Metal-to-Metal Seals Meet Downhole Hazard Demands

Roland van Dort, SPE, Caledyne

As oil and gas production activities continue to shift toward more hostile and unconventional environments, such as reservoirs with high-pressure/high-temperature (HP/HT) or very acidic characteristics, the use of elastomeric sealing materials in wells and subsea piping face limits to their durability and reliability.

Seal failure can have major safety and environmental consequences, as well as resulting in costly repairs and lost production. The record of failures of critical liner-hanger seals in HP/HT completions, for example, has become a large concern. Operators globally have been adopting the most rigorous quality-assurance procedures for these seals to prevent dangerous and costly incidents. As many as 18% of offshore wells worldwide are estimated to have some form of weakness or uncertainty in their integrity. This includes a sizable number of abandoned wells that may repressurize and leak through damaged or poor cement jobs.

Rubber-based seals are used throughout the production industry. However, they begin to break down in HP/HT reservoirs, in downhole settings high in H_2S or CO_2, or in thermal-recovery applications where temperatures may approach 600°F. In addition, rubber-based seals on retrievable devices can be damaged and compromised by downhole debris, including during retrieval operations.

In response to the shifts occurring in the producing environment, and to other downhole operating risks, metal-to-metal (MTM) sealing technology capable of withstanding extreme temperatures and pressures—and debris impact as well—has been developed by Caledyne. MTM technology provides the safe, cost-effective seals needed in packers, bridge plugs, flange seals, and other components for many of the most challenging projects to proceed **(Fig. 1).**

Metal-To-Metal Seal Systems

These MTM systems employ a flexible metal seal, rather than an elastomer, as their external sealing element to contact the surrounding tubing or pipe and form a tight, durable seal that withstands HP/HT and corrosive-fluid conditions in the well even when they are changing and volatile. To achieve the needed flexibility, the metal sealing element houses silicon-based filler that is stable at temperatures above 644°F—with higher-temperature filler currently being tested. The MTM seals are certified to ISO 14310, the international standard for oil and gas industry downhole equipment, and performance-rated to more than 15,000 psi at 572°F. Available in a wide range of sizes, MTM seals can be installed indefinitely and in most cases will last as long as the pipe.

