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Drilling Riser Alternative Repair Methods for Leaking Joint Seals Utilizing Pressure Activated Sealant Technology

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Abstract

Since the inception of deep water operations, drilling riser seal component failures have been a persistent problem worldwide. Traditionally these failures have required that the drilling riser be pulled, the affected seals replaced and then the drilling riser re-installed; resulting in substantial rig down time and expense to the operators and service companies. Seal-Tite International has developed a unique array of pressure activated sealants able to withstand the high pressure and extreme temperature conditions associated with subsea drilling and production operations. The sealant is polymerized by the differential pressure created through the leak sight. The polymerization process only occurs in the sealant that passes through the leak sight; all other sealant remains liquid and can be circulated out of the well with no damage to any of the well components. Subsequent to extensive testing, pressure activated sealant technology was utilized to repair a leaking joint in a drilling riser choke line at approximately 4200 ft water depth in the Gulf of Mexico. The leak was repaired and the client was able to continue and complete drilling operations with no downtime. The riser was tested to operating pressure every three days for the duration of the drilling operation with no leaks observed.

Introduction

In the drilling of deepwater wells, the floating drilling equipment is connected to the seafloor wellhead by means of a riser. This riser consists of the main bore housing the drill string and tools, as well as several ancillary pipes providing the function of choke line, kill line, boost line, and hydraulic power to the subsea BOP's. The riser is made up of numerous sections which are flanged together to provide the total length required. Typically the pressure barriers at each flange are provided by metal-to-metal seals, elastomeric seals or some combination of the two. Each connection must be tested and proved able to withstand the pressure requirements for full functionality during the most critical period of well control operations.

Root cause analysis of rig downtime revealed that drilling riser leaks were a very significant percentage of the overall total. While minor leaks could be tolerated in some instances, critical well control components such as the choke line and kill line must pass stringent pressure test criteria on a routine basis. Failure to pass the test criteria resulted in significant downtime to locate the leak area, disconnect and pull the riser to replace the faulty seals, and then re-run the riser and reconnect it to the wellhead. On a worldwide basis, the financial impact of this downtime exceeded 2 $MM. Transocean identified this area as a priority for development of best practice equipment and procedures in order to minimize future downtime.

Seal-Tite International's pressure-activated sealant technology has been used with success in oilfield leak repair since 1995. However the vast majority of applications were associated with producing wells. Testing and job histories specifically for deepwater drilling operations were minimal. Transocean's Process Improvement Team approached Seal-Tite to learn whether riser leaks were a potentially valid application, and if so to develop a test protocol to qualify the sealant for eventual use.

Testing Program

The objective of the test program was to set up a riser choke/kill line connection and subject it to leak damage similar to that observed on prior leaks. Seal-Tite's pressure activated sealant would be used to repair the leak. The damaged connection would then be subjected to pressure tests similar to that required on the actual location to verify the durability of the seal.

Transocean provided to Seal-Tite a typical pin-and-box connection from a 4" I.D. riser choke line. The open ends of the tubes were seal-welded and injection/pressure monitoring ports were added. Due to the significant separation forces that high pressure testing would create, a containment frame was constructed to house the connections and allow safe observation of the testing activities. Below in Figures 1, 2 and 3 are photographs of the box connection, pin connection and the testing frame.

Figure 1: Box Connection

Figure 2: Pin Connection

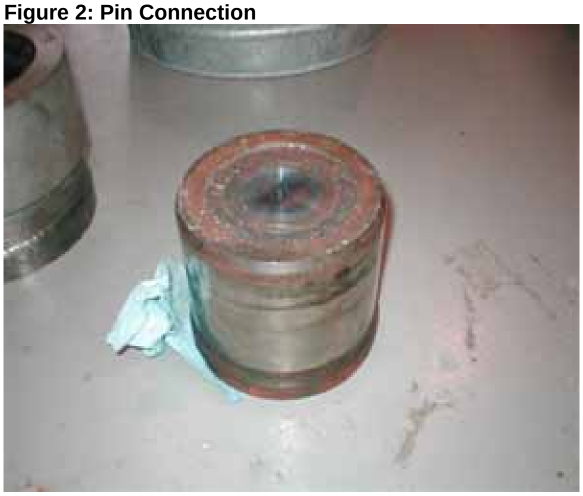

Figure 3: Testing Frame

The seal employed on this connection is a standard "polypack" arrangement consisting of two 95 Durometer Viton seals each with 6" I.D. x 6 ½" O.D. spaced approximately 1" apart. The seals were removed from the housing and damaged with a hacksaw, then reinserted into the housing. The unit was then assembled and water injected into the housing to evaluate the leak severity at various injection pressures. Pressure-activated sealant was then injected into the housing and squeezed into the leaking seals. The repaired seals were then tested to 5000 psi for 6 hours. Once a successful test had been recorded at the initial leak rate, the seals were removed and cleaned. The seals surfaces were damaged further to increase the leak rate and reinstalled. The sealant injection and testing process was then repeated for the increased leak rate.

This repair cycle was repeated for leak rates ranging from 0.25 liters per minute to 2.5 liters per minute. In each case, the pressure activated sealant was able to repair the damaged seals and maintain a 5000 psi test for 6 hours.

