NEW POSITIVE-SEAL SHROUD HANGER DESIGN SOLVES PRODUCTION PROBLEMS IN NEW MEXICO GAS WELLS

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ABSTRACT

Motor shrouds and shroud hangers are commonly used to set electric submersible pump (ESP) systems below well perforations in order to maximize well drawdown and/or to minimize gas interference in the pump. The shroud orients wellbore fluid around the downhole motor, thus helping to cool it. In this New Mexico gas field, conventional shroud hangers often create multiple problems, including:

- misdirected fluid flow creates motor heating
- excessive heat causes scale buildup between the motor and the shroud
- optimum water production and well drawdown are not achieved due to scaling
- poor gas separation due to fluid and gas leakage through the shroud hanger
- gas production below expectations
- wells continually shut down due to high temperature effecting motor performance
- scale restricted fluid flow, which creates additional heat and causes eventual motor failure.

Downhole re-circulation systems have been only marginally successful in solving these problems.

A field discovery on the Brannigan ANF #4 well in New Mexico, followed by laboratory testing and engineering analysis of the conventional shrouded ESP system, determined that wellbore fluids and gas were leaking through the shroud hanger. Additionally, the leakage increased at very high rates as flow between the shroud and motor was restricted. The discovery confirmed this operator's ongoing problems with conventional shroud hangers.

The discovery and subsequent solution are discussed in this paper. Based on the findings, a new intake body and shroud system was designed to eliminate problems associated with conventional shroud systems.

INTRODUCTION

A typical ESP system is comprised of several components. These components are assembled from the bottom up as follows: a sensor or base, motor(s), seal(s), intake, pump(s) and a discharge head. Typically the system (Fig. 1) is installed in the wellbore above perforations. These systems are designed to allow wellbore fluids to flow around the motor to help dissipate heat. When the fluids do not cool the motor sufficiently, the motor temperature will eventually rise above an acceptable operating range creating overheating, which can result in an equipment failure. This is referred to as a motor burn (Fig. 2).

In some areas, installing electrical submersible pumps below the perforations is becoming more and more commonplace. This is usually done in an attempt to maximize production or to allow for better gas separation. However, installing the ESP below the perforations places the motor below the flow of wellbore fluids. Hence, the fluid is drawn in at the intake and the motor continues to generate heat until it burns.

To overcome this drawback, the industry developed a mechanical method (Fig. 3) to force wellbore fluid around the motor by installing a shroud (usually a piece of pipe that covers the intake and extends down below the motor). With the intake covered, the fluid falls past the shroud then up between the OD of the motor and the ID of the shroud. As long as the shroud does not become blocked and there is sufficient fluid produced, the fluid will dissipate heat away from the motor and help extend the system's run life. Using a shroud to direct fluid flow in a below-perforation installation is conceptually sound, especially in wells prone to gas interference. However, historically shrouds have been only marginally successful.

Some operators have been reluctant to use shrouded ESP systems below perforations because by design the system OD is larger and the potential for sticking the ESP system in the well increases. The main reason for skepticism, however, has been whether or not the shroud was actually effective in preventing motor burns. In some cases, even with shrouded equipment, ESP systems still fail because the motors are operated beyond an acceptable operating temperature.

As downhole sensors have become more and more effective, it has become apparent that shrouded equipment does not always ensure long motor life. In some shrouded installations, rising temperatures are recorded over longer equipment runs. Sophisticated sensors and control systems are set to actually shut the well down, allowing the motor to cool and start up again after a predetermined off period. However, cycling a well on and off can be detrimental to the equipment's extended life as well as to production totals.

FIELD DISCOVERY

In the last quarter of 2002, a major manufacturer of ESPs and an operator of wells in New Mexico were analyzing typical shroud problems in several of the operator's wells. Most wells in this area are typically gas wells that produce tremendous amounts of water that must be pumped-off. An ESP unit with a TD1750 pump (a 4-in. OD pump rated at 1750 b/d) and a conventional shroud had been installed below the perforations in one of the operator's wells, the Brannigan ANF #4. The purpose was to allow for better gas separation. In this application, as the operator pumps the water lower, the gas should flow at higher volumes. High volumes of gas and water are difficult for any type of artificial lift system and often result in gas locking.

