FORMATION DAMAGE EVALUATION OF LIQUID CASING

FOR:

LIQUID CASING, INC.
HOUSTON TX

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STIM-LAB Inc.

Introduction

A sample of Liquid Casing was evaluated to determine the damaging and subsequent cleanup characteristics in polymer muds to Berea and Brady sandstone cores. Liquid Casing was developed as a seepage control and loss circulation additive for sealing depleted formations.

Core Preparation

Stock Berea and Brady sandstones were cut to 1 inch diameter and 2 to 3 inch length core plugs for this test. The Berea sandstone used in this study has a liquid permeability of approximately 100 md and exhibits better flow stability to higher brine concentrations and thus 7% KCl was used as the base fluid. The particular Brady sandstone used in this study exhibits a permeability to potassium chloride solutions of 1 to 2 Darcies. After the core faces were trimmed to parallel, the core was vacuum saturated in 2% KCl and 7% KCl respectively and placed into the core holder.

Liquid Casing Preparation

Deionized water in a Waring blender mixing at medium to high speed was adjusted to a pH of 6 with dilute hydrochloric acid. Liquid Casing and polymer were added to achieve a total concentration of 1.14% (by wt). This is equivalent to 4 lbs/bbl. The pH of the mixture was then adjusted to 8 with dilute sodium hydroxide and mixing was continued for 15 minutes to allow polymer hydration to occur. Potassium chloride (KCl) was added to a concentration of 2% (by wt.) or 7 lb/bbl. The pH was lowered to 6 with dilute hydrochloric acid just prior to loading into the core flow system reservoir.

Core Flow Procedure

The procedures for evaluating the Liquid Casing in polymer muds were as follows:

1. The core was mounted in a Hassler sleeve and placed into a heating jacket. Closure pressure was maintained at 1500 psi throughout the test. Back pressure of 800 psi was held on the system to simulate downhole conditions.

2. Five percent HCl, preheated to 180°F, was flushed through the Berea core only for cleanup.

3. An Initial Permeability to 2% KCl and to Klearoil was determined.

4. 4 lbs/bbl Liquid Casing/polymer in 2% KCl was injected into the core until a ΔP of 500 psi or higher was achieved to ensure penetration.

5. The core was shut-in for a period of 3 hours.

6. Following shut-in, a Klearol regain was determined to measure the amount of damage.

7. A KCl solution was flushed across the face of the core.

8. A Klearol regain permeability was determined.

The sequence of events outlined in the procedures section of this report were performed to evaluate the effectiveness of a KCl solution in cleaning up the filter cake from the face of a permeable formation.

The effectiveness of a particulate fluid loss additive often depends on the ratio of size of the particulate to the pore throat size. If the particle size is too large, small pores may not be effectively bridged. If the size is too small, the particle may enter the pore and while it effectively controls fluid loss, it can permanently block permeability. Therefore, the study was conducted with low permeability (50 md) and high permeability (1 darcy) core samples to examine the permeability range where Liquid Casing is applicable.

Rheological Properties

A portion of the 4 lbs/bbl Liquid Casing/polymer mud in 2% KCl was tested to determine the apparent viscosity, plastic viscosity, yield point, gel strength, and fluid loss characteristics. The results are listed in Table 3.

Discussion

The effectiveness of a brine flush in removing a polymer mud filter cake has not been observed previously in a large number of other polymer and non-polymer fluids examined. This result is unexpected and contrary to our previous experience in that most effective mud filter cakes are usually very resistent to removal by flush fluids.

The regain oil permeability following mud-off alone ranged from 25-40% depending on permeability and type of polymer. The brine flush stage is required to obtain the final regain in oil permeability.

Liquid Casing should effectively control fluid loss in brine weights up to saturated Calcium Chloride over a wide range of permeabilities and types of polymers. The remaining filter cake should be effectively removed from the formation with little or no impairment by first circulating a brine flush followed by oil production.

