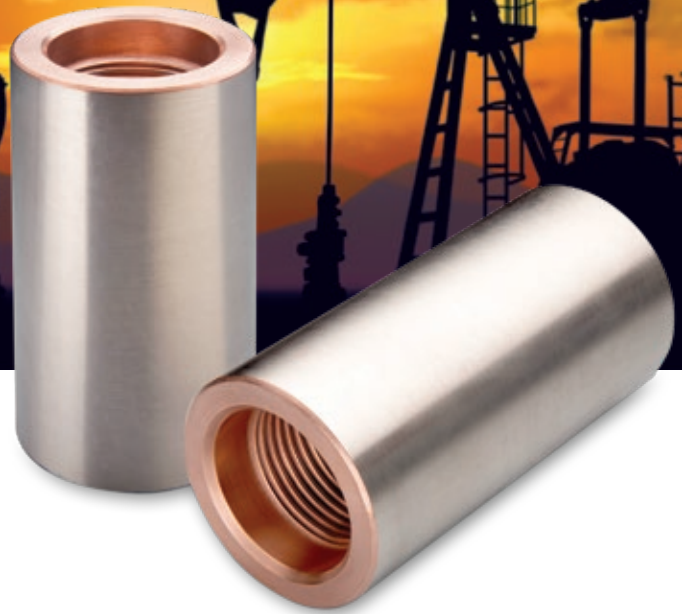




MATERION



TOUGHMET[®]3
ARTIFICIAL LIFT COUPLINGS

TOUGHMET® COUPLINGS

Eliminate frequent workovers, lower production costs and improve margin and cash flow

ToughMet copper-nickel-tin alloys have been successfully used in the oil and gas industry for decades. The newest ToughMet temper—ToughMet 3 TS 95 material—was specifically engineered for ToughMet sucker rod couplings, which eliminate well failures caused by coupling-on-tubing wear.

In addition, wells using 150 or more ToughMet couplings can increase production by nearly 13% due to lower friction, improved plunger travel and increased well efficiency.



TOUGHMET COUPLINGS FINANCIAL VALUE PER WELL PER YEAR

Due to Failure Prevention	
Failure prevention rate (Failures/Yr.)	1
Tubing workover cost	\$55,000
Investment for 40 ToughMet couplings	\$ (3,960)
Value of deferred oil production (\$)*	\$55,000
TOTAL ADDITIONAL CASH FLOW	\$106,040
Due to Increased Productivity	
Output increase %	12.6%
Value of increased oil production**	\$252,945
Investment cost for 150 ToughMet couplings	\$ (14,850)
Additional cash flow – increased oil production	\$238,095
Additional cash flow – avoiding workover	\$55,000
TOTAL ADDITIONAL CASH FLOW	\$293,000

*10 days at 100 bbl/day at \$55/bbl

**for Well Producing 100 bbl/day at \$55/bbl=

LOW FRICTION / NON GALLING

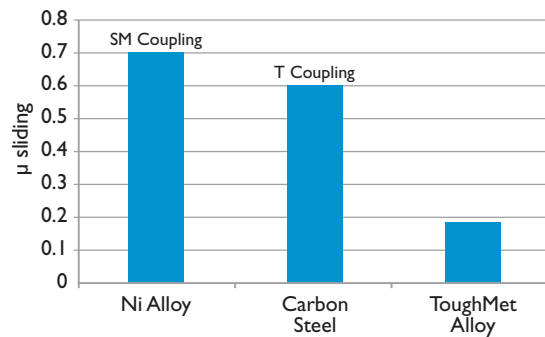
The unique non-galling properties of ToughMet® 3 TS 95 alloy, along with high fatigue strength, provide longer coupling and tubing life than couplings made of conventional materials.

When used in wells in place of Spraymetal (SM) and Class T couplings, ToughMet couplings last longer – without sacrificing the tubing.

ToughMet 3	Spraymetal (SM)	Class T
97 HRB minimum (20 HRC)	Coating hardness 595 HV (60 HRC)	16 – 23 HRC
No coating	Nickel-based alloy coating	No coating
High fatigue strength, low friction. Does not sacrifice tubing or coupling.	High hardness, high friction. Sacrifices tubing.	Low hardness, high friction. Sacrifices coupling.