This ESP system, which employed a downhole sensor and intelligent surface control system, was installed below the perforations in an effort to provide the operator with the best opportunity to produce cycle free. However, the system began to cycle immediately. The well shut-off every time the motor oil temperature reached 225ºF. Generally, the well would pump for about an hour and shut-off for two. It was cycling on and off eight times a day. Until the day it was pulled, the system was producing at a rate of 1750 bbl of water per day through a pump designed to produce 1800 BOFD. It was speculated that there was a problem with the sensor because the amount of fluid being produced should have been sufficient to cool the motors.

The unit was pulled and it was discovered that the bottom of the shroud was packed with wellbore fill all the way up past the sensor. The unit had inadvertently been installed deep into the bottomhole fill. It seemed impossible that the system could produce 1750 b/d through the relatively small leak paths at the top of the shroud where it attached to the bottom pump. But, that was exactly the case. Accordingly it was determined that:

• misdirected fluid flow was creating motor heating
• excessive heat caused scale buildup between the motor and the shroud (Fig. 4 and 5)
• optimum water production and well drawdown were not achieved due to scaling
• scale restricted fluid flow, which created additional heat and caused eventual motor failure (Fig. 2)
• there was poor gas separation due to fluid and gas leakage through the conventional shroud hanger
• continuous cycling due to high temperature was effecting motor performance
• gas production was below expectations.

ENGINEERING FOR POSITIVE RESULTS

Subsequent tests (Fig. 6) at the manufacturer's engineering technology laboratory confirmed that wellbore fluids and gas were leaking through the conventional shroud hanger and that leakage increased at very high rates as flow between the shroud and motor was restricted. This discovery led to the development of a new, patented positive-seal shroud (PSS).

Based on the findings, the ESP manufacturer's engineering team designed (Fig. 7), tested (Fig. 6) and manufactured a totally new intake body and shroud system. In the new design the shroud was hung directly from the intake body, special elastomers were used to seal the gaps between the shroud housing and the intake, and all connections were sealed with a specially designed bolting system (Fig. 8 and 9).

PRODUCTION PERFORMANCE

Initially, the operator was reluctant to downsize the lift system for fear of gas locking and the possibility that the well would not pump down properly. Accordingly, another TD1750 pump was reinstalled with the new PSS and the system performed as anticipated. The well was pumped off within a very short period of time (Fig. 10). In order to achieve a continuous pumping process and to lower operating costs, the manufacturer suggested that the system be pulled and downsized.

A TD460 pump (a 4-in. OD pump rated at 460 b/d) with the PSS was then installed. The system was optimized by fine tuning the downhole sensor's input parameters via the surface control unit and the well has been continuously monitored (Fig. 11).

With the more efficient system, horsepower was lowered from 150 HP to 50 HP. Electrical costs dropped dramatically, the system has run continuously with no cycling problems and gas production stabilized at a high rate. The well has continued to perform with no interruption in service for six months.

Production data from the Brannigan ANF #4 before and after the positive-seal shroud installations demonstrates the increased drawdown efficiency and elimination of troublesome cycling problems (Tables 1, 2 and 3).

CONCLUSION

Documented production performance and recorded downhole parameters during the evaluation period on the Brannigan ANF #4 proved that the new positive-seal shroud:

- efficiently forced wellbore fluid past the motor
- reduced motor temperature 30°F to 50°F
- reduced scaling
- allowed for more accurate equipment sizing (which in several cases since the original installation has lowered the HP requirement by 50%)
- provided better gas separation
- increased drawdown efficiency
- increased equipment run life and production.

The new design has since been installed with the same positive results for this operator in 10 wells that had problems similar to the Brannigan ANF #4. Additionally, other operators in the region have employed the new PSS in 14 wells with equivalent successes.

ACKNOWLEDGMENTS

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Table 1
Production Data From The Brannigan ANF #4
Prior To Installation of The Positive-Seal Shroud

Brannigan ANF #4 Production with TD1750s					
Date	**TFPD** (bbl)	**BHP** (lb)	**Gas** (mcf)	**Temp** (ºF)	**Downtime** (hr)
6/17/2003	580	310	2026	232	2
6/18/2003	555	310	1991	229	2
6/19/2003	476	236	1974	242	3
6/20/2003	392	388	1961	170	3
6/21/2003	486	395	1992	175	3
6/22/2003	328	305	1963	230	4
6/23/2003	878	302	1875	223	4
6/24/2003	794	327	1894	192	3
6/25/2003	593	295	1982	243	4

Table 2
Production Data From The Brannigan ANF #4 After
Installation of The Positive-Seal Shroud And TD1750 ESP

