THE PROPER APPLICATION OF CEMENTING SPACERS AND WASHES CAN IMPROVE PRODUCTION OF OIL AND GAS

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INTRODUCTION

The future of an oil or gas well is dependent on its early life. One of the things occurring in a well's early life which affects its future is cementing the well. Proper application of cement ensures good zone isolation and protection of casing. Good zone isolation is necessary to ensure that the stimulation treatment is applied only to the zone of interest and to limit production of undesirable well fluids.

ELEMENTS OF GOOD CEMENT JOB

To ensure a good cement job, the best possible cementing techniques must be employed. Of course the first element of a good cement job is the cement itself. The cement system must be properly designed for the well conditions. [1,2,3] If well conditions will permit, casing hardware such as centralizers and scratchers should be employed, especially across any zones of interest or future zones of interest. [4,5] After the casing or liner has been run into the hole, the mud should be circulated at least "bottoms up," or until it is in good shape. Following mud conditioning, the cement must be mixed and placed using proper techniques. For cement to make intimate contact with the formation and pipe, which is necessary to achieve good bonding and good zone isolation, all the mud must be displaced. Pipe movement such as rotation or reciprocation during placement of the cement will greatly aid mud removal. [4,5] Fluids such as spacers and washes are also available which will improve mud removal and its replacemnt by cement.

REMOVAL OF MUD

Removal of mud may be a very difficult task, even with very simple muds and proper mud conditioning, pipe movement, and use of casing hardware. Most muds are incompatible with cement, whether the muds are water-base muds prepared with clay or polymer or oil-base muds. This incompatibility is frequently in the form of a gelatinous or thickened interface which occurs between mud and cement when they come in contact. This gelatinous mass can bridge off in the annulus, causing fracturing of weak formations and subsequent loss of cement to these formations. This, of course, can result in irreparable formation damage. If the formation is not fractured, bridging can cause high displacement pressures, perhaps rupturing the pipe or forcing job termination due to pressure limitations. Of course, this also leaves cement inside the pipe and cement is not applied across the zone of interest. Squeeze jobs must be performed to attempt to place cement across this zone, and such squeeze jobs are often unsuccessful.

The bridging may not be complete, allowing the cement to be pumped through the bridged-off area. As the cement passes through the cement-mud interface, it comes in contact with additional mud, creating additional thickened interface through which the cement continues to pass. This results in the mud or the thickened intermix of mud and cement lying against the formation or pipe. Neither the mud or mud-cement intermix has much strength. Thus, a channel is present along the face of the formation which can result in interzonal communication, especially if high pressure stimulation treatments are used on the zone of interest. This communication can allow the stimulation treatment to go out of zone, thus achieving little or no stimulation in the desired zone (Figure 1). Or even worse, it can stimulate a zone, up

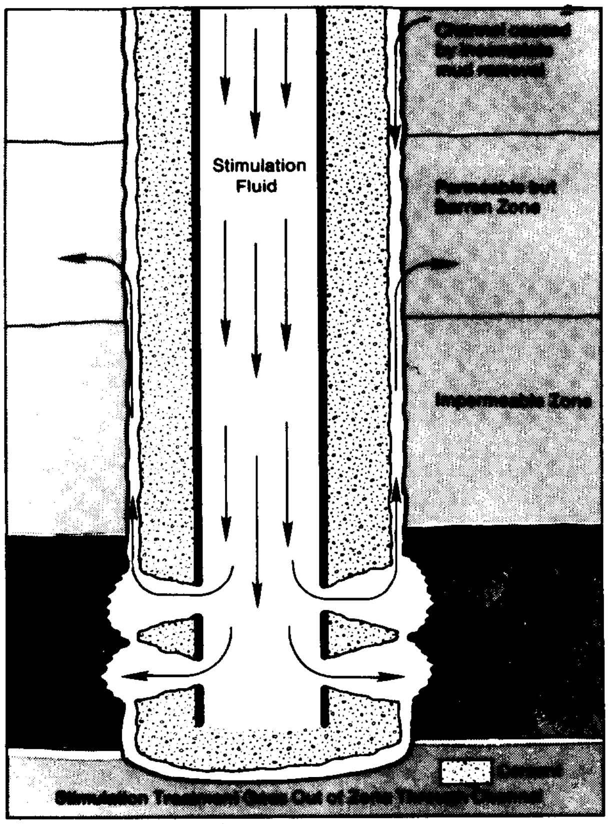

FIG. 1—CHANNELING OF CEMENT DUE TO INCOMPLETE MUD REMOVAL CAN ALLOW STIMULATION TREATMENT TO GO OUT OF ZONE.

