TEST OF FORMATION WATER AND CHEMICAL COMPATIBILITY FOR REMOVAL OF MUDCAKE IN WELLBORE

by
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I. INTRODUCTION

Laboratory and field studies indicate that almost every operation in the field, such as drilling, completion, workover, production and stimulation are potential source of damage to well productivity. Formation damage has long been recognized as a source of serious productivity reduction in many oil and gas reservoirs. The mud cake is a damage that occurs in formation caused by drilling process. Prevention of formation damage has the following advantages : a) To reduce ultimate completion costs; b) To preserve barriers; c) To improve sweep efficiency.

Potassium chloride (KCl) and breaker are chemical materials used in mud clean up system to remove the mud cake formed in drilling process. In relation to this, it is very important to know whether the formation water and KCl solution, then the formation water and breaker, are compatible or not. This paper is written based on our experience in formation damage laboratory tests. Therefore, the main topic of this paper is *"Test of Formation Water and Chemical Compatibility for Removal of Mudcake in Wellbore* ". Hopefully, the laboratory test results presented in this paper are valuable, not only for LEMIGAS as Research and Development Centre For Oil and Gas Technology, but also for oil companies as the user which will apply the chemical material in oil fields (cost efficiency), chemical material supplier (particularly in design of breaker).

II. SCOPE OF WORK

Three types of formation (1950, 2420 and 3140 sands) that have salinity (NaCl) in range 890.36 – 3778.33 mg/l, and KCl 2 % , and breaker solutions (CAT-1 and GBW41LD) are used in the compatibility tests. The function of KCl with 2 % concentration solution is for circulation process and to prevent swelling caused by clay. While, breaker to remove damage caused by mudcake. Compatibility test are carried out at reservoir temperature (200 °F). The scope of work is shown in Table 2.1.

III. PROCEDURE

Water compatibility test is carried out in order to know whether there is compatiblity or not between water formation vs 2% KCl solution, and water formation vs breaker at reservoir temperature condition (200 °F) for 1959, 2420 and 3140 sands. Mixing ratio of formation water vs 2 % KCl and formation water vs breaker solutions are as follows :

- 10 : 90 %,
- 25 : 75 %,
- 50 : 50 %,
- 75 : 25 %
- 90 : 10 %

If formation water and 2% KCl concentration solution are compatible, no new solids are formed on mixing. Incompatible fluids interact to form new solids. The same analysis system is applied for compatibility test of formation water vs breaker solution. Compatibility test laboratory results are plotted as relation between mixing ratio vs the formed scale (gram/ltr).

IV. THE FORMATION MUDCAKE PROCESS

The process of mudcake formation is briefly described in Figure 4.1, then the process of breaker to remove the mudcake can be seen in Figure 4.2.

Circulation of mud is carried out from the left hand side valve to the right hand side valve in order to displace the formation water out. In this position, the left hand side valve is opened, the right hand side valve is also opened, but the bottom of valve is closed. Experimental conditions are as follows: temperature (200 °F), pressure (low, just to displace formation water out). It must be ensured that, all formation water is definitely

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Table 2.1
Scope of compatibility tests formation water vs KCL 2 % and formation water vs breaker at different types of sand and breakers at reservoir temperature (200 °F)

Sample/ No.	Samples	Mixing ratio of samples	Type of sand	Type of breaker
1	Formation Water (FW) and KCl 2 % solution	10 % FW + 90 % KCl 25 % FW + 75 % KCl 50 % FW + 50 % KCl 75 % FW + 25 % KCl 90 % FW + 10 % KCl	1950	-
2	Formation Water (FW) and breaker solution	10 % FW + 90 % breaker 25 % FW + 75 % breaker 50 % FW + 50 % breaker 75 % FW + 25 % breaker 90 % FW + 10 % breaker	1950	GBW41LD
3	Formation Water (FW) and KCl 2 % solution	10 % FW + 90 % KCl 25 % FW + 75 % KCl 50 % FW + 50 % KCl 75 % FW + 25 % KCl 90 % FW + 10 % KCl	2420	-
4	Formation Water (FW) and breaker solution	10 % FW + 90 % breaker 25 % FW + 75 % breaker 50 % FW + 50 % breaker 75 % FW + 25 % breaker 90 % FW + 10 % breaker	2420	GBW41LD
5	Formation Water (FW) and KCl 2 % solution	10 % FW + 90 % KCl 25 % FW + 75 % KCl 50 % FW + 50 % KCl 75 % FW + 25 % KCl 90 % FW + 10 % KCl	3140	-
6	Formation Water (FW) and breaker solution	10 % FW + 90 % breaker 25 % FW + 75 % breaker 50 % FW + 50 % breaker 75 % FW + 25 % breaker 90 % FW + 10 % breaker	3140	CAT-1
7	Plot data mixing ratio vs formed scale for formation water and KCl 2 % solution	10 % FW + 90 % KCl	1950, 2420, and 3140	-
8	Plot data mixing ratio vs formed scale for formation water and breaker	10 % FW + 90 % breaker	1950, 2420, and 3140	GBW41LD CAT-1