Brannigan ANF #4 Production with TD1750s & PSS					
Date	**TFPD** (bbl)	**BHP** (lb)	**Gas** (mcf)	**Temp** (ºF)	**Downtime** (hr)
6/28/2003	949	451	615	176	9
6/29/2003	951	390	2289	180	2
6/30/2003	669	432	2236	159	4
7/1/2003	534	246	2118	209	0
7/2/2003	282	361	2093	189	1
7/3/2003	350	402	2040	172	17
7/4/2003	537	397	1954	173	11
7/5/2003	548	275	1954	176	5
7/6/2003	504	352	2015	158	5
7/7/2003	476	343	2000	164	5
7/8/2003	448	310	1978	172	4
7/9/2003	437	345	1937	157	4
7/10/2003	387	335	1944	176	10
7/11/2003	394	364	1893	156	11
7/12/2003	346	340	1924	158	8
7/13/2003	385	341	1880	175	8
7/14/2003	340	241	1875	204	6
7/15/2003	342	234	1841	218	3
7/16/2003	351	220	1913	208	6
7/17/2003	303	225	1908	208	0
7/18/2003	363	304	1943	194	3
7/19/2003	291	277	1900	204	3
7/20/2003	313	284	1864	222	0

Table 3
Production Data from the Brannigan ANF #4 After Re-Sizing The System And Installing The Positive-Seal Shroud and the TD460 ESP - After installation, inputting the correct downhole sensor parameters via the surface controller optimized the system. The unit has pumped continuously without the previous cycling problems.

Brannigan ANF #4 Production with TD460s & PSS					
Date	**TFPD** (bbl)	**BHP** (lb)	**Gas** (mcf)	**Temp** (ºF)	**Downtime** (hr)
7/25/2003	320	404	1670	175	4
7/26/2003	289	400	1730	177	1
7/27/2003	211	388	1834	176	4
7/28/2003	435	376	1830	174	4
7/29/2003	427	359	1697	179	4
7/30/2003	476	376	2071	187	0
7/31/2003	538	358	1957	183	0
8/1/2003	562	348	1894	183	0
8/2/2003	582	336	1834	181	0
8/3/2003	566	320	1783	181	0
8/4/2003	541	233	1764	180	0
8/5/2003	491	368	1798	160	3
8/6/2003	519	329	1775	186	0
8/7/2003	583	314	1769	186	0
8/8/2003	555	287	1774	181	0
8/9/2003	515	212	1736	185	0
8/10/2003	428	336	1694	165	1
8/11/2003	446	207	1710	185	4
8/12/2003	430	314	1759	183	4
8/13/2003	423	323	1726	182	4
8/14/2003	529	204	1738	185	4
8/15/2003	535	200	1814	184	0
8/16/2003	537	210	1824	185	0
8/17/2003	451	232	1813	189	0
8/18/2003	394	233	1786	189	0
8/19/2003	408	227	1799	190	0
8/20/2003	377	204	1779	188	0
8/21/2003	435	196	1846	186	0
8/22/2003	365	216	1788	187	0
8/23/2003	273	213	1722	190	0
8/24/2003	306	217	1724	190	0
8/25/2003	332	221	1737	200	0
8/26/2003	322	216	1717	188	0
8/27/2003	394	213	1722	187	0

