RiLOCK™ Resin Sealant
Cement Alternative has Unique Properties

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While not ideal, Portland cement has developed into the sealant of choice for well applications. Reasons for its wide acceptance include history, availability and price. Early drillers needed a material that would start as a fluid and set after falling to the bottom of a well. In the late 19th century, Portland cement was the only common material that fit the bill. Low price and wide availability of the base material has been sufficient to drive a significant development effort in the well service industry over the last century to yield Portland cement-based systems that are adequate sealants for a wide range of well applications.

However, Portland cement is not ideal for many applications encountered in a well. First, it is too brittle, and tensile strength is too low to be durable under cyclic stress conditions. Cement seal reliability declines with well operations over time. Second, the solid particles that comprise oilwell cement slurry are too large to penetrate into small places such as formation porosity or a micro-annulus. Portland cement seals created across these areas therefore rely on surface bonding because the reactive sealant material does not permeate small holes. These and other drawbacks often result in repeated remedial applications to correct well problems.

RiLOCK Sealant, outperforms Portland cement in a number of well applications. RiLOCK sealant is a true fluid that reacts to form a hard solid. Mechanical properties of the solid, especially tensile strength, shear bond strength and mechanical durability, are vastly superior to those of Portland cement. Therefore, RiLOCK sealant will create a stronger, longer-lasting seal. Being a true fluid that can enter into formation porosity or a micro-annulus allows the sealant to be squeezed into place and then left to set, creating a deeper, stronger seal.

RiLOCK Sealant advantages

RiLOCK sealant is a two-part system consisting of an epoxy resin and a hardener. The chemistry of this system differs from that of epoxy sealants previously used in oilfield applications, which were sensitive to water contamination and therefore hard to mix and place in well operations. The system is not affected by water or water-based well fluids. It is very cohesive and will fall through water without dilution or detriment to hardening reaction.

Set times of previously used epoxy sealants were difficult to control and were temperature- sensitive, so they could be used only in a very narrow temperature range. The new formulation's set time is easily controlled over a temperature range from 36°F (2.2°C) to 350°F (176.5°C) with slight formulation modifications.

Density of the base fluid is in the range of 9.5 lb/gal. However, the resin can be weighted with normal weighting materials to densities as high as 19.0 lb/gal. Addition of ultra-low-density hollow glass spheres to the fluid results in slurries with density lower than that of water. The resin, hardener, other performance modifying materials and weighting materials are easily mixed and pumped with standard oilfield equipment. They can be conveyed down the well through jointed tubing, coiled tubing or a dump bailer. In one case, the material was simply dumped into a well's annulus at the surface and allowed to fall more than 10,000 ft (3,050 m) through completion fluid to the point of application.

Unlike Portland cement slurry, the epoxy sealant behaves as a

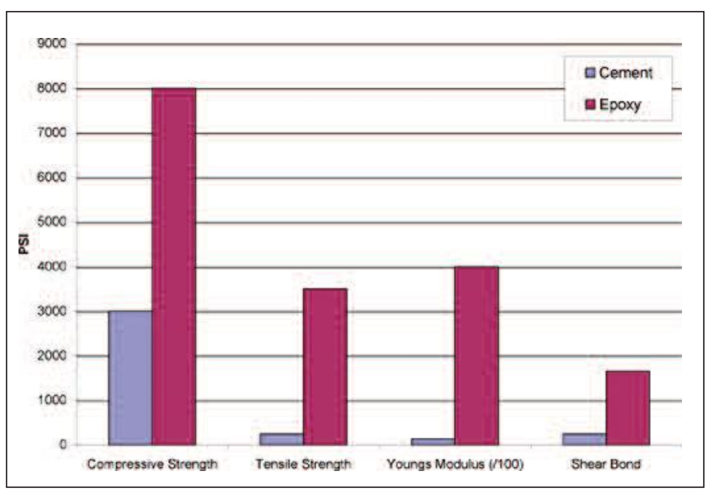

Figure 1. Mechanical properties of resin compared to those of Portland cement.

true fluid during its set reaction. This feature allows the epoxy to set in a well with gas flow potential without undergoing gas cutting to form permanent flow channels. The set sealant is impermeable to gas and non-shrinking.

Performance properties

RiLOCK sealant exhibits extremely high tensile strength, shear bond strength and compressive strength compared to Portland cement (Figure 1). Tensile strength increase is especially critical in well applications since many stresses imposed on a well sealant are tensile. Shear bond strength to pipe is equally significant since it allows for shorter plugs to be set inside tubing to with-stand differential pressure.

The resin's consistency allows permeation into sand packs with just gravity flow as illustrated by an experiment shown in Figure 2, in which resin-displaced seawater inside a gravel pack screen flowed out the screen and into a sand pack consolidated and sealed the pack. This fluid placement property has proven useful in shutting off water from the bottom portion of a gravel pack or bottom perforations. The resin can be squeezed into formation permeability and will harden to consolidate and seal.

Once the resin hardens, the solid material can be drilled or milled easily with standard oilfield tools. The solid seal withstands the force of a perforation charge, creating a perforation tunnel (Figure 3).

The sealant has been used on more than 50 different wells for remedial or abandonment purposes. Many operators have chosen the resin only after attempting unsuccessfully to seal the area with Portland cement. Three case histories illustrate the versatility of the resin sealant.

P&A offshore well with gas communication to surface

Multiple attempts to seal the 9 7/8-in. casing and 9 7/8-in. by 13 5/8-in. annulus failed, and gas was percolating to the mud line. The operator milled a window in the casing at approximately 1,500 ft (457.5 m), exposing both leak paths at that depth. After setting a cast-iron bridge plug in the casing below the window and topping off with sand, 13 bbl of resin weighted to 16.5 lb/gal and designed to set in 4 hours at 85°F (29.4°C) were pumped into the well to fill the window. The was then shut in with 800 psi surface pressure a held for 24 hours. On releasing the pressure and monitoring the well, no bubbling was noted.

Seal leaking production packer

A small volume of resin was used to seal a leaking production packer at approximately 11,000 ft (684.72 m). The packer leaked when pressure was applied to the annulus. Four bbl of RiLOCK sealant weighted to 14 lb/gal was pumped into the 3 1/2-in. by 7-in. annulus at the surface and allowed to fall through the comple-tion fluid to the bottom of the annulus. RiLOCK sealant was designed with a fluid time of more than 10 hours at a tempera-ture of 210°F (98.8°C) to allow the resin to settle to the packer before setting. The well was shut in for 14 hours and successfully pressure-tested.

Seal lower perforations to reduce water production

A well was producing increasing amounts of water. Logs and production history indicated the water was coming from the lower portion of the producing zone at a depth of around 8,700 ft (2,653.5 m). When the rate reached 500 bw/d, the well was treated with 4 gallons of resin at a density of 9.5 lb/gal and a set time of 5 hours at 175°F (79.4°C). After dumping the resin, the well was shut in for 24 hours and production re-started. Water production dropped from 500 bw/d to 270 bw/d with no decrease in hydrocarbon production.

Summary

The system has proven versatile in oilfield sealant applications. The system is easily mixed and placed and will flow into and seal areas inaccessible by cement slurry such as sand packs and formation porosity. The resin's superior mechanical properties allow use of smaller volumes to achieve seal strength compared to Portland cement

Figure 2. Consolidation of 20 to 40 sand pack outside a gravel pack screen by resin gravity fed through water inside the screen.

Figure 3. Perforation shot through a 4-in. gravel pack screen, gravel pack, 5 1/2-in. casing and into simulated formation (resin-consolidated sand) in a full-scale experimental fixture.

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