TOUGHMET 3 ALLOY GALLING/WEAR RESISTANCE

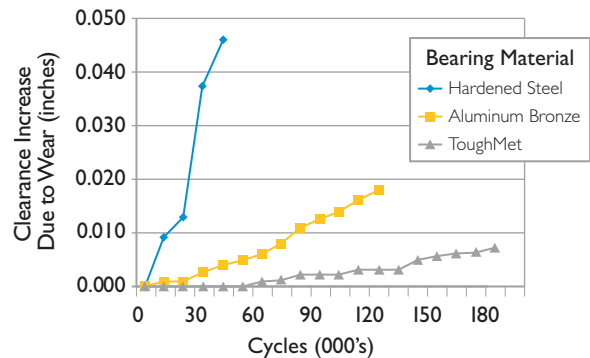
Anti-Galling to typical steel production tubing and sucker rods



SM and T coupling friction would be similar to that of the nickel alloy and carbon steel, respectively.

TRIBOLOGY

Metal-on-Metal Wear



Oscillating axial motion with side loading.
Average bearing stress @ 2,000 psi. Carburized steel shaft.



One ToughMet coupling (vertical) with three conventional couplings after 600 days in service.

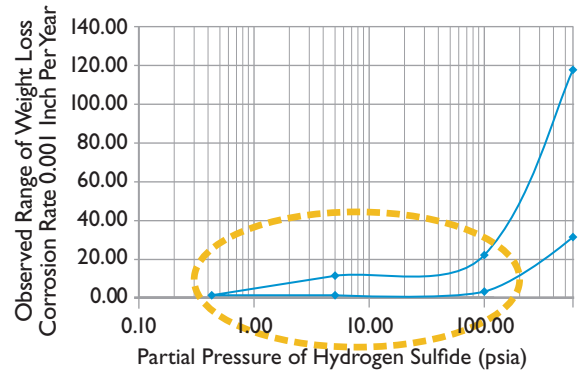


New ToughMet (vertical) coupling with ToughMet (horizontal) coupling after 600 days in service.

CORROSION RESISTANT

NACE MR0175 and ISO 15156 allow unrestricted use of ToughMet® couplings in sour environments because it is a copper alloy. ToughMet couplings will not crack in hydrogen sulfide (SSC). The general weight loss corrosion rate of ToughMet couplings in well fluids depends on the temperature and partial pressure of hydrogen sulfide. ToughMet alloy resists CO₂ corrosion, chloride stress corrosion cracking (SCC) and hydrogen embrittlement (HE), and it is compatible with commonly used well-treatment chemicals.

EFFECT OF HYDROGEN SULFIDE on Weight Loss Corrosion of ToughMet 3 Alloy



Temperature range from 80 - 150 degrees Celsius

Environments having hydrogen sulfide > 0.05 psia partial pressure are considered "sour."

SOUR SERVICE – ToughMet Alloy Weight Loss

Environment	pH	PP H ₂ S psi	PP CO ₂ psi	NaCl %	Temp deg C	Weight Loss 0.001 inch/year
Production	~3	1200	400	25	175	huge
Production (NACE VII)	~3	508	508	25	205	137
Production	~4	580	189	15	90	117
Production	~5	568	237	8	100	32
Production (NACE V)	~3	101	203	15	150	4 to 22
Production	~5	5	200	25	150	12
Production	~3	5	200	25	95	1 to 3
Production (NACE IV)	~3	0.43	101	15	90	1
Production (NACE II)	~3	14.7	–	5	23	1

STRENGTH

ToughMet® sucker rod couplings are made from the strongest coupling material that mitigates failures caused by coupling-on-tubing wear.

