

HALLIBURTON ENERGY SERVICES

DUNCAN TECHNOLOGY CENTER - DUNCAN, OKLAHOMA
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PRODUCTION ENHANCEMENT PRODUCTS & PROCESSES

PROJECT REPORT

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To: Dr. Steve Almond
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TST-6813-96

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Title: **Evaluation of Mag-Well Magnetic Fluid Conditioner**

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PROJECT

The purpose of this project was to evaluate the Mag-Well Magnetic Fluid Conditioner using a calcium sulfate scaling test.

CONCLUSIONS

The majority of scale formed on heater element A was calcium sulfate. A moderate to large amount of sodium chloride and zincite were found on heater element B. Large chunks of white scale, identified as calcium sulfate were found directly behind tool A upon disassembly of the test system. No solid material was found behind tool B. There was a large difference in calcium and sulfate concentration between the original starting solutions and the samples collected at various test times. The calcium and sulfate concentrations of samples taken at the same time, from both sides A and B of the system, were very similar. Fine particulate material obtained from all test samples was identified as calcium sulfate. Neither tool prevented the formation of calcium sulfate. Tool B prevented the calcium sulfate from adhering to the heater element and forming large chunks of scale directly behind the tool in the flow line. Tool A appeared to have no effect at all on the precipitation of calcium sulfate either on the heater element or in the flow line.

RECOMMENDATION

Tool B, assuming that it is the functional magnetic fluid conditioner, should be further evaluated in the areas of scale dissolution, paraffin deposition prevention and paraffin dissolution. The team agrees that the magnetic fluid conditioner does show some merit in the prevention of scale deposits, not complete elimination of scale formation, and should be marketed accordingly.

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DISCUSSION

Introduction

Halliburton had entered into an agreement with Mag-Well to market their downhole magnetic fluid conditioners. Mag-Well had no research data to show that this product worked but several successful field case histories. A team consisting of Halliburton and Mag-Well personnel was assembled to try and devise a method to evaluate the downhole magnetic fluid conditioner. The team consisted of Tance Jackson, Product Manager Subsurface Products Halliburton, Bill Ford, Principal Chemist Halliburton, Bill Dillard, Mag-Well, John Corney, Mag-Well and Mark Varel, Mag-Well. A calcium sulfate scaling test was decided upon to evaluate the effectiveness of the tool. Two tools, one functional and one nonfunctional, were to be marked "A" and "B" and delivered to Duncan for blind testing. Only Mag-Well was to know the true identity of each tool until this report was written.

Calcium Sulfate Scaling Test

Two fifty barrel tanks were filled with fresh water and heated until the fluid temperature was 150 °F. Approximately three hundred pounds each of calcium chloride and sodium chloride were added to Tank A while circulating. This would produce a solution that would contain 16.8 g/L calcium chloride and 15.0 g/L sodium chloride. Circulation was continued for fifteen minutes after all of the solids were in solution. Four hundred pounds of sodium sulfate and three hundred pounds of sodium chloride were added to tank B while circulating. This would produce a solution that would contain 15.0 g/L sodium chloride and 21.3 g/L sodium sulfate. Circulation was continued for fifteen minutes after all of the solids were in solution. When the two solutions were allowed to mix, a calcium sulfate scale would be produced. The contents of both tanks were allowed to gravity feed simultaneously to a Triplex pump operating at a twenty-five gallons per minute pump rate. A five foot long pipe was connected to the discharge side of the pump. A tee connection was installed at the end of the pipe to divert flow equally to the two magnetic fluid conditioner tools. One hundred foot lengths of pipe were connected to the end of each tool. A tee connection was placed at the end of each one hundred foot length of pipe. A one foot long pipe containing a hot water heater element was attached to one outlet side of each tee and sealed. The elements were connected to an electrical source. The open end of the tees were allowed to drain test fluid into a pit. Once the test began, the electrical source was activated as soon as test fluid exited the ends of the tees. A schematic of the test system is illustrated in Figure 1. An initial sample of test fluids were obtained from tanks A and B for calcium and sulfate determination. Samples were collected from the open ends of the tees at five, ten, fifteen and twenty-five minutes after the initial test fluid exited the tees. Samples were labeled A1, A2, A3, A4, B1, B2, B3 and B4 respectively. Each sample collected had a white, milky appearance.

DISCUSSION (Cont'd)

Sample Analysis

All samples were filtered through a 0.45 micron filter before analysis. Calcium and sulfate concentration were determined for each sample. Calcium concentration was determined by inductively coupled plasma analysis. Sulfate was determined by standard wet chemistry analysis. Results are presented in Table 1. There is little variation between any of the samples taken at various times with respect to either calcium or sulfate concentration. There is however, a rather large difference between initial concentrations of calcium and sulfate and those measured at the various sampling times. This is indicative of precipitation occurring. X-ray diffraction analysis was performed on the material left behind after filtering. There appeared to be an equivalent amount of material left behind on the filter after each sample was filtered. These results are displayed in Table 2. The majority of the material recovered from the filter was gypsum, a form of calcium sulfate. Bassanite, another form of calcium sulfate, was detected in the first three samples from tool A, while it was only present in the first sample from tool B. Sodium chloride was detected in all eight samples collected.

Large, white chunks of a solid material were found directly behind tool A when it was removed from the test system. X-ray diffraction analysis indicated that the solids contained a large amount of gypsum and a small amount of sodium chloride (Table 3). No solid material was found behind tool B upon disassembly.

