



FreezeLITE

Low density freezable fluid that can displace hydrocarbon-based fluids and stay suspended in the freeze zone



WELL CONTROL

LOCATION

MENA Regional Client



Industry-changing technology is developed through years of innovation - continually expanding the boundaries of what is possible in the oilfield. In order to tackle the ever-evolving challenges in today's oilfield, Wild Well has worked to pioneer methodologies that improve wellsite performance. A new low density freezable fluid, FreezeLITE, has recently been developed for use as a barrier in oilfield well freezing applications; a procedure that is commonly required so that work or replacements can be undertaken on a wellhead.

When liquid hydrocarbons are present, Wild Well's newly developed FreezeLITE, a special water-based fluid, can be injected into the freeze zone. FreezeLITE will displace hydrocarbon-based fluids and stay suspended in the freeze zone above the hydrocarbon-based fluid. This allows a freeze to be put into effect without having to remove the hydrocarbon based fluids in the well – saving thousands of dollars in terms of product and time. FreezeLITE is non-hazardous and safe for onshore and offshore applications.

IDENTIFYING THE PROBLEM

The process of freezing a well, which can be required for a number of reasons including corrosion, excessive age of well, enhancement of technology, etc., involves accessing the casing or tubing at the point at which the flow barrier is desired, including removing any earth around the wellbore to expose the outermost casing below the wellhead.

An aluminum heat exchanger is then placed around the outermost casing of the well and liquid nitrogen is pumped into the heat exchanger. The liquid nitrogen, which has a temperature below -321°F , comes in contact with the outer wall of the outermost casing string and, through heat transfer, cools and eventually freezes the liquids in the wellbore. This creates a solid ice plug that prevents fluids and gas from flowing so that work or replacement of the wellhead can be performed safely.

Although freezing is a common procedure, a typical challenge arises when the wellbore contains a hydrocarbon-based fluid with a freezing point lower than that of fresh water. Such a fluid base can even make it impossible to create a suitable flow barrier to allow remedial work. Even if the hydrocarbon-based fluid can be frozen, the resulting ice plug is usually weak and incapable of providing adequate resistance to flow of fluid from below the plug.

To successfully freeze a well, a static column of freezable fluid is needed. This requires replacing or displacing the hydrocarbon-based fluid with a water-based fluid, which can be very difficult, costly and impossible in some instances.

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In addition to poor freezing qualities, hydrocarbon-based fluids are low density (around 7 lb/gal) making displacement with a freezable water-based fluid to create a stable, balanced column, impossible. Attempts have been made to displace the hydrocarbon-based fluids with water (8.3 lb/gal) and try to rapidly freeze the column of water in place. While this has had some very limited success, rapid fluid swapping usually transpires and either freezing does not occur or a very poor ice plug is made. Because of these issues, very few wells are considered candidates for well freezing, even though potential cost and time-savings associated with well freezing to produce flow barriers is significant.

THE LOW DENSITY GLASS BUBBLE

In response to this challenge, Wild Well's engineers and CSI Technologies teamed up to design a low-density, water-based fluid capable of displacing hydrocarbon-based fluids—one that is easily frozen using the previously discussed liquid nitrogen technique.

Comprised of low-density particulates, water, gelling agents and other minor chemicals used to adjust pH, inhibit bacterial growth, surfactants, etc., this innovative fluid has a current density range of 5.8 to 8.0 lb/gal, allowing it to float above the hydrocarbon or other low-density fluid currently in a well and be frozen. After the work has been performed, the fluid will be thawed and flowed from the well.

This fluid consists of low-density hollow glass bubbles suspended in gelled water. The actual chemicals and materials used in making this gel are commonly used well cementing and stimulation materials. However, these materials are combined in a unique way. First the appropriate amount of hollow glass bubbles is mixed into water. The gelling agent is then added with continuous agitation to the slurry to form a linear gel. This gelled water alone is not sufficient to suspend the glass bubbles long term, so they will float to the top of the blender at this point without continuous agitation. Sufficient soluble boron exists in the glass bubbles to dissolve into the aqueous phase within minutes after addition. This reactive metal can crosslink the gel to form a highly viscous fluid. Once the boron and gel are present in the water, the pH is adjusted to trigger rapid crosslinking of the polymer gel. The crosslinked gelled fluid is sufficiently viscous to overcome the buoyancy of the hollow glass bubbles resulting in a stable fluid under static conditions.

Fluid mixing begins by combining pre-weighed amounts of hollow glass bubbles and other minor chemicals into a blender filled with a pre-measured volume of water. The gelling polymer is then added, followed immediately by the lowering of pH to approximately 6. This causes the hydration of the polymer and cross-linking by the boron in the glass bubbles to happen simultaneously locking the glass bubbles inside the three-dimensional structure of the gelled formulation.