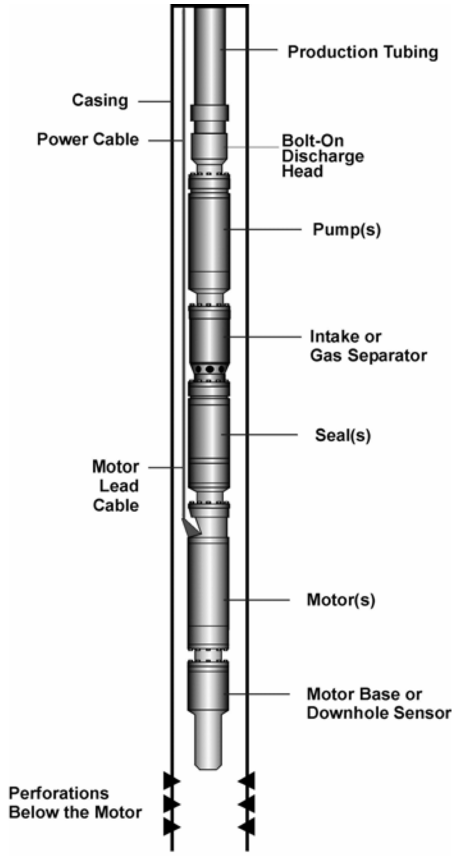

Figure 1 **-** Typical Diagram of ESP System Installed Above Perforations

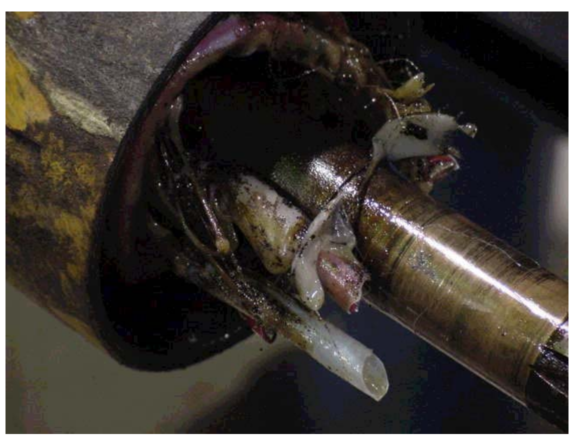

Figure 2 – “Motor Burn”

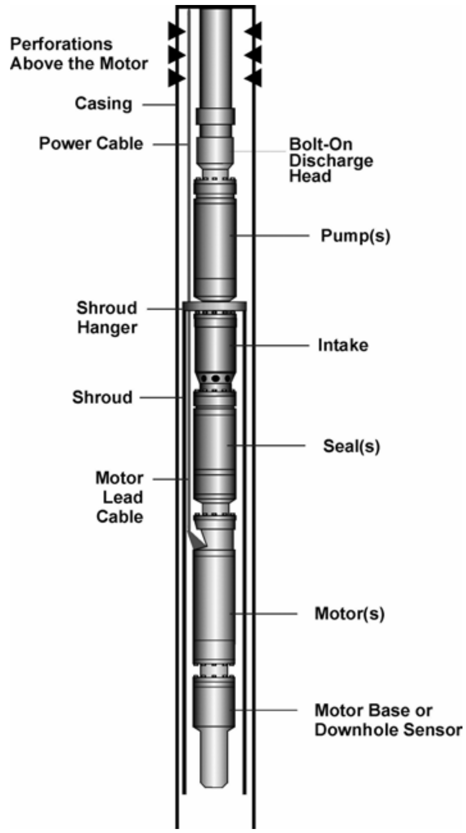

Figure 3 **-** Diagram of ESP System and Conventional Shroud Installed Below Perforations

Figure 4 - Scale And Produced Solids Bonded to the ESP Motors Inside
the Shroud Causing Excessive Heating And Motor "Burn Out"

Figure 5 - Another View of Scale and Produced Solids Bonded to the ESP Motor

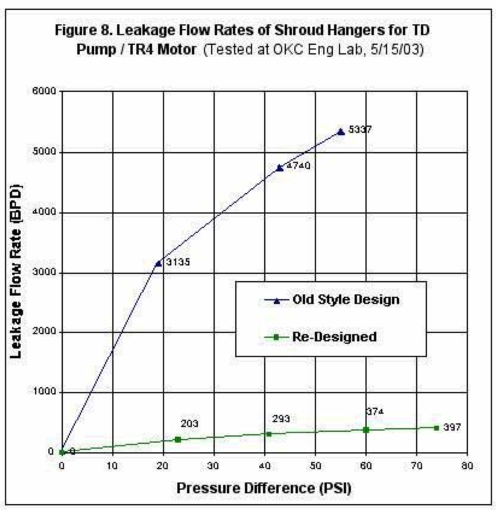

Figure 6 - Leakage Flow Rates of Shroud Hangers - Pressure tests at the manufacturer's engineering technology laboratory confirmed that wellbore fluids and gas were leaking through the conventional shroud hanger and that leakage increased at very high rates as flow between the shroud and motor was restricted.

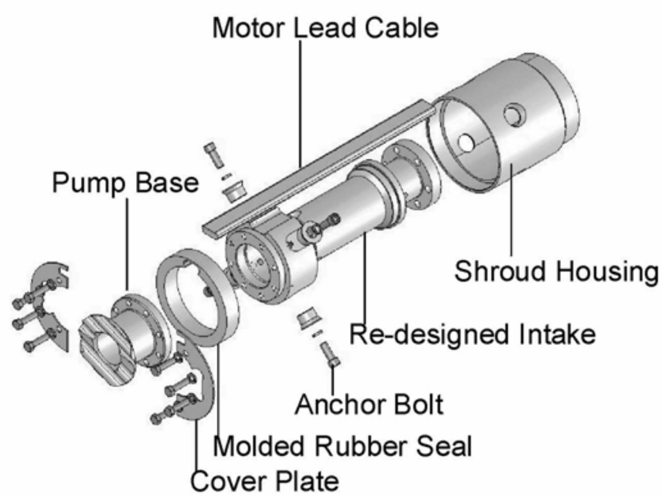

Figure 7 - The new shroud was hung directly from the intake body, special elastomers were used to seal the gaps between the shroud housing and the intake, and all connections were sealed with a specially designed bolting system.