Conclusions

The flow experiments with the Berea core (Figure 1) showed that the Liquid Casing effectively stopped fluid flow through the core quickly at a differential pressure of 500 psi. The flow experiments with Berea core (Figure 1) showed that the Liquid Casing effectively stopped fluid flow through the core quickly at a differential pressure of 500 psi. The 100% regain oil permeability after a brine flush demonstrated the low damage potential of the Liquid Casing/polymer mixtures in lower permeability cores. The results with 1 Darcy Brady Sandstone (Figure 2) shows that the system is also effective and non-damaging in high permeability cores. Formation damage studies with these polymer systems typically show permeability damage ranging from 5-40% depending on the polymer pretreatment[1]. Furthermore, the re-exposure of the core to the polymer fluid typically results in a much greater damage. Polymer solutions containing Xanthan Gum and/or PAC[2] polymers with Liquid Casing showed little or no damage even on repeated exposure indicating that the filter cake formed effectively and prevented polymer extrusion into the core and formation damage. This again demonstrates the low damage potential of the material in both low and high permeability cores.

We also theoretically determined the overall fluid invasion of Liquid Casing when used as a perforating fluid. Table 4 shows the total simulated fluid invasion for a 100 ft. section of Berea equivalent producing sand (perforating 23 shots per foot of 0.25 inch perforations) to be 2.3 gallons.

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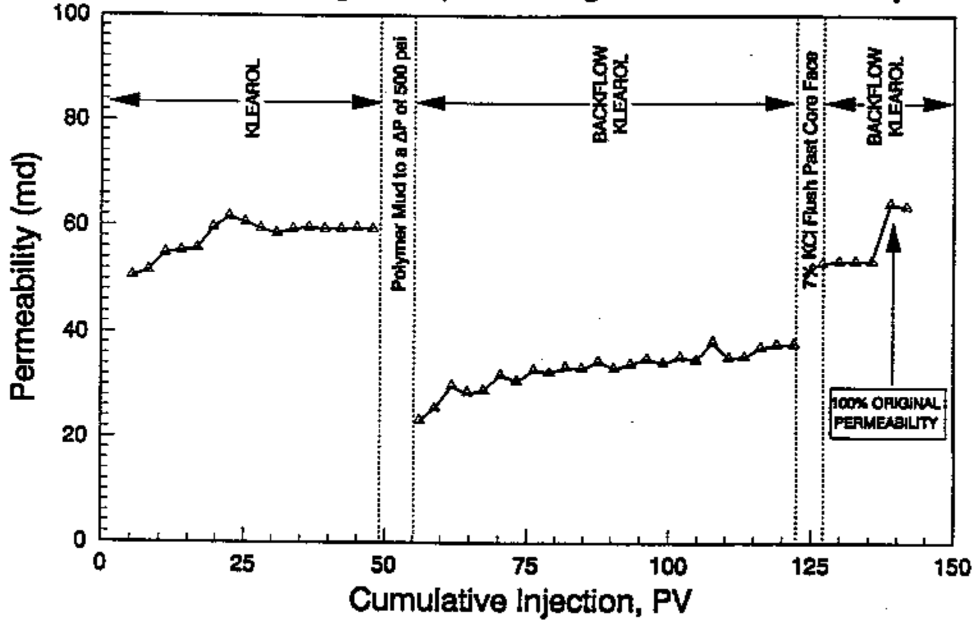
[1]Underdown, D.R., Calvert, A.L., Newhouse, D.P., SPE 19751: Comparison of HEC and XC Polymer Gravel Pack Fluids. Presented at the 64th Annual Technical Conference on the exhibition of the SPE, San Antonio, Oct.1989.

[2]Polyanionic Cellulose (PAC)