Riser Repair

Shortly after the sealant test was completed, an opportunity arose for an actual field repair. The Transocean Marianas was drilling for Murphy Oil Corporation in 5795 feet of water. During a routine BOP / riser test sequence, the 4" I.D. choke line failed the required pressure test. Using dye and ROV inspection, the leak was identified as a connection at 4275'. This connection was leaking at a rate of 8.5 gallons per minute at 2000 psi injection pressure. Seal-Tite personnel and sealant were mobilized to the location. The sealant for this application is not DOT regulated and can be transported by helicopter. It is shipped in concentrated form, with each 5 gallon container blended with seawater to create approximately 35 gallons of final product.

The Marianas was equipped with a typical cementing unit including two 10 bbl paddle-type blending tanks. To ensure accurate system volumes a dye pill was displaced to the leak site while volumes were carefully monitored. A 2.5 bbl sealant pill was prepared in one 10 bbl tank while the second tank was utilized to prepare 3 bbls of gel pad. The gel pad was only used to help protect the sealant pill – one barrel was pumped ahead of the sealant and 2 bbls were pumped behind. The sealant was displaced to the leaking connection with seawater by circulating down the choke line and taking returns on the kill line. Once in position the BOP crossover valve was closed and sealant was squeezed into the leaking seals. Over the next 12 hours the sealant injection pressure was steadily increased until an 8000 psi seal was achieved. This pressure was held for 8 hours to allow the sealant to cure, during which no significant pressure bleedoff was observed. The sealant was then flushed from the system and the choke line tested to 7500 psi, allowing normal drilling operations to resume.

During this repair the riser was subjected to severe loop currents as high as 2.6 knots. These currents caused significant oscillation in the riser, and clearly had an impact on the repair as a small amount of sealant could be seen coming from the leak point with each oscillation of the riser. It is logical to assume that this movement also contributes to abnormal wear of the polypack seals.

The well was then taken to TD over the next 30 days. Normally the BOP/Riser equipment would be tested every 14 days. However to provide maximum confidence in the sealant process, the choke line was successfully tested to 7500 psi every three days. Once the well had been suspended, the riser was pulled to the leaking connection and the damaged seals removed for inspection. Below in Figures 4, 5, 6 and 7 are photos of the riser stack and seal subs as they were removed. It can be seen that one of the polypack seals was completely separated. The second polypack seal had significant damage to the seal areas.

Figure 4: Riser Flange

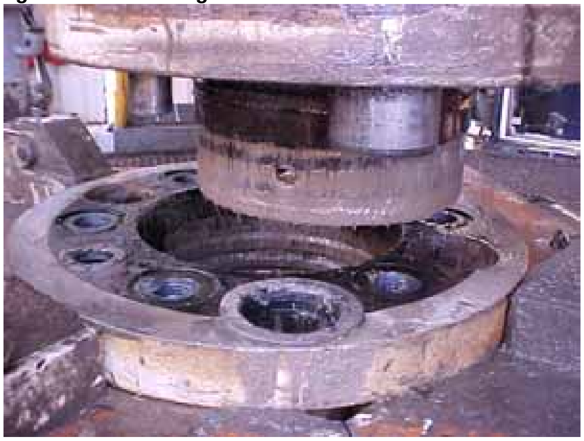

Figure 5: Damaged Choke Line Seals in Riser

Figure 6: Damaged/Split Choke Line Seals

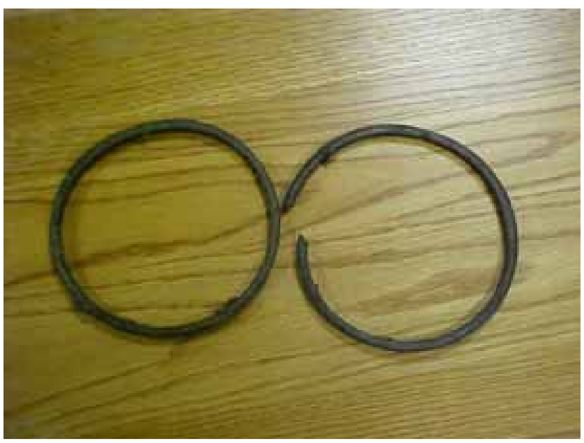

Figure 7: Close-up of Damaged Seals

Additional Testing

Following the repair it was decided to pursue additional testing to confirm the ability of Seal-Tite's sealant to achieve repairs under pressure differentials as high as 15,000 psi. The box/pin connection frame used in the previous testing was upgraded to accept the additional forces generated by the higher pressure. A similar testing protocol was established and followed, whereas the seals were manually damaged and then installed in the test unit. After documentation of leak rates the pressure-activated sealant was injected and squeezed into the leak site. Injection pressures were gradually raised until the desired 15,000 test pressure was achieved. The test pressure was held for 45 minutes with no leakoff observed.

Conclusion

As evidenced by the outlined testing and actual field operations, pressure-activated sealant technology provides a safe and economic method to repair leaks in deepwater riser systems. As drilling operations move into ever deeper waters and more hostile current environments, this technology can be a useful tool to minimize riser-related rig downtime.

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Metric Conversions

psi x 6.894 757	E+00 = kPa
in x 2.54*	E-02 = m
ft x 3.048*	E-01 = m
mi x 1.609344	E+00 = km

Acronyms and Abbreviations

in.	Inches
ft.	Feet
km	Kilometers
mi	Miles
m	Meters
mm	Millimeters
psi	Pounds Per Square Inch
”	Inches