2-7/8" Tubing Wall Loss at 57 lbs. Side Load

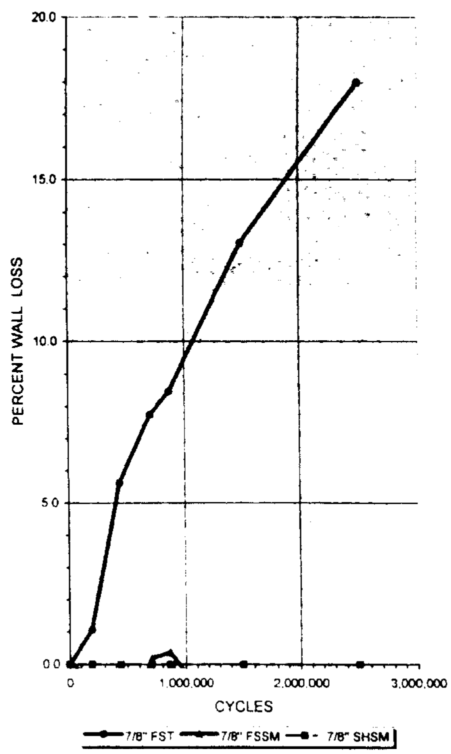

Figure 2 - Percent Coupling Wall Loss at 57 lbs. Side Load

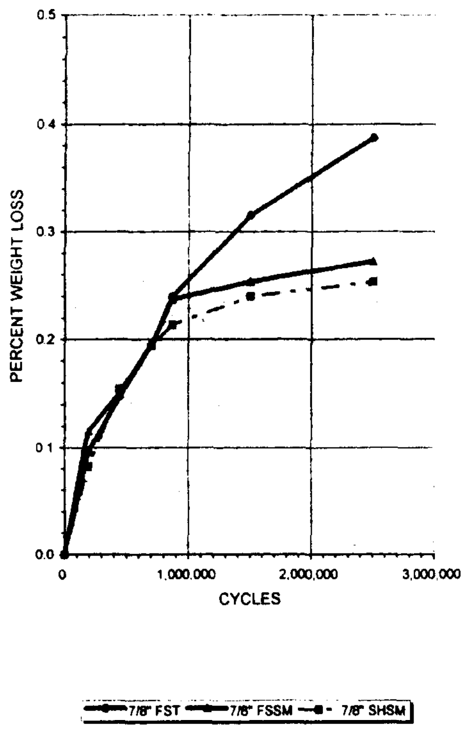

Figure 3 - Percent 2-7/8" Tubing Weight Loss at 57 lbs. Side Load

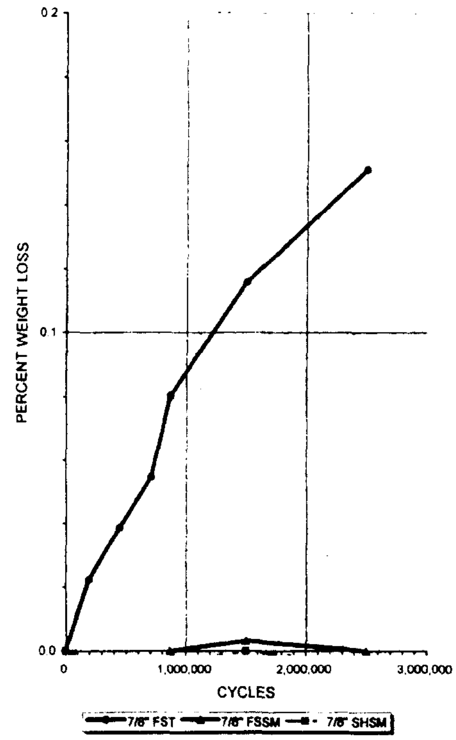

Figure 4 - Percent Coupling Weight Loss at 57 lbs. Side Load

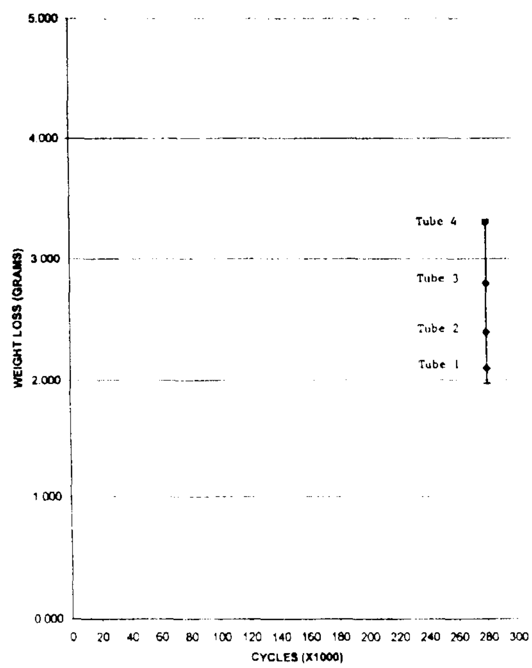

Figure 5 - Flat Plate Validation Test at 57 lbs.
1.3 Standard Deviation