

Sean Hollis and David Brown, CSI-Technologies, USA, show how common well repair problems can be overcome with an engineered sealant.



**T**ime is not kind to wellbore equipment. Equipment like casing, tubing, packers, control lines and wellheads can degrade over time due to operation in harsh environments. Corrosion and unplanned equipment failure can result in leaks, which require repair to protect the environment, maintain well productivity and ensure regulatory compliance.

Every year, hundreds of wells located on the Gulf of Mexico shelf develop leaks. These leaks can be located virtually anywhere in the well and under a variety of conditions. A large number of these are very costly to fix and remediation via conventional means is not usually economically justified. Furthermore, many of these leaks are on wells that have been plugged and abandoned or on depleted wells. The cost of mobilising a rig to fix a leak on this type of well is extremely uneconomical and is avoided as much as possible by operators. However, the issue poses operational problems, environmental hazards and regulatory compliance concerns.

A range of conventional options is available for repair, ranging from cement to mechanical solutions. Leaks in

wells can be in a variety of areas such as packers, wellheads, cement plugs, primary cement, control lines and other areas. Many of these areas provide significant sealing challenges that are either too costly to

repair with cement or mechanical devices or simply cannot be repaired by these methods. This issue creates the need for an easily applied, economical sealing solution that provides significant benefits to the operator. A unique and effective sealing solution has been proven to be effective in repairing a wide range of leaks in wells. This solution is a unique resin sealant that does not require a rig and can be placed in the well quickly and easily.

### **Novel sealant**

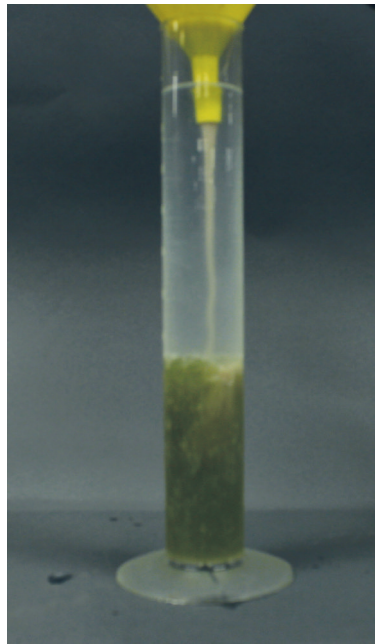
A simple solution to satisfy these sealing needs is the use of unique two-part resin sealant. This sealant has many characteristics that make it an ideal choice for sealing unique and difficult leaks. It provides excellent mechanical properties, unique placement options, and allows variable densities and cure times.

The resin sealant possesses mechanical properties that make it extremely effective at sealing leak paths in a wellbore. Many wells contain high wellbore stresses that can cause other sealing materials to fail. The resin sealant has over twice the compressive strength of a typical cement system<sup>1</sup> and over six times the tensile strength.<sup>1</sup> Flexibility is another key property of the resin. The Young's, or elastic modulus of the resin is extremely high. This allows the resin to deform under changing conditions without failing. It will also return to its original size and shape once the stresses are removed. The resin also has great shear bond qualities. This allows it to adhere and maintain a strong bond with casing, cement, and many other materials. The combination of these excellent mechanical properties allows the resin to maintain its seal even under extreme stress conditions.

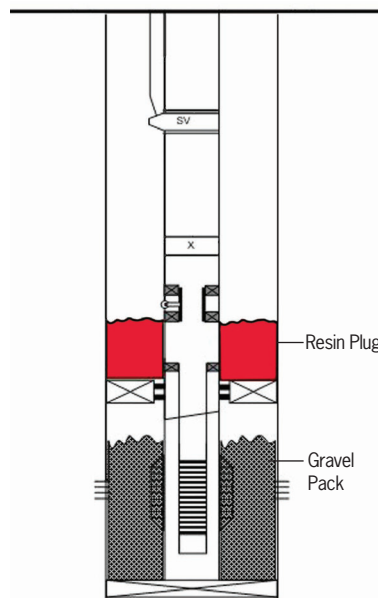
The resin sealant is impervious to water or brines.<sup>1</sup> This quality allows for more and easier placement options. For example, quite often a production packer between the production tubing and the casing will have a small leak. The leak is small enough to prevent sufficient circulation around the leak path but large enough to necessitate sealing. This essentially prevents the placement of typical sealing materials such as cement, but it is not a problem for the resin sealant. Because of the impervious nature of the resin, it can be pumped into annulus from the surface and allowed to fall on top of the packer. The resin sealant does not need to be pumped down to the packer as it will fall in a 'rope' through the annular brine and puddle on top of the resin. This method of placement has been proven to be very simple and effective.