LAB TESTING

A simulated freeze job was performed in CSI Technologies' state-of-the-art lab to ensure that the invention would freeze and hold pressure. The

fluid that was used for the test had an overall density of 6.2 lb/gal. The test was performed in an 8 ft tall, 2 7/8 in. oilfield tubing with a liquid nitrogen heat exchanger around a 1 ft section approximately 5 ft from the bottom of the tubing. The tubing was filled with diesel fuel (approximately 6.8 lb/gal) to approximately 18 in. below the heat exchanger. The tubing was then loaded with the freeze fluid to approximately 2 ft above the heat exchanger.

The column sat undisturbed for a moment to allow fluid segregation to occur and let the column stabilize. Liquid nitrogen was then pumped into the heat exchanger and freezing was observed. The resulting temperature profile of the test fluid is displayed in Figure 1. The low-density fluid reached -40°F in approximately 50 minutes according to the thermocouple placed directly above the heat exchanger. This is similar to a freeze profile of water, which is to be expected. At this point the fluid was deemed ready to pressure test. Before evaluating barrier integrity, the pressure that had built up from expansion while freezing above the plug was released so that an accurate differential pressure could be measured. Up to 3000 psi pressure was then applied to the bottom portion of the tubing below the plug and held. During this differential pressure test, the pressure in the upper portion of the tubing remained at zero, thus verifying that the freeze plug was a flow barrier holding a 3000 psi differential. The approximate frozen gel plug dimensions for this test were 30 in. in length and 2.44 in. in diameter. Figure 2 illustrates the results of the pressure test performed on the frozen fluid plug described in this testing.

CASE STUDY: OFFSHORE WELL

BACKGROUND:

The wellhead of an offshore well scheduled for plug and abandonment malfunctioned with all valves stuck in the open position. This malfunction meant no vertical access to the well, and no traditional means of well entry using tubing or wireline was possible. With wing valves not operational, no means to connect to the well for injection existed either. This left the operator without any normal means of establishing the necessary mechanical well control barrier in order to repair the wellhead. Additionally, no reliable access point existed for bullheading kill fluid into the tubing. The tubing pressure was approximately 35 psi with seawater in the tubing. Height of the fluid column was not precisely known, and potential for liquid hydrocarbons on top of the seawater could not be ruled out. Gas hydrate formation had been an issue during previous well operations.

SOLUTION:

Engineering analysis indicated that the quickest, safest method of making the well ready for re-entry and abandonment was to set a freeze plug in the tubing below the top valve. With this flow barrier in place, the faulty top valve would be removed and replaced with two new gate valves. In order to reduce potential of liquid hydrocarbons or gas



hydrate formation, a 15 bbl mixture of methanol and seawater was to be pumped into the well followed by ½ bbl freeze fluid formulated at a density of 6.3 lbs/gal. This low density ensured that the freeze fluid would float on the brine/methanol as well as any liquid hydrocarbon that might percolate to the surface. Thus, a stable volume of easily-freezable liquid would remain in the freeze zone.

A wing valve on the wellhead was hot-tapped and a 2 in. connection installed. After successfully pressure testing to 4750 psi, injection was performed with nominal injection pressure of 3500 psi at ¼ bpm. After injecting methanol and seawater, the ½ bbl batch of low density freeze fluid was mixed as described earlier. Injection completed at ¼ bpm, and the well was shut in. A freeze jacket was installed and N2 circulation

started. After two hours circulation, temperature at the wellhead surface had cooled to -30°F. At this point, engineering predictions indicated that the freeze plug had formed an adequate flow barrier. The wellhead and freeze plug seal were successfully pressure tested to 5000 psi. Pressure was bled to 0 psi, and the well was monitored for flow. No flow was detected, indicating the freeze plug barrier was holding.

With the barrier in place, the top wellhead valve was removed, and replaced with two new valves. This new valve assembly then was successfully pressure tested to 5000 psi against the freeze plug barrier. Once the two new valves passed this pressure testing, the plug was thawed and abandonment operations initiated.

CONCLUSION

FreezeLITE, a unique, low-density fluid forms an effective medium for nitrogen freezing operations in challenging wells that may contain hydrocarbon based fluids in the wellbore, which have been resistant to freeze operations using conventional methods. As a result, costly fluid kills can be eliminated and downtime minimized. At times, this method presents the only option to establish a flow barrier if no direct method for vertical entry exists. With a sufficient supply of the N2 or CO2 on hand and the ability to monitor the freeze process accurately in real time, freeze plugs can be installed and maintained indefinitely in a safe and controlled manner.

Wild Well offers three freeze application systems: Flex Wrap, Coil Line and Aluminum Canister Freeze. The application of these systems requires specific pre-job information and planning to identify the best possible method. While this innovative fluid mixture continues to gain notoriety in the field as it allows operators to perform successful freezing operations under a variety of circumstances, its full capabilities and utilizations have yet to be realized.