Figure 1A

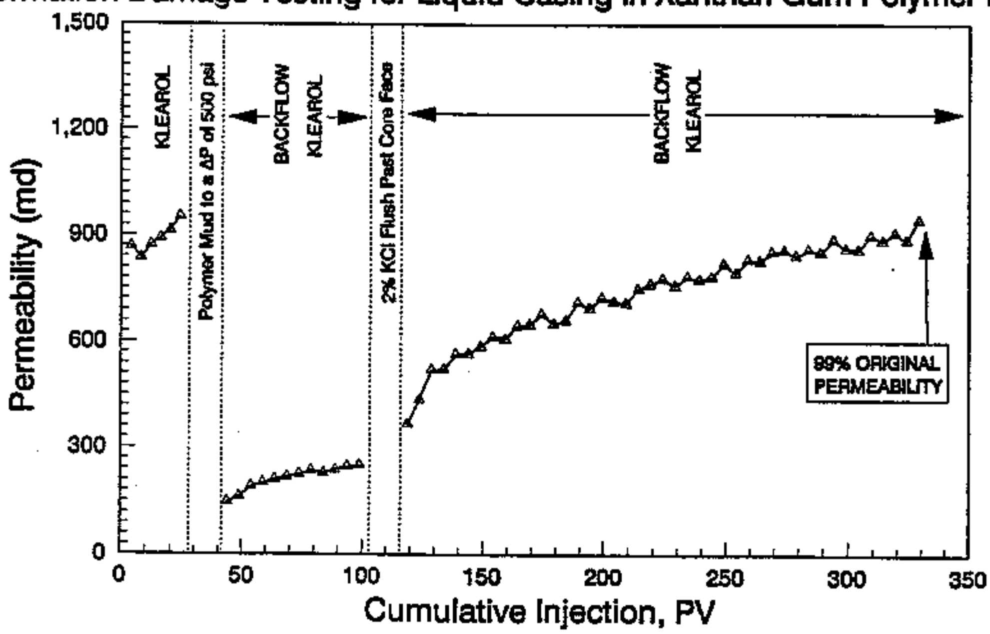
Formation Damage Testing for Liquid Casing in Xanthan Gum Polymer Mud



Effect of Liquid Casing on permeability in 7% KCl brine on a low permeability Berea sandstone core.

Figure 1B

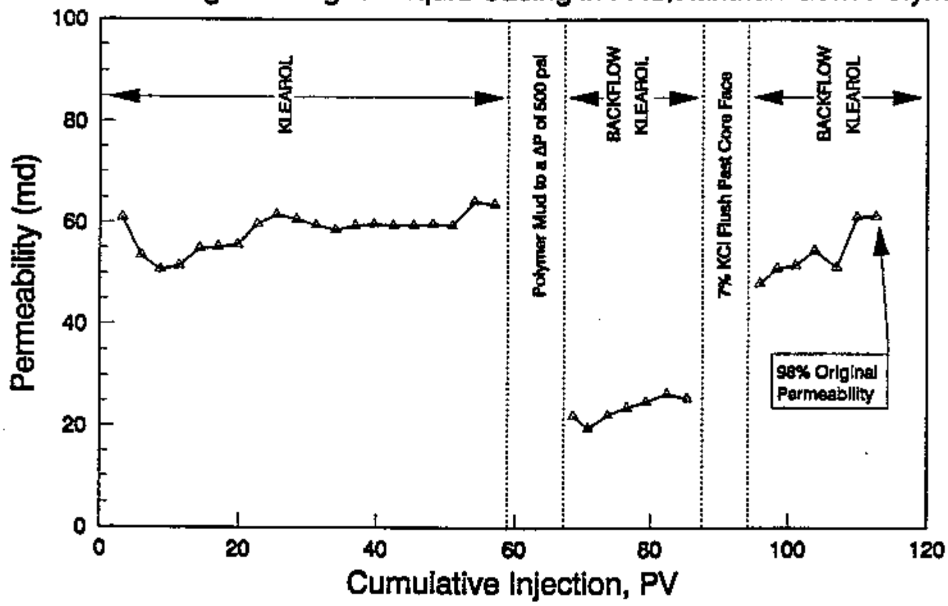
Formation Damage Testing for Liquid Casing in Xanthan Gum Polymer Mud



Effect of Liquid Casing on permeability in a 7% KCl brine on a high permeability Brady sandstone core.