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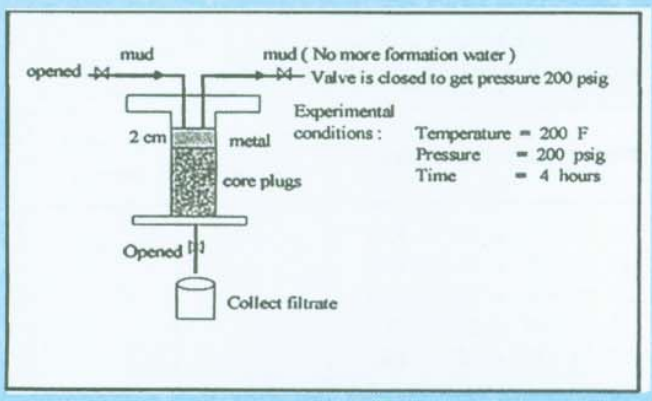

Figure 4.1
Process of the mud cake formed

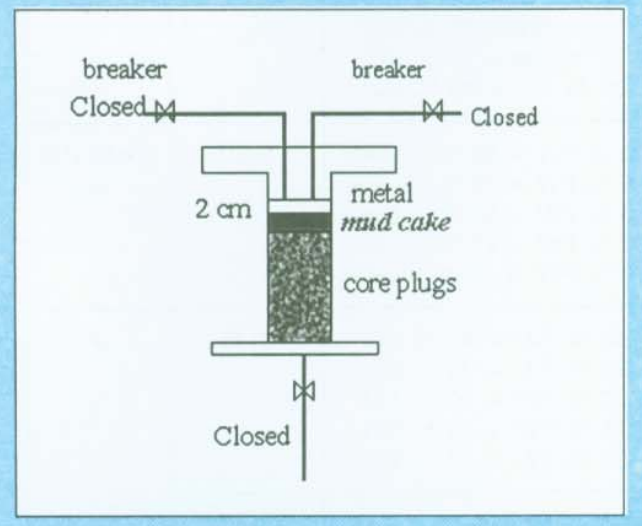

Figure 4.2
Process of breaker to minimize the formed mud cake

out (clean). After no more formation water inside (in the space 2 cm), the pressure 200 psig slowly. At condition of pressure 200 psig, the position of the right hand side valve is closed and the bottom of valve is opened. Time recording by stopwatch is carried out at the initial stage (pressure 200 psig).

Mud that is injected from the top to the bottom, goes to the space (2cm), flows through the core until the filtrate out. It is left for 4 hours, and the filtrate is collected. Finally, the mud cake will be formed (see Figure 4.1).

Experimental conditions are carried out at temperature of 200 °F. Breaker is circulated from the left hand side valve to the right hand side valve in order to displace formation water out. It must be ensured that formation water has been displaced by breaker totally, then the right hand side valve is closed to get pressure 200 psig. The confining pressure is maintained stable at pressure 500 psig. After positions of the left hand side, the right hand side and the bottom valves are closed, it is left overnight or approximately for 12 hours (see Figure 4.2).

V. LABORATORY TEST RESULT

As mentioned in Section 1, KCl and breaker solution are chemical materials used in the compatibility test. This test was carried out to know whether formation water is compatible or not with 2 % KCl concentration and breaker solutions for different types of sand and breaker at reservoir temperature conditions (200 °F). Types of sand that are selected and utilized in this test are 1950, 2420 and 3140. While types of breaker are CAT-1 and GBW41LD.

Generally, the scope of compatibility laboratory test that are carried out in LEMIGAS, is shown in Table 2.1.

The results of water compatibility test are as follows :

1950 Sand

The test results for formation water vs KCl @ 200 °F are tabulated and plotted in Table A5.1 and Figure A5.1. The value of compatibility test is in range 0 – 0.01 gr/ltr. While, the result for formation water vs GBW41LD breaker are indicated in Table A5.2 and Figure A5.2. The amounts of formed scale are in range 0.03 – 0.15 gr/ltr.