The hot water heater elements were removed from the test system, visually inspected and given a microscopic exam. Solid material adhering to the elements were removed and identified by x-ray diffraction analysis. Results of the microscopic exam are presented in Figures 2 and 3. Figure 2, a microscopic picture of heater element A, shows a large amount of white material coating the heater element. X-ray diffraction analysis indicated that the material contained a large amount of gypsum, a small to moderate amount of sodium chloride and a trace amount of celestite. Figure 3, a microscopic picture of heater element B, shows only a trace amount of material on the heater element. X-ray diffraction analysis identified the material composition as moderate to large amounts of sodium chloride and zincite, a small to moderate amount of gypsum and a small amount of vaterite. These results are listed in Table 3.

DATA

Table 1

Calcium and Sulfate Concentrations

<u>Sample</u>	<u>Calcium (mg/L)</u>	<u>Sulfate (mg/L)</u>
Calcium Solution Tank A	10,650	-
Sulfate Solution Tank B	-	38,250
A1	975	8,100
A2	918	9,300
A3	1034	7,800
A4	1025	7,700
B1	993	7,900
B2	881	9,000
B3	999	7,900
B4	1015	7,400

Table 2

X-ray Diffraction Analysis of Filtered Test Samples (%)

<u>Sample</u>	<u>Gypsum</u> <u>CaSO₄ 2H₂O</u>	<u>Bassanite</u> <u>CaSO₄ 0.5H₂O</u>	<u>Sodium Chloride</u> <u>NaCl</u>
A1	90-100	2-5	2-5
A2	40-50	40-50	5-10
A3	90-100	2-5	2-5
A4	90-100	-	2-5
B1	90-100	2-5	2-5
B2	90-100	-	2-5
B3	90-100	-	2-5
B4	90-100	-	5-10

Table 3

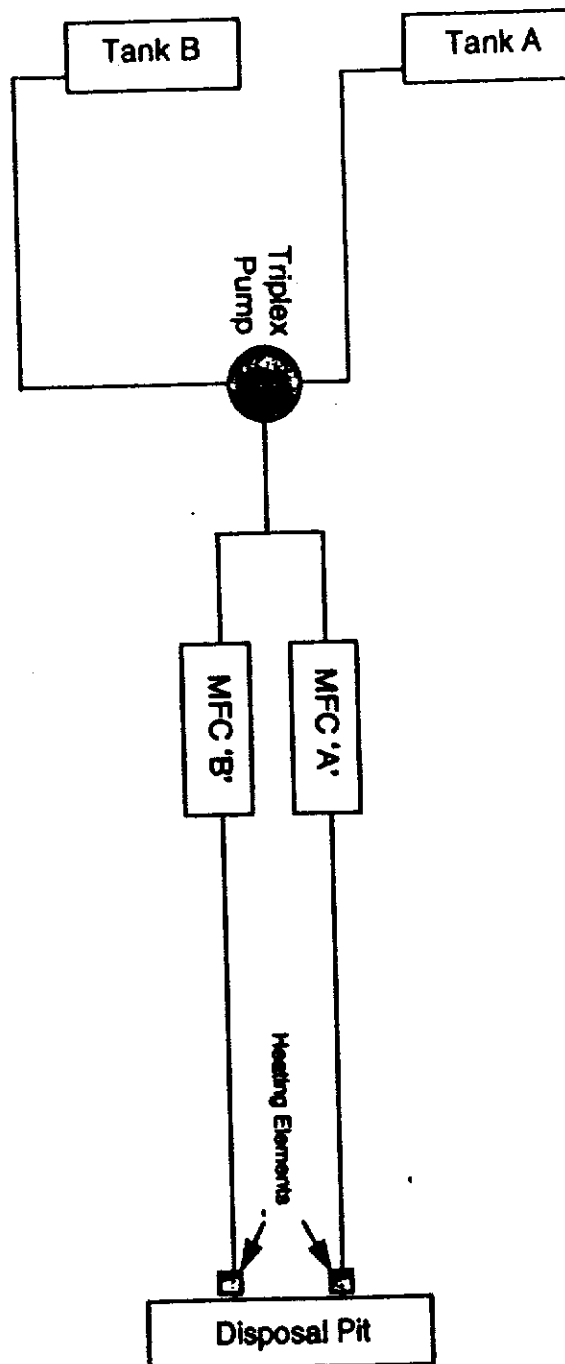
X-ray Diffraction Analysis of Heater Element Material and Solid Material

	<u>Element A</u>	<u>Element B</u>	<u>Solid Material</u>
Gypsum - CaSO ₄ 2H ₂ O	Large	Small-Moderate	Large
Sodium Chloride - NaCl	Small-Moderate	Moderate-Large	Small
Celestite - SrSO ₄	Trace	-	-
Zincite - ZnO	-	Moderate-Large	-
Vaterite - CaCO ₃	-	Small	-

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Figure 1
Test System Schematic



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Figure 2

Photomicroscopic Print of Hot Water Heater Element A



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Figure 3

Photomicroscopic Print of Hot Water Heater Element B



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DATA BOOK REFERENCE

The data presented in this report are recorded in:

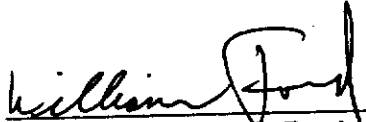
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