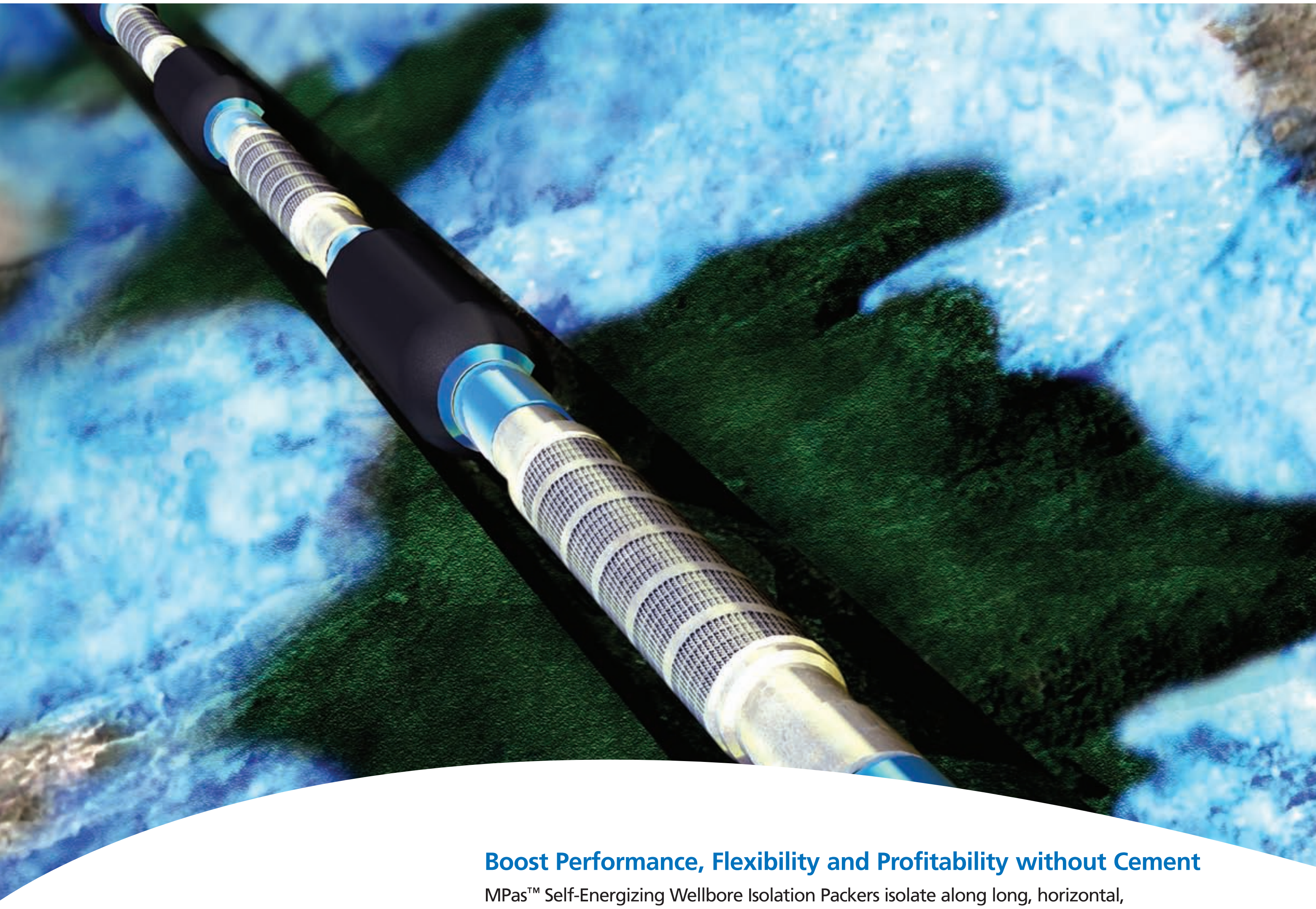
In addition to their technical benefits, MTM seals provide a commercial advantage because each seal is suitable for any downhole condition, regardless of temperature, pressure, corrosive reservoir environment, or the chemicals injected downhole. Thus stock levels of seal equipment can be minimized.

Case Study: Retrievable MTM Bridge Plug Deployment

A Caledyne-manufactured retrievable bridge plug (RBP), incorporating the MTM seal, was deployed successfully for Talisman recently on the Bunga Kekwa project in Malaysia to temporarily plug the BKC-20 gas well **(Fig. 2).**

Fig. 1—The rubber seal element of a bridge plug (left) shows damage, such as chunks of rubber missing, after retrieval. The MTM seal element (right) is completely intact, with no damage, after retrieval.

Isolate This!



Boost Performance, Flexibility and Profitability without Cement

MPas™ Self-Energizing Wellbore Isolation Packers isolate along long, horizontal, open-hole wellbores to manage water and maximize production, reserves, profitability and well life — without cementing or perforating.

More than 2,000 MPas Packers help operators

- isolate gas caps where exact top and base positions are unknown
- isolate lost circulation and water in high-angle wells that would be difficult to plug back with cement
- enhance EQUALIZER™ Reservoir Optimized Completion System performance by sealing between sections of varying permeability"
- improve production an average of 2,000 bbl/d
- improve incremental recovery as much as 60%

Get the benefits of MPas Wellbore Isolation Packers in your open-hole wells.

www.wellboreisolation.com

BAKER HUGHES Baker Oil Tools

THE Completion and Intervention Company

Fig. 2—An RBP with an MTM seal is shown during installation in the BKC-20 well at the Bunga Kekwa field in Malaysia.

