ControlSEAL™

High Performance Epoxy Resin to Restore Well Integrity

During conformance operations, an operator in west Texas conducted a pressure test and encountered excessive leak-off into perforations recently squeezed with cement. The conformance cement squeeze was performed on perforation located in a reef zone that historically depletes at an accelerated rate compared to the rest of the producing zone. After drillout of the cement squeeze, the 1800 psi pressure test resulted in a 200 psi pressure loss over 25 min with no measurable injection which was found to be unacceptable. The operator was motivated to re-squeeze the fast zone using ControlSEAL since the particle-free, low viscosity fluid can penetrate the micron-size tight channels that are the source of pressure loss. Having the ability to squeeze a small amount of ControlSEAL in zero injection, leakoff situations would offer operational cost savings by reducing the rig-time associated with acidizing or perforating to improve injection rates to levels compatible with cement. Improving injection rates sufficiently to attempt a second squeeze with cement would be a requirement as otherwise squeezing cement would likely result in bridging off of the solid particles and injection of filtrate with no sealing ability. The objective for the ControlSEAL was to penetrate the micron sized flow paths and set/seal the source of pressure leakoff into the reef zone so operations may resume.

Well Information

Using the tubular and application data in Table 7 and Table 8, below, volumes were calculated for the treatment. For this treatment, a CIBP was to be run 20 ft below the perforation intervals lowest perforation and sufficient ControlSEAL volume would be pumped to span 20 ft above the uppermost perforation. A low squeeze volume factor of 0.05 bpf of perforation was used in the calculations due to minimal-to-no well injectivity.

The following volumes were calculated:

Resin to fill 5 ½" from 6,600' – 6,700'
Fill: 100 ft
Fill Volume: 100 ft X 0.0232 bbl/ft = 2.32 bbls
Squeeze Volume: 62 ft X 0.05 bbl/ft = 3.1 bbls
Total Volume: 2.32 bbls + 3.1 bbls
= 5.42 bbls → 5 bbls

Casing Information

String	Casing Size	I.D	WT	Grade
Production Liner	5-1/2"	4.892"	17#	L-80
Tubing	2-7/8"	2.441"	6.5#	J-55

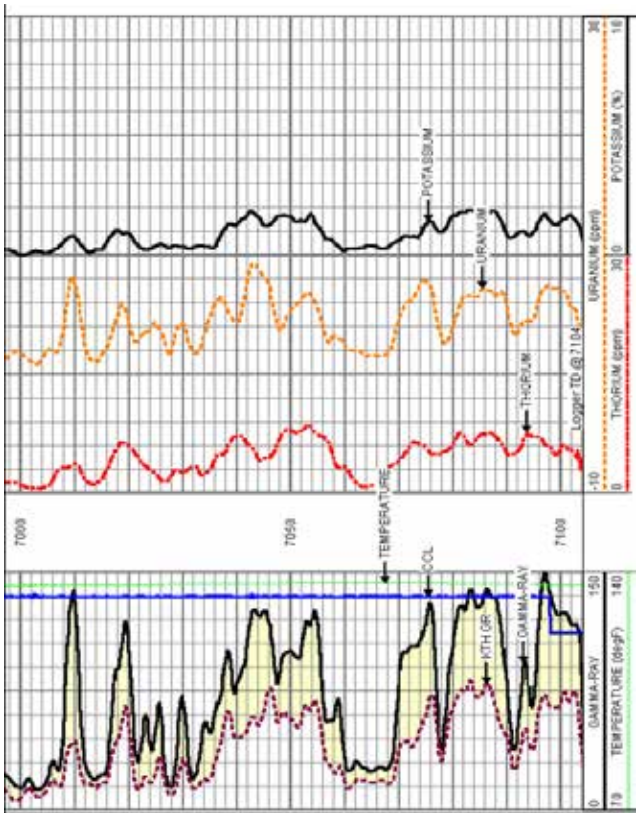
Application Data

Treatment Temperature	131°F
CIBP	6,700 ft
Reef Zone Perforations	6,620-6,682 Ft
Well Fluid	Fresh Water

Treatment temperature was calculated using the average temperature gradient of three wells drilled in the area. A Spectral Gamma Ray/ CCL Log was provided for each of the offset wells and examined for temperature data. A snippet of the Spectral Gamma Ray/ CCL Log for the southern offset well is illustrated in Figure 16Figure 16: Southern Offset Spectral Gamma Ray/ CCL Log. Using ambient as 80 °F, the following gradients and temperatures were determined at 7,000 ft.

Offest Well Temperature Data

Offset Direction	Gradient (°F/100ft)	Temperature at 7000 ft
North	0.669	127
Middle	0.825	137
South	0.788	135
Average	0.761	133



- *Figure 1: Southern Offset Spectral Gamma Ray/ CCL Log*

The available leakoff data of 200 psi in 25 min with no The available leakoff data of 200 psi in 25 min with no measurable fluid injection guided the design the ControlSEAL system. A solids free, low viscosity ControlSEAL system would be used in order to flow deep into the existing microchannels. Taking in to account the wells configuration and placement method for the material a job placement time of ~21.5 min was calculated. The placement time and desired fluid time for block squeezing at downhole temperature were two additional components considered when determining the amounts of hardener and/or catalyst to use. Moreover, the operator required a maximum of 24 hr wait on resin time before drill out.