Figure 8 - Components of New Positive-Seal Shroud Hanger

Figure 9 - New Positive-Seal Shroud Assembly

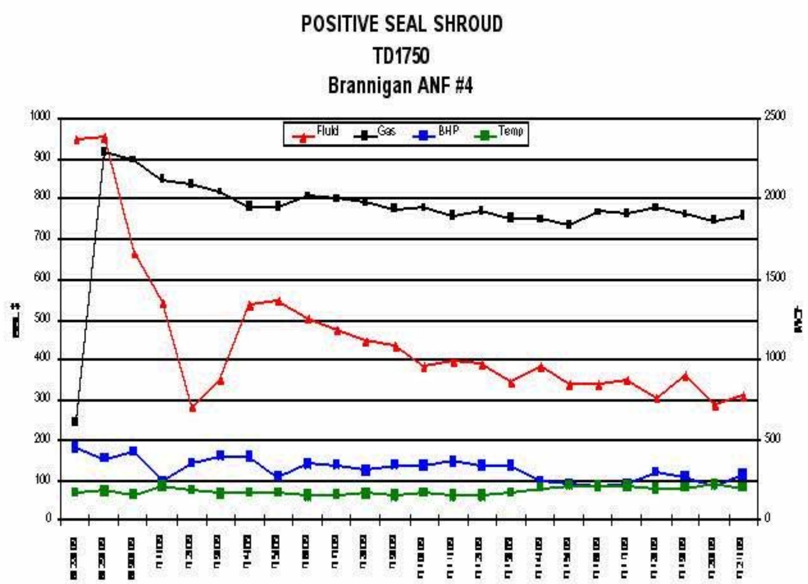

Figure 10 - The Brannigan ANF #4 was pumped-off within the first 24 hours after the initial installation using the new positive-seal shroud and a TD1750 pump.

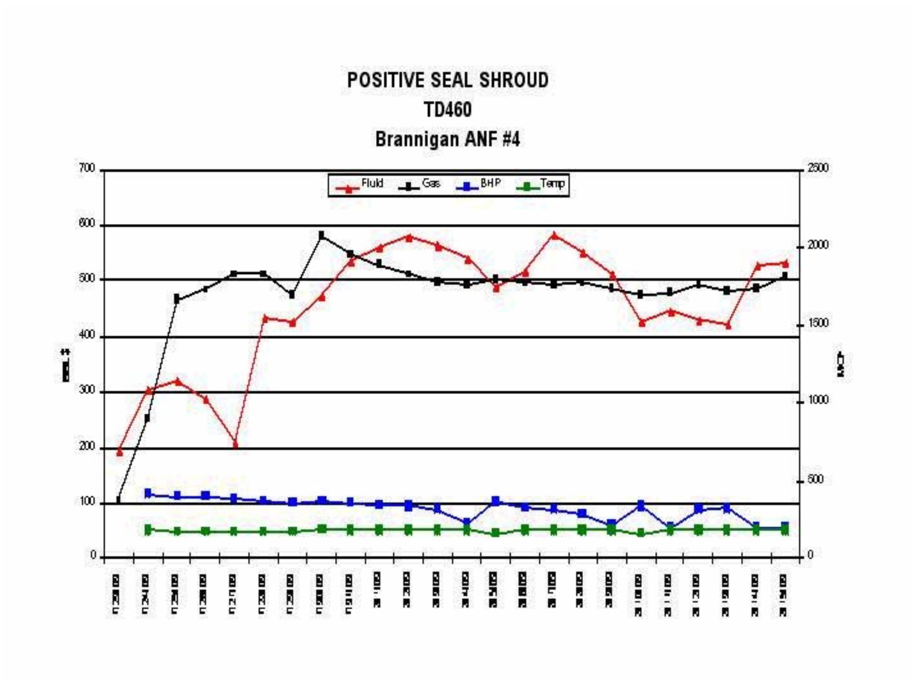

Figure 11 - The Brannigan ANF #4 After Final Installation with the Positive-Seal Shroud and A TD460 Pump