

Don't Lose your Hydrostatic Head - Intelligent Fluids Approach to Curing Loss Circulation and Minimizing NPT

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This paper was prepared for presentation at the 2022 AADE Fluids Technical Conference and Exhibition held at the Marriott Marquis, Houston, Texas, April 19-20, 2022. This conference is sponsored by the American Association of Drilling Engineers. The information presented in this paper does not reflect any position, claim or endorsement made or implied by the American Association of Drilling Engineers, their officers or members. Questions concerning the content of this paper should be directed to the individual(s) listed as author(s) of this work.

Abstract

Loss circulation is one of the biggest challenges in oil and gas drilling operations, causing high levels of non-productive time and in some cases leading to additional drilling challenges such as stuck pipe, borehole instability, pressure control situations and, in extreme cases, loss of the well. Conventional Loss Circulation Material has traditionally been used to cure partial/severe loss circulation but may have limitations with respect to reservoir damage and failure to cure the losses due to lack of strength.

In some wells, carbonate sequences can suffer anything from partial to complete losses, which can be incurable, and require mud cap drilling to reach casing point. Weak reservoir sands that are depleted and interbedded with shales and can also experience severe loss circulation. In addition, loss of hydrostatic pressure when experiencing losses in the sands can lead to instability of the shale resulting in stuck pipe.

A novel, magnesia based, phase-transformation fluid >90% acid soluble system has been developed which is easy to place downhole across the loss zone. This treatment exhibits thixotropic behaviour under downhole conditions and can be customized to set based on bottom-hole temperature and application time required. It forms high compressive strength plug to combat severe loss circulation

This paper will discuss the development of this magnesia-based system, which after the extensive testing validated the suitability for the particular well conditions and the results of the system deployment on a well where losses were completely cured allowing the section to be drilled to depth without further losses

Introduction

Lost Circulating Material: Different methods have been used to mitigate the lost circulation problem while drilling and during workover operations. The most common method is using solid particles, which are referred to as LCM (lost circulation materials) to reduce and prevent any loss of circulation. The common LCMs include granular, fibrous, blended, water/acid-soluble, hydratable/swellable LCMs, nanoparticles, cement plug, polyurethane grouting, settable plugs, and crosslinked gel.

Intelligent Fluids LCM is a high compressive strength lost

circulation material (LCM) provides a single step solution for combatting lost circulation with more than 90% acid soluble. The compressive strength characteristic of this LCM allows it to effectively seal fractures and highly permeable formations. Its particle size distribution and unique formulation allow it to be squeezed into the thief zone, forming a solid plug that stops severe losses and reduces wellbore stress. Intelligent Fluids LCM can be used in a wide variety of drilling fluid applications including all water-based and invert emulsion systems. Through its unique mode of action, this LCM replaces costly cement squeezes and prevents side tracking of the wellbore. With more than 90% acid solubility,

The Intelligent Fluids LCM is a mixture of several materials prepared to achieve required properties and functions as the LCM. The composition includes water as the base fluid, setting control additive for set time design, viscoelastic surfactant (VES) to build the viscosity, acid soluble weighting additive to achieve the required density, monovalent or divalent salt as ionic strength additive to increase the efficiency of VES, and the dispersant. The formulation forms a solid hard plug like cement when the powders are properly mixed and reacts with water, and the reaction is retarded with the setting control additive.

The density range of Intelligent Fluids LCM is from 12.5 to 16.5 pounds per gallon (ppg) and can be increased to a higher required density.

Features & Benefits

- Thixotropic slurry, viscous under static condition
- Shear thinning fluid
- Plug develops compressive strength (>500 psi).
- Resistant to contamination.
- It can be used either with fresh water or sea water.
- Setting time can be adjusted depending on applications.
- Higher compressive strength with set material.
- It can be used with most of the monovalent and divalent salts.
- Effective in both weighted and low-solids mud and over wide range of pH.
- Environmentally friendly

- Loss circulation treatment that seals most type of fractures and highly permeable formations
- Can be pre-mixed and stored at the rig-site as a lost circulation contingency.
- Temperature stable up to 250°F.
- It can work with both oil-based Mud and water based Mud.

It can be used at higher mud weights (~ 16.5 ppg) using Manganese Tetra Oxide

Experimental Evaluation:

Intelligent Fluids LCM formulation needs to be tested for thickening time for a potential application.

Following test conditions are obtained from operation team based on available offset well data.

Pill density: 12.5 ppg

Temperature: 150°F

Pressure: 3000 psi

Thickening Time: 2 to 2:30 hr:min

Laboratory Mixing Procedure:

- Fill the required amount of fresh water and defoamer and set the mixing speed from 1000-4000 rpm as needed.
- Add retarder and mix for 2-5 minutes and check for solubility (Note: visually observe the solubility and increase the speed and time if required).
- Add surfactant and mix for 2 minutes.
- Add the sealant powder at 4000-6000 rpm to form uniform mixture. Increase the speed if needed.
- Add dispersant if needed.