Resin Sealant Design and Testing

A modified penetrometer test was performed at the application temperature to evaluate the curing process and obtain the fluid and set time properties. The modified penetrometer test involved the monitoring of the sealants level of gelation. After mixing the ControlSEAL system at room temperature, it was placed in a water bath at BHT. Lab personnel measured the level of gelation over time. As a result, a system was designed with an appropriate loading concentration and type of diluent and hardener to achieve a 3 hr fluid time and to be fully hard-set for drill-out after 24 hrs. The viscosity was measured using a viscometer and API rheology testing procedures for cement systems. Taking into account the above prerequisites, a low viscosity solids free system with a sub 50 cP viscosity, 3 hr fluid time, and 24 hr drill out time was developed.

An additional requirement from the operator was a mobilization time less than 12 hrs. Typically, ControlSEAL is blended after call out since each design is fit for purpose and may not be used elsewhere if the job is not executed. In this case, the testing on the aforementioned ControlSEAL design was completed prior to actual knowledge of the specific well detail. Instead, communication with the operator provided a good understanding of common well scenarios/issues and common well configurations. With this information, the above system was included in a prepackaged setup which involved a set volume of the base component and hardener with a separate catalyst packaged in 6 containers and weighting material. The numerous catalyst containers provided the flexibility to modify the designs fluid and set time within known limitations. The optional weighting material would be used if density hierarchy is required or to restrict flow in large channel scenarios.

Description of Operation

Once the call was received to mobilize ControlSEAL to location, the prepackaged ControlSEAL design was loaded out and arrived on location within 12 hr. Personnel arrived on location with the bridge plug set and drill pipe being run in hole to 6513 ft MD. During this time, a review of the placement procedure occurred between the ControlSEAL field specialist and the company representatives that proved to be highly valuable. The job procedure agreed upon between the operator's operation engineer and ControlSEAL engineering team is detailed below:

Bullhead Procedure

- Hold Pre-Job Safety Meeting with all parties involved and review JSA and procedure for mixing and pumping.
- Rig up pumps, blenders, and associated equipment. Pressure test pumps and lines to maximum allowable pressure as discussed in the safety meeting.
- Run workstring in hole to depth 190 feet above top of bridge plug (6513' MD)
- Transfer ControlSEAL into blender.
- Add hardener to blender.
- Add 3 container of catalyst to blender.
- Note: Ensure all equipment, material and personnel are ready to pump ControlSEAL downhole because no delays must occur once hardener has been added.
- Verify total volume to be 5 bbls, blend to ensure homogenous mixture.
- Pump 5 bbls into the 5.5" casing thru the drillpipe.
- Displace ControlSEAL with fresh water to clear lines and drillpipe (37.7 bbls). The ControlSEAL will gravity displace to the top of the CIBP located at 6700 ft MD.
- POOH with drillpipe 500 ft. Start clean up detailed below.
- Bullhead squeeze 2 bbls of ControlSEAL into perforations. Stay below maximum allowable squeeze pressure of 1800 psi. Record all volumes pumped.
- If leak off continues, squeeze up to an additional 1 bbl of ControlSEAL.
    - Apply squeeze pressure in 5.5" casing to 1800 psi. Monitor for 2 hours and if it leaks off 100 psi, re-pressurize. Record all volumes pumped. DO NOT SQUEEZE MORE THAN 3 BBLS
    - Shut well in and allow resin to cure for 24 hours before testing

The company representatives had an alternate procedure planned which involved tripping out of hole for a packer, running back in hole to set packer and then apply squeeze pressure. It was estimate these additional steps would add an estimated 4 hrs to the time before squeeze pressure was applied. With a fluid time of 3 hrs, this delay would have been detrimental to the objective of squeezing ControlSEAL into the micro sized channels since it would have transitioned from a low viscosity fluid to a high viscosity viscoelastic fluid. After the discussion, the company representatives understood why trying to isolate the plug with a packer prior to applying pressure would be detrimental to the objective of the job.
With the drill pipe at 6513 ft and JSA conducted, mixing and placement of ControlSEAL began and proceeded as follows:
- With backside open, pumped 2 bbls of fresh water to fill lines and establish circulation
- Mixed 5 bbls of ControlSEAL using pump truck mixing tub and pumped at 2 bpm
- Displaced ControlSEAL with 31 bbls of fresh water at 2 bpm
- Continued displacing ControlSEAL to end of DP with 6.7 bbls of fresh water at a reduced rate of 0.4 bpm
- Pulled 8 strands of drillpipe and reverse circulate 1-hole volume
- Close annular BOP's and using reverse circulation unit applied 1500 psi down annulus
- Pressured up down drillpipe to 1800 psi and monitored leak off
- Over two hours, pressure bleed off to ~1700 psi 10 times and was bumped up to 1800 psi. Estimated 0.75 to 1 bbl ControlSEAL squeezed away.
- Pressured up to 1800 psi and held for 24 hrs.

Results

Operationally the placement of the ControlSEAL treatment was a success and there were no issues during the mixing and pumping. The measured squeeze volume indicated the low viscosity ControlSEAL was able to penetrate the source of leakoff and the extended fluid time allowed ample fluid time for continued leakoff into the microchannels.
After 24 hrs, the ControlSEAL inside the casing was tagged and 214 ft of ControlSEAL was milled out. After drillout down to the cast iron bridge plug, the 5.5" casing was pressure tested to 1800 psi for 30 min and was successful. Zero pressure leaked off over the 30 min pressure test confirming the ControlSEAL penetrated the source of leakoff, set and sealed. The operator could then proceed with operations.