Figure 2A

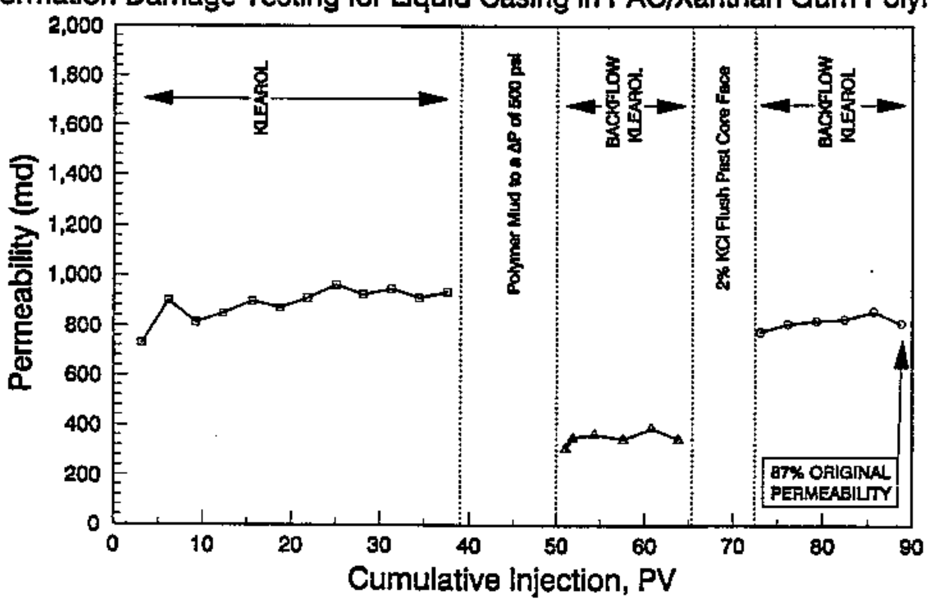
Formation Damage Testing for Liquid Casing in PAC/Xanthan Gum Polymer Mud



Effect of Liquid Casing on permeability in a 7% KCl brine on a low permeability Berea sandstone core.

Figure 2B

Formation Damage Testing for Liquid Casing in PAC/Xanthan Gum Polymer Mud



Effect of Liquid Casing on permeability in a 7% KCl brine on a high permeability Brady sandstone core.

Table 3

RHEOLOGICAL PROPERTIES OF 4 LBS/BBL LIQUID CASING / POLYMER IN 2% KCl BRINE

Parameter	Measured Value by Polymer Type	
	Xanthan Gum	PAC / Xanthan Gum[1]
FANN 600, cps.	44	31
FANN 300, cps.	34	20
Apparent Viscosity, cps.	22	15.5
Plastic Viscosity, cps.	10	11
Yield Point, lbs. / 100 sq. ft.	24	9
Gel Strength, Initial, lbs. / 100 sq. ft.	14	4
Gel Strength, 10 min., lbs. / 100 sq. ft.	20	6
API Fluid Loss, mls.	12.7	16.8

[1] Polyanionic Cellulose (PAC)

Table 4

THEORETICAL FLUID LOSS INVASION INTO A SIMULATED PERFORATION OF A 100 FOOT PRODUCTION FORMATION

Perforating Fluid: 4 lb/bbl Liquid Casing / Xanthan Gum Polymer in 2% KCl Brine

Well Data for Simulation		Core Data for Simulation	
Interval Length (IL)	100 feet	Core Diameter (d)	1.01 inches
Shots per Foot (SPF)	12	Porosity	0.14
Perforation Diameter (d)	0.25 inches	Permeability	60 md
Perforation Length - Tunnel (h) - Cone (h')	 6 inches 2 inches	Pressure Differential	500 psi
Shot Efficiency (SE)	0.8	Pore Volume	4.00 ml
Filtrate Volume (FVAw)	unknown (calculate)	Filtrate Volume (FVAc)	1.80 ml

Equivalent Surface Area Computations

A = Aw ={ [.7 (3.14dh) +.3 (3.14d/2 [(.25d)*2+ (h')*2])] / 144 x SPF IL}SE,

where Aw = total surface area contributing to inlet / outlet flow in the well in square feet

Aw = 27.41952 sq. ft.

A = Ac = {[3.14 (d/2)*2] / 144},

where Ac = total surface area of the core face in square feet

Ac = 0.005451 sq. ft.

FVAw unknown : Aw as FVAc : Ac

Fluid Invasion Determination

FVAw = 9,054 ml = approximately 2.3 gallons Perforating Fluid Invasion