Before installation of the RBP equipped with the MTM seal, a conventional bridge plug had been installed as the lower barrier. This plug was pressure-tested successfully and the operation was rigged down overnight. However, the following morning, a tubing-pressure buildup was noted, and because of the tubing's questionable integrity, additional testing was unable to identify the source of the leak.

The RBP was then installed in the well at 7,244 ft, through the use of a Schlumberger casing packer setting tool (CPST)—a standard industry pyrotechnic setting tool. The bridge plug uses a setting adapter, which was made up to the CPST and snapped into the plug. The assembly then was run to depth, and the setting tool activated, which sheared off the bridge plug. The setting tool then was removed from the well. Well deviation at the RBP was 45°, and the plug then was successfully pressure-tested to 350 psi. A straightline pressure test with zero dropoff after 1 hour was recorded, and 0-psi pressure buildup in the tubing after 24 hours subsequently was recorded. A tubing-stop-type debris catcher then was installed above the RBP to keep out cuttings.

Repair activities were carried out, which included removal of the tubing safety valve and the debris catcher before the re-engagement of the overshot and the new upper tubing part. Some problems were encountered during this process, and a second tubing cut was required below the original cut. This process was performed without a debris catcher in the well, resulting in considerable debris landing on top of the RBP. The new completion components then were installed a month after the RBP.

With a substantial amount of debris above the RBP, multiple bailer and venture runs were made to remove the debris. A high-temperature setting tool had been mobilized that could be used in conjunction with the RBP-pulling adapter to remove the plug by means of a slickline. However, the decision instead was made to remove the plug by means of a standard flow-release pulling tool and hydraulic jars, deployed on coiled tubing. But because of the large amount of debris, the pulling tool was unable to latch the fishing neck on the RBP. This resulted in further bailing runs to remove debris from the top of the plug until the pulling tool could land the fishing neck.

At this point, the plug was released but could not be pulled. The RBP could be pushed down the well but could not be moved upward. Several maximum overpulls of 30,000 lbf were applied to the RBP, and various scenarios were analyzed and presented to the customer. The decision was made to proceed with further maximum overpulls working the string, and after some time, the plug moved uphole, slowly at first and increasing in speed as it progressed up the well.

Once removed, the RBP appeared to be in good condition. The MTM seal was fully intact, sitting just above gauge diameter. However, the plug had sustained some damage during retrieval. Several major items of debris were found in the fishing neck, including items from a fishing magnet and a hinge from one of the control-line clamps. It was also clear that large amounts of debris had been around the plug on top of the element during retrieval.

The presence of large metal items of debris on top of the MTM seal wedged the tool and debris into the tubing, thus explaining why the plug would only move downhole initially. After sustained, heavy jarring, the plug was free to move uphole, but this resilience was a reflection of the strength, construction, and design of the MTM seal. The plug by then had been downhole for 2 months, and after retrieval, the metal seal was fully intact. This demonstrated the integrity of the MTM seal and its mechanical strength compared with more traditional rubber sealing elements.

Since this initial deployment, the operator has ordered several additional RBP units with MTM seals for similar reservoir applications.

Conclusion

Providing a complete metal barrier that is reliable, durable, and resistant to the most extreme conditions ensures that completion and intervention operations can be performed as safely as possible. The ability to work in such environments enables the extension of field life, so that additional resources can be found and produced safely and cost-effectively.

In the Bunga Kekwa field, BKC-20 well, application, the benefits of using a metal seal, compared with a rubber one, were very evident. A rubber seal would have been critically damaged during the bridge-plug retrieval process, resulting in the loss of substantial rubber in the well. However, the metal seal was removed from the well fully intact, with the operation resulting in no further debris in the well. This not only saved substantial expense for workhours, equipment, and replacement parts, it also ensured that the well's integrity remained uncompromised. **JPT**