Product Brochure
Oilfield Solutions

RiLOCK™ Resin Sealant

Proper design is the key to the ultimate sealant for durable, permanent barriers in the harshest, most difficult-to-access well environments.

RiLOCK resin sealant is the answer to the oil and gas industry's most pressing operational need: ensuring well integrity for the lifetime of the well. Well integrity optimizes well performance and reduces remedial cost. Well integrity also reduces the risk of chronic issues such as sustained casing pressure or catastrophic failures, including blowouts. RiLOCK resin sealant consists of durable sealant materials engineered to produce fluids that can be mixed and placed easily and harden to produce durable flow barriers that endure mechanical, chemical, and thermal stresses imposed by a lifetime of well operation.

Outstanding performance attributes of RiLOCK resin sealant include:

- Excellent tensile strength, bond strength, and resiliency compared to Portland cement.
- Durable barrier in large-hole geometry as well as when permeating small flow channels or formation.
- Use in oil and water filled formations for fluid shutoff; chemically resistant to the entire range of aqueous and organic well fluids.
- Cohesive structure permits freefall through well fluid to coalesce at leak location without dilution.
- Success in dozens of formation shutoffs; field experience in formation shutoff is excellent.
- Uniform formation penetration without channels or fingering.
- Testing to ensure complete uniform displacement in a formation.
- Viscosities can be engineerred to less than 100 cp to ensure manageable friction pressure and permeation of formations.
- Viscosities can be pumped through coiled tubing.
- Chemical and mechanical properties optimized to control shrinkage during set.
- Control exotherm upon setting in large masses.
- Positive bonding to casing/formation.

This novel sealant is based on epoxy resin with hardeners, diluents, bonding enhancers, and solid particulates formulated to function across a wide range of well conditions and geometries. The chemistry of RiLOCK resin sealant hardening and bonding functions identically to that of commercial epoxy glue. However, Riteks design engineers have tailored the reaction kinetics and thermodynamics of this chemistry to achieve seal durability far beyond that demonstrated by other resins applied in the oil field today.

In fact, resins in general are under intense investigation as well sealants. Resins have far superior strength, durability, and chemical resistance properties compared to those of Portland cement. Several resin types are offered for commercial oilfield application, with most prevalent being epoxy. General industry consensus, expressed at a recent North Sea Sealant Technology Forum, is that resins shrink and are subject to chemical and thermal degradation. These fears are justified for the majority of commercially-available resins offered as well sealants. They lack the chemical stability or formulation design and control to produce a viable seal. These shortcomings are not a universal condemnation of resin as a well sealant. Rather, these shortcomings indicate that resin chemistry is not being correctly addressed or controlled.

Riteks, Inc. has invested years of research and development to understand the fundamentals of RiLOCK resin sealant performance. The result is a formula and design protocol (patented, patent pending, and proprietary) that yields a sealant that is pumpable even through coiled tubing, can be placed into large volumes or into formation permeability, is cohesive and unaffected by well fluid dilution, reacts producing a controlled exotherm to produce a monolithic barrier that adheres to adjacent solids producing a strong seal with extraordinary mechanical properties, chemical resistance, and thermal resistance.

This fundamental understanding guided Riteks to recognize causes of general industry concerns and resin application failures. Resin shrinkage is not just reduced dimension caused by chemical reaction. A major cause of resin volume change is thermal expansion and the driver for shrinkage is exotherm timing compared to early adhesion and bond strength. These factors can be controlled, and Riteks developed methods to epoxy formulation that produce controlled reaction. The drivers to RiLOCK resin success include stoichiometry of the reactive components, timing of reaction kinetics, and control of reaction exotherm. Timing is the key.

This concept is illustrated in figures 1 and 2. Epoxy crosslinking reaction is highly exothermic. Temperature increases of 200 to over 300F are not uncommon when large volumes of epoxy are reacted (such as a plug in 9 5/8-inch or larger casing or in a 13 3/8-inch x 18-inch annulus). Normal exotherm, as illustrated in Figure 1, drive the temperature of the resin high while it is still fluid. Resin has a significantly higher coefficient of thermal expansion than steel or rock. Therefore, the heated resin fluid expands more than the solids in which it is contained. The hot resin sets and bonds to casing and/or hole while the system is heated due to the exotherm. As the system begins to cool, the resin shrinks at a faster rate than its surroundings. This differential contraction rate induces tensile stress at the resin bond interfaces. If adhesion of the setting resin is less than the stress, the bond breaks and the barrier seal is lost.