2420 Sand

At the same mixing ratio, but different type of sand, the results of compatibility test of FW : KCl @ 200 °F are in range of 0 - 0.1 gr/ltr, and 0.02 - 0.07 gr/ltr for formation water vs GBW41LD breaker. The results of this test can be seen in Table A5.3, Figure A5.3 and Table A5.4, Figure A5.4

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Table A5.1
Water compatibility test (sand 1950) formation water vs KCL @ 200 °F

No.	Sample Formation Water and KCl	Compatibility gr/lt
1	10 % FW + 90 % KCl	0.0000
2	25 % FW + 75 % KCl	0.0000
3	50 % FW + 50 % KCl	0.0100
4	75 % FW + 25 % KCl	0.0100
5	90 % FW + 10 % KCl	0.0100

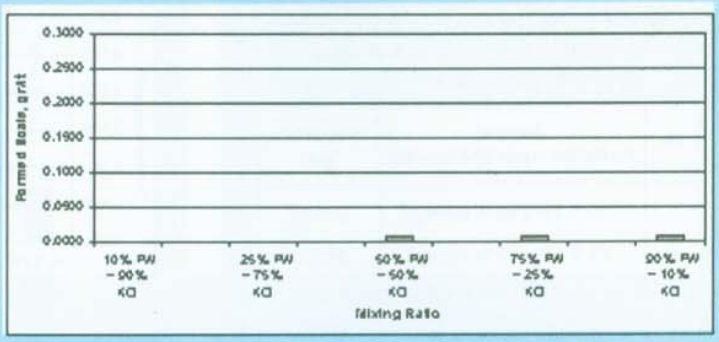

Figure A5.1
Water compatibility test (sand 1950) formation water vs KCl @ 200 °F

Table A5.2 Water compatibility test (sand 1950) formation water vs GBW41LD breaker @ 200 °F

No.	Sample Formation water and breaker	Compatibility gr/lt
1	10 % FW + 90 % Breaker	0.1500
2	25 % FW + 75 % Breaker	0.1000
3	50 % FW + 50 % Breaker	0.0600
4	75 % FW + 25 % Breaker	0.0400
5	90 % FW + 10 % Breaker	0.0300

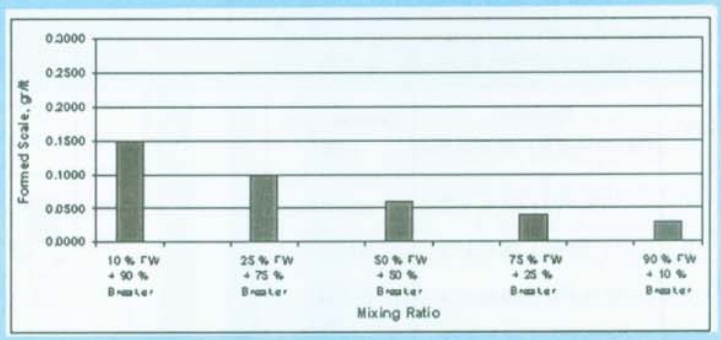

Figure A5.2
Water compatibility test (sand 1950) formation water vs GBW41LD breaker @ 200 °F

Table A5.3
Water compatibility test (sand 2420) formation water vs KCL @ 200 °F

No.	Sample Formation Water and KCl	Compatibility gr/lt
1	10 % FW + 90 % KCl	0.0100
2	25 % FW + 75 % KCl	0.0100
3	50 % FW + 50 % KCl	0.0100
4	75 % FW + 25 % KCl	0.0000
5	90 % FW + 10 % KCl	0.0000

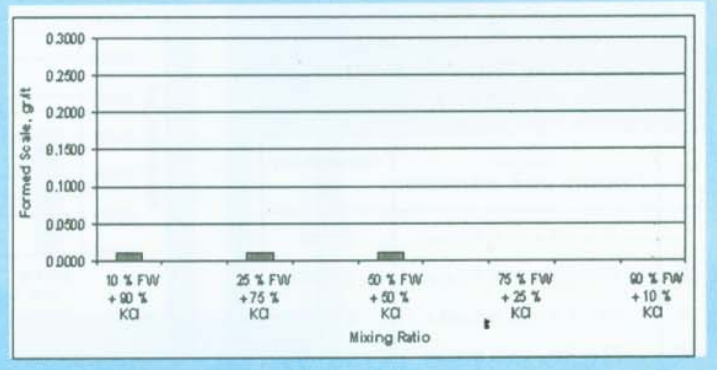

Figure A5.3
Water compatibility test (sand 2420) formation water vs KCl @ 200 °F

Table A5.4
Water compatibility test (sand 2420) formation water vs GBW41LD breaker @ 200 °F

