ControlSEAL

High Performance Epoxy Resin to Remediate Sustained Casing Pressure

Well Information

An operator preparing to fully abandon a previously temporarily abandoned well located in GOM discovered the well had developed sustained casing pressure in the 16" by 11-7/8" and 11-7/8" by 7-5/8" casing by casing annuli's. When temporary abandonment (TA) procedures were completed in 2012 the shelf well met all requirements set by the Bureau of Safety & Environmental Enforcement (BSEE) for TA including passing 1000 psi pressure tests and 30 min bubble tests in each of the annuli. Well diagnostics performed 2016 revealed 350 psi and 250 psi on the 16" by 11-7/8" and 11-7/8" by 7-5/8" annuli's, respectively. In order to proceed with the plugging and abandonment of the well both annuli would need to once again pass a pressure test and bubble test. Then, cutting and removal of casing to at least 15' BML may begin. The sustained casing pressure was believed to be migrating through microchannels and/or micro-fractures in the annular cement plugs set during temporary abandonment.

Due to the surface plug set inside the 7-5/8" casing from 134' to 308' BML, the most economical route for treating each annulus was through their corresponding casing valves. Traditionally, injection with an acceptable rate and pressure would need to be established in order to bullhead cement into each annulus, otherwise costly operations, involving rigging up a BOP, coil tubbing unit, milling assembly on pipe, and TCP guns, would be required to have the ability of circulating into place annular cement plugs.

Pre-job diagnostics determined there was no injection into 16" by 11-7/8" and 11-7/8" by 7-5/8" casing by casing annuli's eliminating cement, the industries sealant of choice, for treating thru the casing valve. A product that could be slowly introduced into the annulus, allowed to gravity displace to the top of the cement plug and then squeezed into the fluid migration paths was required. The operator chose to deploy ControlSEAL Epoxy Resin because its immiscibility in water-based fluids would allow the product to free-fall to treatment depth then coalesce to provide annular isolation. Figure 1, below, illustrates the wells temporary abandoned wellbore schematic.

Figure 1: Field Test 3 Wellbore Schematic

With no ability to inject in either annulus, a method to introduce ControlSEAL into each annulus needed to be developed. One method considered was to create a void space in the annulus by evacuating the well fluid with an end-suction pump. The limited void that could be evacuated via suction lift eliminated this option since it would not allow a sufficient plug volume to be introduced.

Another method considered was to insert a stinger hose sufficiently deep into the annulus being treated and pumping the ControlSEAL from the bottom up with well fluid returns being captured. Further engineering resulted in the manufacturing of stinger, 1502 union, and ball valve setup that maintained well control while introducing ControlSEAL in and displacing well fluid out of the annulus. A CAD drawing of the manufactured setup is shown by Figure 2. On the return side, a 1502 union with attached ball valve is to be connected to a return hose raised 10 ft above the casing inlet to reduce the likelihood of ControlSEAL flowback.

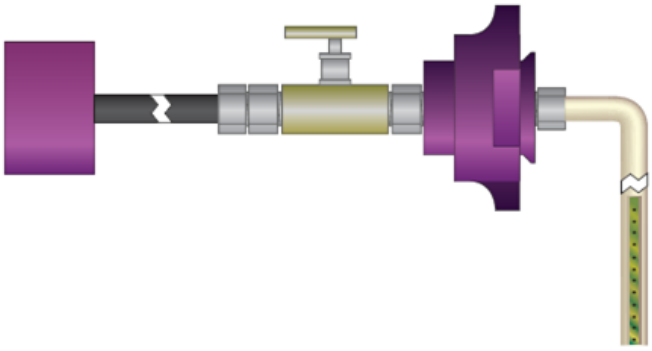

Figure 2: CAD Drawing illustrating pump to ball valve to 1502 union to stinger hose setup

Using the tubular and application data in Table 1 and 2, below, volumes were calculated for each stage. Moreover, taking into account the sustained casing pressure on each annulus and the tortuous application method, a moderate sized resin plug fill length of 100 ft was recommended. The following volumes were calculated for each stage:

ControlSEAL Volume Calculations

Stage 1 - ControlSEAL to Fill 16” X 11-7/8” Casing by Casing Annulus

Fill: 100 ft

Fill Volume: **100 ft X 0.0819 bbl/ft**

= 8.2 bbls → 8 bbls

Stage 2 - ControlSEAL to Fill 11-7/8” X 7-5/8” Casing by Casing Annulus

Fill: 100 ft

Fill Volume: **100 ft X 0.0550 bbl/ft**

= 5.5 bbls → 6 bbls

Casing Information

String	Casing Size	I.D	WT	Grade	MD
Surface Casing	16”	15.01”	84”	N-80	3,930 ft
Intermediate Casing	11-7/8”	10.711”	71.8”	Q-125	12,265 ft
Production Casing	7-5/8”	6.625”	39”	Q-125	15,880 ft

Application Data

Treatment Temperature	90 °F
SCP 11-7/8” X 7-5/8” Annulus	10 psi
SCP 16” X 11-7/8” Annulus	150 psi
TOC 11-7/8” X 7-5/8” Annulus	887 ft
TOC 16” X 11-7/8” Annulus	887 ft
Water Depth	33 ft
Well Fluid	Sea Water