Following is the sequence of addition of the additives in gram and mixing time for preparing 600 ml of 12.5 ppg Intelligent Fluids LCM for 150°F temperature. Rotation of mixture should be around 4000-6000 RPM, increase the speed if needed.

Table: Mixing time and sequence of additives

Additives	Weight (gm)	Mixing Time
Location Water	433	-
De-foamer	1	10 sec
Retarder	10	2-5 min (ensure solubility)
Cross-Linker	5.5	2 min
Weighting Agent	447.3	1 min (till uniform mix)
Deflocculant	1.2	If needed

Results:

Thickening Time test is performed in HPHT Consistometer at 150°F temperature and 3000 psi pressure. 2: 25 hr:min of Thickening Time is achieved as shown in the chart below.

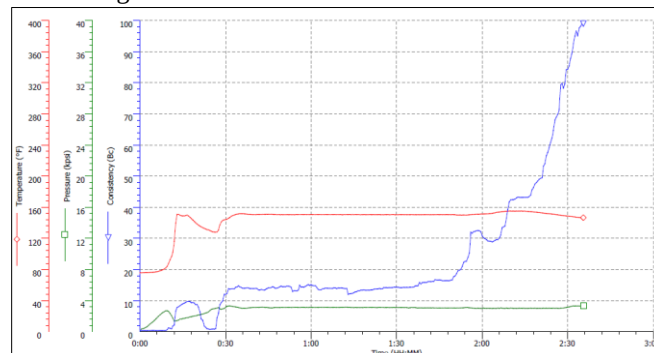


Figure: Thickening Time Chart at 150°F

Field Evaluation

. Table: Intelligent Fluids LCM Formulation

Product	Amount (ppb)
Water	252.6
De-foamer	0.6
Retarder	5.8
Cross-Linker	3.2
Weighting Agent	261
Deflocculant	0.5

Intelligent Fluids LCM Mixing and Pumping:

Pre-Job safety meeting was held with crew to discuss mixing procedures and mentioned importance of wearing proper PPE and mentioned cleaning dedicated pits and flush the lines then mixing was done as below:

Spacer's were mixed in a dedicated reserve tank, total volume prepared is 70 bbl as below formulation:

- Drill Water
- Caustic Soda – 0.25 ppb
- Xanthan Gum – 1.5-2 ppb
- Barite up to 9.8 ppg.

Intelligent Fluids LCM Mixing in Slug Pit:

The recommended formulations for Intelligent Fluids LCM pill considering thickening time of two and half hours:

Product	Amount (ppb)
Water	252.6
De-foamer	0.6
Retarder	5.8
Cross-Linker	3.2
Weighting Agent	261
Deflocculant	0.5

Pumping procedures:

Prior to pumping have all spacers, Intelligent Fluids LCM, and sufficient displacement mud available.

Confirm reciprocation and rotation while pumping the Intelligent Fluids LCM pill Confirmed all pits levels, confirmed all operations staff understand their duties and confirmed Communications, Opened PBL SUB, Pumped the calculated volume (35 bbl) 9.8 ppg viscous spacer ahead using rig pump to minimize contamination. Reciprocate (10 ft) and rotate (45-60 rpm) while pumping (5-6 bpm) to ensure effective displacement. Pumped Intelligent Fluids LCM Pill, 12.5 ppg. Rig Pumped 75 bbl at 5-6 bpm Pumped Viscous WBM spacer, 9.8 ppg Rig Pumped 35 bbl at 5-6 bbl/min behind.

Displaced with 95 bbl 9.8 ppg Active mud with 5-6 bpm rate. It was noticed that while pumping Intelligent Fluids LCM the pressure was steady between 286-294 psi and while displacing with Mud the pressure was recording values ranging from 268-370 psi.

Operations sequences:

After pumping and displacing as mentioned above Pumps were slowly turned off then pulled out 3 stands above the expected top of Intelligent Fluids LCM pill.

Flushed string by circulating one string volume then pulled out of hole to casing shoe.

Loss rate has been monitored and level was completely stable in both cases static and dynamic. Intelligent Fluids LCM has been squeezed with 180 psi while waiting on Intelligent Fluids LCM pill to soak for three hours as per plan.

After soaking time was over, opened the well and resumed tripping in hole while washing down with soft reaming to bottom.

Established circulation in stages up to 850 gpm to simulating drilling flow rate. Losses were monitored and showed no dynamic losses. Drilling was continued with no dynamic losses.

Conclusions

Intelligent Fluids LCM can deliver consistent performance if applied correctly to help in curing partial to sever losses, which will save customer cost and time.

We are delighted to highlight the demonstrated good performance of Intelligent Fluids lcm in the field, the product was able to achieve 100% recovery of the anticipated loss rate.

Nomenclature

Ppg = pounds per gallon
pH = potential of hydrogen
LCM = Loss circulation material
Bbl. = Barrell
Psi = Pounds per square inch
Min = Minute

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