No.	Sample Formation water and breaker	Compatibility gr/lt
1	10 % FW + 90 % Breaker	0.0700
2	25 % FW + 75 % Breaker	0.0600
3	50 % FW + 50 % Breaker	0.0500
4	75 % FW + 25 % Breaker	0.0400
5	90 % FW + 10 % Breaker	0.0200

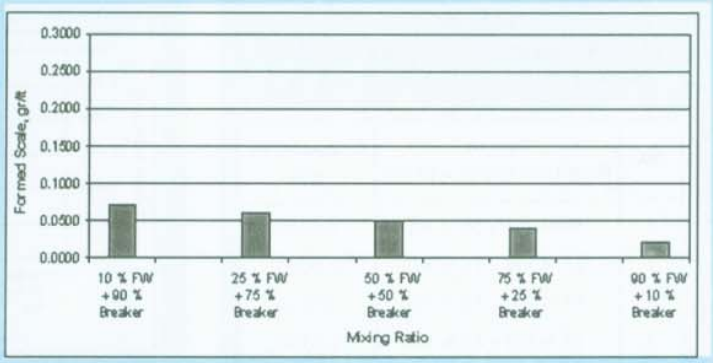

Figure A5.4
Water compatibility test (sand 2420) formation water vs GBW41LD breaker @ 200 °F

Table A5. 5
Water compatibility test (sand 3140) formation water vs KCL @ 200 °F

No.	Sample Formation Water and KCl	Compatibility gr/lt
1	10 % FW + 90 % KCl	0.0700
2	25 % FW + 75 % KCl	0.0200
3	50 % FW + 50 % KCl	0.0100
4	75 % FW + 25 % KCl	0.0100
5	90 % FW + 10 % KCl	0.0100

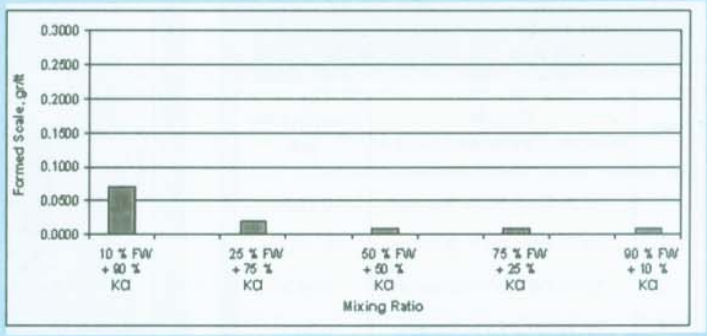

Figure A5.5
Water compatibility test (sand 3140) formation water vs KCl @ 200 °F

Table A5.6
Water compatibility test (sand 3140) formation water vs CAT-1 breaker @ 200 °F

No.	Sample Formation water and breaker	Compatibility gr/lt
1	10 % FW + 90 % Breaker	0.1600
2	25 % FW + 75 % Breaker	0.0700
3	50 % FW + 50 % Breaker	0.0500
4	75 % FW + 25 % Breaker	0.0300
5	90 % FW + 10 % Breaker	0.0100

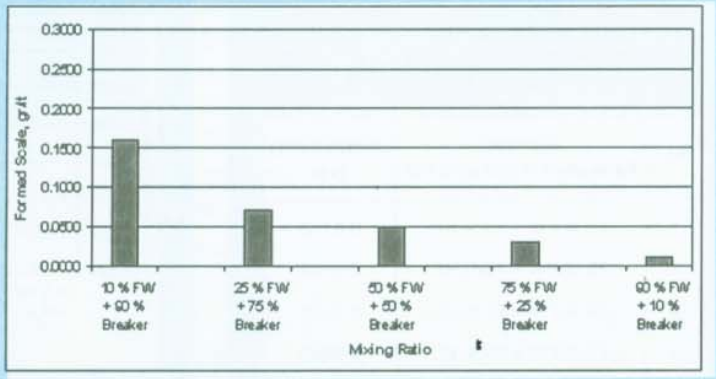

Figure A5.6
water compatibility test (sand 3140) formation water vs halliburton breaker @ 200 °F

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Table - A5.7
Water compatibility test (1950, 2420, 3140 sands) formation water vs KCl @ 200 °F at mixing ratio of FW : KCl = 10 : 90

No.	Sample formation water and KCl	Compatibility gr/lt
1 (1950 sand)	10 % FW + 90 % KCl	0.00
3 (2420 Sand)	10 % FW + 90 % KCl	0.01
5 (3140 Sand)	10 % FW + 90 % KCl	0.07