ControlSEAL Design and Testing

Displacing the ControlSEAL into the annulus and allowing it to gravitate down to the top of cement requires the ControlSEAL to have a density greater than the well fluid. Furthermore, the operator was not 100% certain the well fluid was seawater do to the lack of documentation. Seawater was agreed on by all parties as the likely well fluid due to numerous cement plugs circulated into the annulus. A treatment specific to this well was developed using a 13.5 ppg ControlSEAL design weighted with a micro-fine weighting material. A conservative density differential was chosen to maintain density hierarchy between the ControlSEAL and the undocumented well fluid. A static settling test was performed on the solid laden design to evaluate its ability to remain stable at bottom hole temperature. This test is used as an initial indicator of the solids affinity to precipitate out during gravity displacement. The system exhibited strong adhesive forces between the liquid ControlSEAL and solid particles and had a variance less than 5% from top to bottom.

The selected placement method required ControlSEAL remain a fluid during the freefall period so it may coalesce at the top of cement before beginning to set. At an average fall rate of 25 ft/min, the sealant will need to remain fluid a minimum of 36 min. Due to the similar temperatures seen at surface and downhole, we factored in the time to spot resin in annulus at a 1/5 bpm and 2 hrs of squeeze time for total fluid time of 3:06 hr:min for stage 1 and 3:00 hr:min for stage 2. The same depth of top of cement in both applications allowed for the same ControlSEAL design to be used on each application.

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 >4 hr fluid time. In addition, the final design demonstrated to be hard-set after 72 hrs.

Description of Operation

Upon being called out, transportation of 8 and 6 bbls of ControlSEAL for the stage 1 and 2 applications was coordinated. Once on location, 10 ft of stinger hose was inserted into the 16" X 11-7/8" casing annulus and pumping operation was ready to begin. Mixing and placement of the ControlSEAL for Stage 1 began and proceeded as follows:

- Transferred base component into blender
- Began adding weighting material to blender while circulating and agitating
- Once all weight material added to blender and homogenous, transferred hardener to blender
- Emptied 3 pails of catalyst into blender and mixed homogenous
- Started pumping thru stinger hose at 0.2 bpm and 1900 psi (In 1st gear at idle)
- With 2 bbls of resin pumped, resin is noticed in return fluid and weights 9.6 ppg
- With 6 bbls of resin pumped, return fluid weighs 10.7 ppg
- Wait on resin to gravitate to TOC
- Applied 3000 psi squeeze pressure
- Cleaned-up equipment with ControlSEAL cleaner

Communication between the field and home office and a review of the post job report for the stage 1 application highlighted several issues encountered during the operations. First, the continuous resin returns observed after pumping 2 bbls of resin into the annulus stressed the stinger hose setup was not functioning as desired. The pumping pressure of 1900 psi was considered high for the 0.2 bpm pumping rate and pointed to the high flow restriction in a single open end hose.

After 48 hrs the 16" X 11-7/8" casing annulus was successfully pressure tested to 3000 psi for 15 min. In addition, the well was monitored for gas bubbles and no bubbles were observed indicating a successful seal was created in the annulus. The location surface sample was reportedly set tacky hard after 24 hrs.

After a successful pressure test on the 16" x 11–7/8" casing annulus stage 2 began with some modification to the surface equipment and procedure. To reduce the jetting effect of the stinger hose, 10 ft of polypropylene hose was perforated horizontally once per foot. The diameter of the perforation holes were 0.25". The end of the hose was anchored in order for a longer section of hose to be inserted in annulus. See Figure 3 the perforated polypropylene hose being tested prior to use.

Figure 3: Polypropylene hose showing horizontal streams of fluids from perforations

With these adjustments, mixing and placement of the ControlSEAL for Stage 2 began and proceeded as follows:

- Transferred base component into blender
- Began adding weighting material to blender while circulating and agitating
- Once all weight material added to blender and homogenous, transferred hardener to blender
- Emptied 3 pails of catalyst into blender and mixed until homogenous
- Started pumping resin thru stinger hose at 0.1 bpm and 20 psi
- With 2 bbls of resin pumped, return fluid weighs 8.7 ppg
- With 4 bbls of resin pumped, return fluid weighs 8.7 ppg
- Wait on resin to gravitate to TOC
- Applied 3000 psi squeeze pressure
- Cleaned-up equipment with resin cleaner

Results

Operationally the placement of the ControlSEAL for Stage 2 was a success. A significant reduction in pumping pressure was observed with the introduction of the perforated stinger hose. The returns showed negligible signs of fluids intermixing with a reported 8.7 ppg density throughout the pumping operations.

After 48 hrs the 11-7/8" by 7-5/8" casing annulus was successfully pressure tested to 3000 psi for 15 min. In addition, the well was monitored for gas bubbles and no bubbles were observed indicating a successful seal was created in the annulus. The location surface sample was reportedly set hard after 24 hrs. With the well now in compliance, the operator was able to proceed forward with cutting and recovering the casing 15' BML.