Fig. 1: Conventional Resin

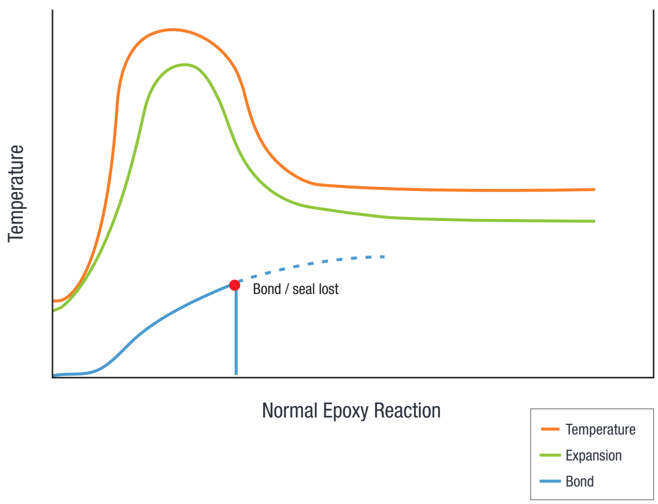
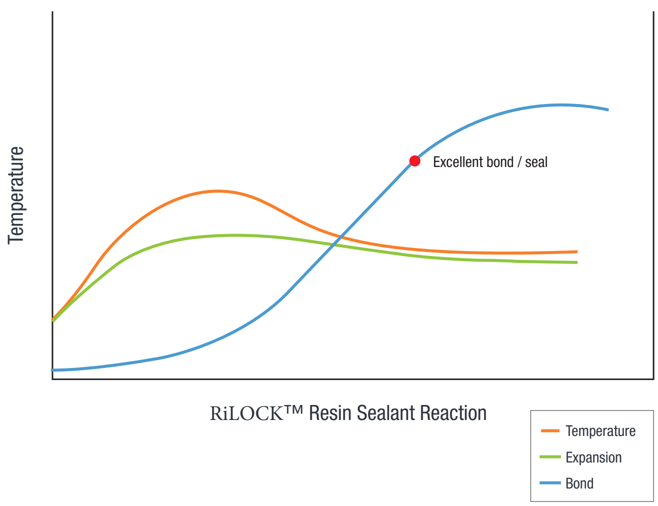


Figure 2 illustrates the RiLOCK setting process. The materials and design method control reaction kinetics to lower and extend exotherm while slowing the initial adhesive bond formations. Thus resin bonds are formed at a lower system temperature, producing less stress due to thermal shrinkage. The bond develops sufficiently while cooling to withstand these internal stresses resulting in a chemical seal. Thermal and mechanical properties are tailored to match temperature fluctuations with bond and mechanical properties of the sealant to yield a durable barrier. The engineering and design protocol developed by Riteks is not a simple, one-size-fits-all, single-attribute method. Five different chemical, dimensional, mechanical, and thermal design criteria are employed to design a RiLOCK formulation. All five criteria must be satisfied to ensure barrier success. This complex systems-design approach captured the fundamental drivers that are currently unrecognized or poorly understood within the industry.

Fig. 2: RiLOCK Resin



An example of the superior mechanical properties and bonding (both shear and hydraulic bond) of a typical RiLOCK compared to neat and optimized cement are shown in Table 1. Both RiLOCK and the cement systems were designed and tested at 175°F.

Table 1: RiLOCK vs Cement mechanical properties and bonding

Testing at 175°F	Standard Slurry	RiLOCK
UCS	6,167 psi	12,772 psi
YM	2.7E+06 psi	4.7E+05 psi
PR	0.30	0.46
Tensile	455 psi	4,364 psi
Water Wet Shear Bond	212 psi	3,922 psi
Oil Wet Shear Bond	132 psi	3,594 psi
Water Wet Hydraulic Bond	<50 psi	+1,000 psi
Oil Wet Hydraulic Bond	<50 psi	+1,000 psi

Fig.3: 16.4 ppg Class H Cement (top) & RiLOCK Resin (bottom) after 60 days of exposure in 14 ppg $CaBr_2$ @ 175°F.

Additionally, RiLOCK resin sealant demonstrates superior bonding in large casings even when tested at elevated temperatures. A mechanical shear bond of 1,200+ psi (maximum load that could be applied) was achieved by a RiLOCK resin system tested in a 1-ft long section of 9 5/8-inch casing cured and tested at 155°F.

The chemical stability of resins compared to Portland cement has long been recognized. In fact, recent studies comparing RiLOCK to Portland cement performance in completion brine emphasized the need for increased durability. Figure 3 shows the effects of $CaBr_2$ brine exposure on the two sealants. Portland cement significantly deteriorated while RiLOCK maintained mechanical integrity.

Recent industry concerns over long-term resin durability are driven by theoretical analysis of glass transition temperature (T_g). All resins exhibit a temperature range above which the polymer chains are more mobile, making the material more elastic. The common example illustrating this is a rubber ball that bounces at room temperature (above T_g). If the ball is cooled to below its T_g in liquid nitrogen, it shatters rather than bounces. Industry material scientists interpret resin performance above T_g as unacceptable with respect to long-term thermal degradation. As with shrinkage, this direct analysis can be misleading.

The same attributes that govern mechanical seal formation also enhance chemical resistivity and thermal stability. Stoichiometric ratios of resin and hardener minimize shift in mechanical properties above T_g. The addition of an engineered composite of solid particulates to which RiLOCK resin bonds further reinforces the three-dimensional resin structure to increase durability. Use of special reactive diluents and proper hardeners also maximizes resin structural stability and durability. These formulation enhancements ensure thermal and chemical stability of RiLOCK over a well's producing lifetime and beyond.

In summary, RiLOCK engineering and design ensures a durable barrier for the life of the well.

RITEKS

Headquarters:
11917 Cutten Road Houston, TX 77066
Ph: [281] 569-3500 • Fax: [281] 569-3508
www.riteks.com

Dallas Plant :
415 Interchange Street McKinney, TX 75071