The resin sealant is also impervious to gases. Many times, a sealant is needed to stop and seal bubbling gas. When the resin sealant is placed on top of a gas leak, the gas will bubble up through the resin until the resin develops enough gel strength to prevent any further gas intrusion. The resin is unaffected by the gas and does not allow the formation of channels like in cement. Once the gel strength of the resin sealant overcomes the gas bubbles, the resin continues to cure and form a solid, channel-free seal.

The density of the resin sealant can be adjusted by adding various lightweight or heavyweight additives. This allows the resin to have a density that can range from 7.0 ppg all the way up to 19.0 ppg. The use of weighting agents is useful in the leaking packer mentioned earlier. The resin sealant density must be weighted above the weight of the annular brine in order to ensure it falls to the top of the packer. While these additives add solids, the base resin



**Figure 1.** Example of resin falling and roping through water.



**Figure 2.** Example of resin to seal a leaking packer.

sealant is a solids free fluid. This allows it to be squeezed into extremely small openings and flow paths. And unlike cement, the resin sealant does not suffer from fluid loss or dehydration. This means the resin will cure regardless of the size, geometry and permeability of its flow path.

The cure time of the resin sealant can also be adjusted as needed. A wide range of downhole conditions can affect the handling and placement of any type of sealant. The resin sealant can be formulated to be placed and cured in temperatures from 40 °F to 300 °F. The amount of time before the resin cures can be increased for squeeze applications or decreased for gas control.

All of these characteristics allow the resin sealant to provide a unique and effective sealing method. The resin sealant has been used in many applications such as to seal casing leaks, packer leaks, wellhead leaks, plug and abandon applications and many other applications. The successful placement of the resin sealant has been carried out with dump bailers, bullheading, pouring and by allowing it to fall into place. Future projects may further the wide range of the resin sealant applications and placement techniques.

### Field application

A recent application for the resin sealant provided a very unique situation to seal. The well contained a control line that ran down the annulus of the production casing and production tubing to a subsurface safety valve. The top of the control line connected to a port inside the wellhead. This port connected to a nipple on the outside of the wellhead to allow pressure to be applied to operate the subsurface valve. This is a common setup in wells with subsurface valves. In this well, however, the production tubing and the control line had both parted 200 ft below the wellhead. Though the well was no longer under production, the operator of the well required the remaining control line to be fully plugged in order to provide a barrier against formation pressure.

The well was located in shallow water in the Vermillion area of the Gulf of Mexico. The temperature at the wellhead was 70 °F. To turn the parted control line into a barrier, 200 ft of the ¼ in. ID line would need to be plugged from the surface and the seal would have to be durable enough to withstand at least 3000 psi. Due to the narrow ID of the control line, a solution using resin sealant was developed. The low viscosity and solids-free formulation meant that the sealant could be pumped down this narrow opening without bridging or plugging. In addition, the physical properties of the resin sealant would provide an impervious barrier once setting inside the line. The resin sealant was designed to fill


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200 ft of the ¼ in. ID control line. The required volume of resin sealant to fill the control line was only 1 gal. Due to the small volume of resin sealant as well as limited space and equipment on location, the placement of the resin sealant would be done with a hydraulic hand pump from a workboat.

The resin was designed and tested prior to the job to ensure sufficient placement time. No solids were added to the resin sealant to ensure it would flow easily through the small ID of the control line. Prior to pumping, the resin

sealant was mixed with an air-powered drill in a 5 gal. bucket. Once it was thoroughly mixed, it was then loaded into the hydraulic hand pump and pumped into the control line port on the wellhead. The resin was slowly pushed into the full length of the hanging control line. The slow pumping allowed the resin to build resistance in the control line as it developed gel strength and began to cure. Once the full volume of the sealant was displaced into the control line, the valve on the control line port was shut to keep pressure on the curing resin. A total of 36 hrs were allowed to pass before opening the valve to ensure the resin had fully cured. The control line was confirmed to be fully plugged, satisfying the operator’s requirements, and further repair operations commenced on the well.

### **Conclusion**

The resin sealant provides an effective sealing method for a variety of well repairs. The excellent mechanical properties, wide temperature and density, adjustable set properties, the ability to fall through water and penetrate small voids gives the resin sealant a distinct advantage over other sealing methods. The resin sealant reduces costs by eliminating the need for a rig and other equipment. Field applications have proven the sealing ability of the resin sealant and future well repair projects will provide brand new challenges for sealing. 

### **References**

1. Sabins, Fred, and Larry Watters. “Cement Alternative Has Unique Properties.” E&P Magazine 4 June 2007: n. pag. *Exploration & Production*. 4 June 2007. Web. 01 May 2013.