ToughMet 3 TS 95 Alloy Material Composition

Cu-Ni 15-Sn8

MATERIAL PROPERTIES (minimum values)

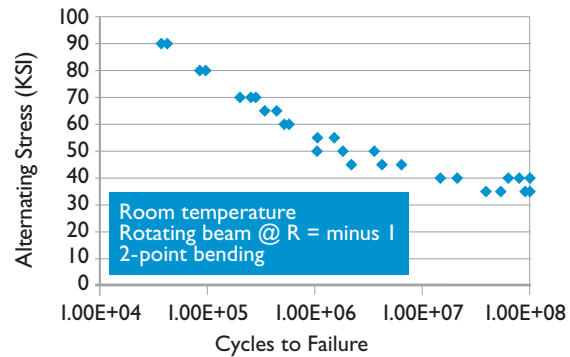
0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation	Hardness
ksi	MPa	ksi	MPa	%(in 4D)	HRB
95	655	106	730	18	97

HIGH FATIGUE STRENGTH

ToughMet properties were upgraded to increase fatigue strength and fracture toughness specifically for artificial lift couplings. ToughMet couplings resist mechanical failure when running in artificial lift systems.

FATIGUE STRENGTH

ToughMet® 3 TS95 Alloy



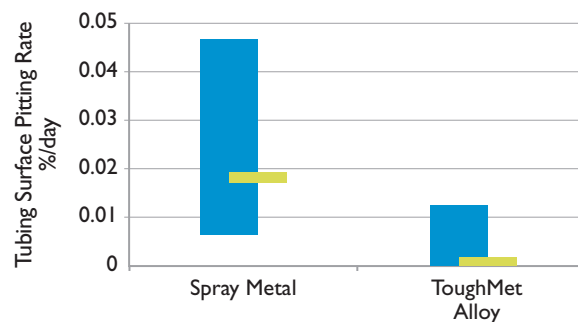
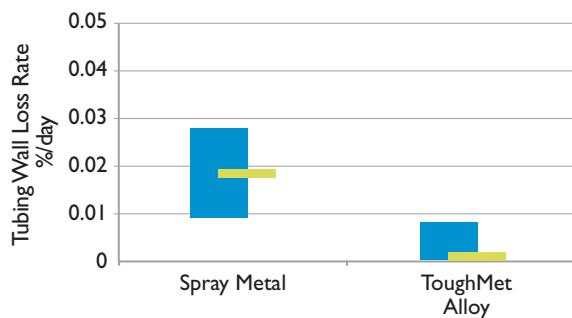
PERFORMANCE IN THE FIELD

ToughMet couplings are a drop-in replacement for conventional couplings. They can be installed using standard make-up and break-out practices and torque/turn controls.

REDUCED TUBING DAMAGE – TOUGHMET COUPLINGS

(highest, lowest and mean values are shown)

ToughMet couplings increase mean time to failure by at least three times.



FIELD TRIAL RUNNING TOUGHMET COUPLINGS IN ENTIRE SUCKER ROD STRING

Due to its non-galling and low friction properties, ToughMet® couplings allow the sucker rod string to move more smoothly and the well to operate more efficiently. Using ToughMet couplings increases downhole stroke, pump fillage, and oil production, and decreases fluid level above the pump, gear box loads, and polished rod loads.

FULL STRING CASE STUDY

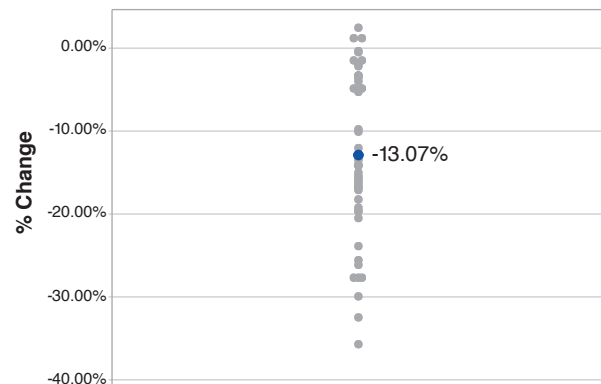
Well Details - No major design changes made to this well besides couplings

Shale Play	Permian
Install Date	August 2017
# ToughMet 3 Couplings Installed	186
Type of Couplings Replaced	Spray Metal + T
Pump Size	1.75"
Pump Set Depth	6656 ft. (pump set in curve)
Tubing	L80
Rods	Fiberglass/Steel
SPM	7 (VSD)
Designed Stroke Length	130"
Side Loads	240 lbs
Rotators	Rod/Tubing Rotators
Guides	Yes
Dog Leg Severity	1.84 at SN