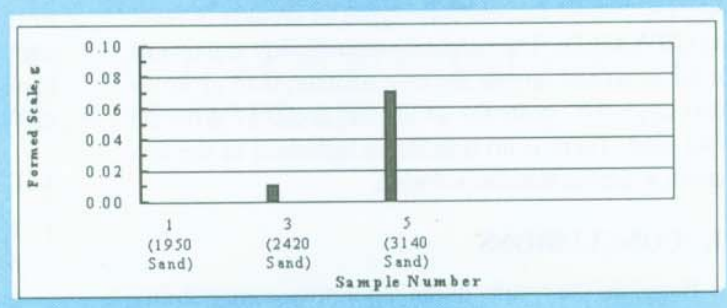

Figure A5.7
Water compatibility test (1950, 2420, 3140 sands) formation water vs KCl @ 200 °F at mixing ratio FW : KCl = 10 : 90

Table A5.8
Water compatibility test (1950, 2420, 3140 sands) formation water vs breaker @ 200 °F at mixing ratio of FW : breaker = 10 : 90

No.	Sample formation water (FW) and breaker	Compatibility gr/lt
2 (1950 sand)	10 % FW + 90 % Breaker (GBW41LD)	0.15
4 (2420 Sand)	10 % FW + 90 % Breaker (GBW41LD)	0.07
6 (3140 Sand)	10 % FW + 90 % Breaker (CAT-1)	0.16

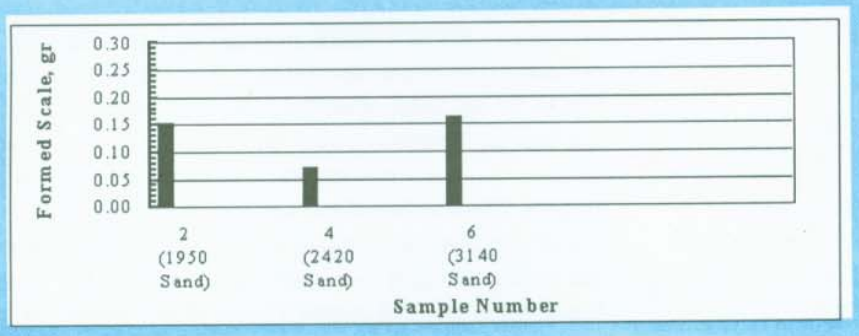

Figure A5.8
Water compatibility test (1950, 2420, 3140 sands) formation water vs KCl @ 200 0f at mixing ratio of FW : KCl = 10 : 90

3140 Sand

Table A5.5 and Figure A5.5 present the results of compatibility tests of FW : KCl at 200 °F that these results are in the value of compatibility in range 0.01 - 0.07 gram/lt, subsequently, 0.01 - 0.16 gr/ltr for formation water vs CAT - 1 breaker solution (see Table A5.6 and Figure A5.6).

Brief summary of compatibility test results for formation water vs KCl at 200 °F with using formation water from different types of sand (1950, 2420 and 3140 Sands) and different types of breaker (CAT-1 and GBW41LD) are tabulated in Table A5.7 and plotted in Figure A5.7.

The values of compatibility test results for the analyzed samples are very low, namely; 0.00, 0.01 and 0.07 gram/ltr from 1950, 2420 and 3140 sands, respectively. So, in this case, the used formation waters from the three types of sand are compatible with potassium chloride 2 % (KCl) solution.

Table A5.8 and Figure A5.8 are brief summary of compatibility test results for formation water vs breaker at 200 °F with using for-

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mation water from different types of sand (1950, 2420 and 3140 Sands) and different types of breaker (CAT-1 and GBW41LD). The value of compatibility test results for the analyzed sample are low, namely; 0.15 gr/ltr for 1950 sand, 0.07 gr/ltr for 2420 sand and 0.17 gr/ltr for 3140 sand. There is no significant influence of the formation water on breaker solution.

VI. CONCLUSIONS

Based on the results of the laboratory compatibility test, they can be concluded as follows:

1. Formation waters from the three types of different sands (1950, 2420 and 3140 sands) are compa- tible with 2 % potassium chloride concentration solution. The values of compatibility test results are in range 0.00 - 0.07 gram/ltr.
2. The results of compatibility test values between formation waters and breakers are as follows :

a. 0.15 gr/ltr (using formation water from 1950 sand and GBW41LD breaker).

b. 0.07 gr/ltr (using formation water from 2420 sand and GBW41LD breaker).

c. 0.17 gr/ltr (using formation water from 3140 sand and CAT-1 breaker).

Although, there are scale formed, but the amounts of the formed scale are small (unit gr/ltr). It means no significant influence of formation water from the three types of sands mentioned above on CAT-1 and GBW41LD breaker solutions.

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