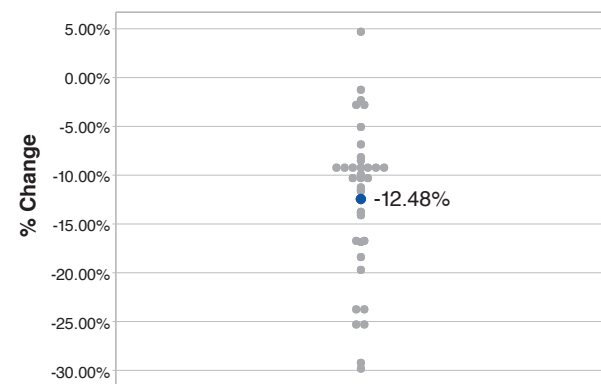
TOUGHMET 3 COUPLING EFFECT ON WELL PERFORMANCE

	Average Change (%)
Oil Production	12.6 ↑
System Efficiency	20.6 ↑
Downhole Stroke	16.0 ↑
Pump Fillage	6.4 ↑
Peak Polished Rod Load	-13.1 ↓
Range Between Max and Min Load on Polished Rod	-12.1 ↓
Gearbox Loading	-12.5 ↓
Fluid Level AP	-23.8 ↓
Failure Rate (FPY)	-0.7 ↓

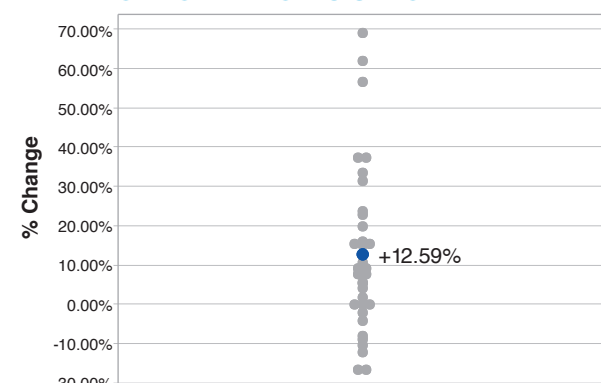
TOUGHMET 3 COUPLING EFFECT ON PEAK POLISHED ROD



TOUGHMET 3 COUPLING EFFECT ON GEARBOX LOADING



TOUGHMET 3 COUPLING EFFECT ON OIL PRODUCTION



TOUGHMET® 3 TS 95 VALVE ROD GUIDE BUSHING COUPLING

The ToughMet 3 Valve Rod Guide Bushing Coupling is Materion's newest solution for eliminating production interruptions in artificial lift systems. The coupling is installed directly above the pump to connect the rod string to the pump drive rod. By reducing HIT failures in an area prone to extreme rod buckling and tubing wear, this oversized coupling provides the opportunity to avoid costly workovers and eliminate production interruptions in rod pumped wells.

THE TOUGHMET VRGB COUPLING:

- Is installed on top of the valve rod bushing
- Acts as a centralizer for the bottom of the rod string
- Prevents the valve rod bushing from wearing out production tubing due to a thicker body design
- Eliminates tubing leaks by preserving adjacent production tubing
- Survives metal-on-metal contact with tubing wall
- Withstands high impact loads from rod buckling

DIMENSIONS

- 2" outer body diameter
- 3/4" rolled threads
- 4" long



Sucker Rod Coupling	O.D.	
	Full	Slim
5/8"	1.50"	1.25"
3/4"	1.625"	1.50"
7/8"	1.812"	1.625"
1"	2.187"	2.000"
1-1/8"	2.375"	N/A

Sub Coupling	O.D.	
	Full	Slim
7/8" x 3/4"	1.812"	1.625"
1" x 3/4"	2.187"	2.00"
1" x 7/8"	2.187"	2.00"
5/8" x 3/4"	1.625"	1.50"

Polished Rod Coupling	O.D.	
	Full	Slim
3/4"	1.625"	1.50"
7/8"	1.812"	1.625"
1"	1.817"	2.000"
1-1/8"	2.375"	N/A

Dimensions conform to API Specification IIB and have rolled threads.

Recommended connection makeup.

Apply appropriate circumferential displacement value proscribed by rod manufacturer for the rod size and grade.



MATERION PERFORMANCE ALLOYS

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