or down-hole, bearing undesirable fluids, causing production of the undesirable fluids and thus inhibiting the production of the oil or gas which was the primary target. The use of a fluid which prevents this intermixing of cement and mud is desirable.

USE OF SPACERS AND WASHES

A number of spacers and washes are available for separating of drilling mud from cement in the annulus during cementing operations. These materials, by separating the cement from the mud, prevent incompatibility problems which occur when the two intermix. In addition to separating the cement and mud, the spacers and washes have properties which are designed for most efficient mud removal.

PROPERTIES OF WASHES

Washes are thin fluids which separate mud from cement and remove drilling mud left on the formation by a combination of turbulent and surfactant action. Of course, the wash itself must be compatible with both cement and drilling mud. Washes can also have low fluid-loss properties, if desired. Low fluid-loss washes are very useful for cementing of wells where the cement will cross highly permeable sections.

Low fluid-loss washes are also very useful for preparing air- or gas-drilled wells for cementing. Some type of fluid is necessary to remove dust and small cuttings from these wells. If the well is "mudded up," there is danger of partial dehydration of the mud. If mud dehydrates, it can lay down a filter cake which the cement cannot remove and also can become too thick to be displaced efficiently. It is also possible for the mud which has been compatible with cement, to become incompatible with the cement upon dehydration. This is due to the increase in concentration of the solid materials in the mud because of its loss of water. The low fluid-loss control solids. Because the material controlling fluid loss is highly efficient and present in low concentrations, the viscosity of the fluid is not increased as water is lost to permeable formations. Containing such a highly efficient fluid-loss control material, very small amounts of water are lost from the wash and no dehydration occurs. The filter cake which is laid down is very thin and does not impair cement bonding (Figure 2).

PROPERTIES OF SPACERS

Washes, because of their properties, are not suitable for all conditions. If highly fractured intervals are being cemented, it is sometimes necessary to use lost circulation materials.

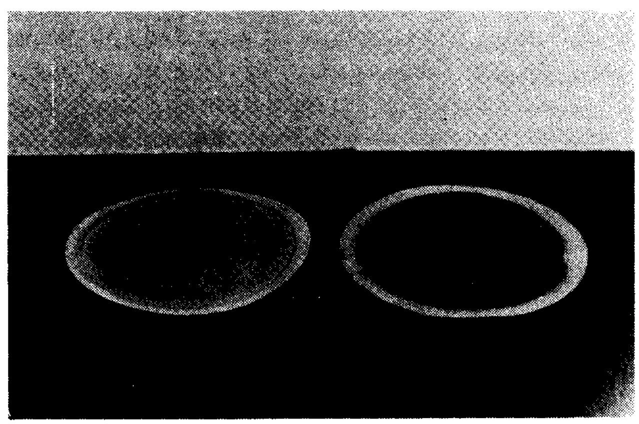

FIG. 2—FILTER CAKE OF LOW FLUID WASH (LEFT) COMPARED TO FILTER CAKE OF BENTONITE PREFLUSH.

Cementing through highly pressured formations requires the maintenance of sufficient hydrostatic pressure to control these highly pressured fluids. The use of washes where these problems are present can lead to inferior results. If used through a highly fractured zone, the wash, which cannot carry lost circulation materials, can be lost to the fractures. This allows the cement and mud to come in contact and compounds the problem. Lighweight washes can reduce the hydrostatic pressure sufficiently to allow highly pressured formation fluids to enter the wellbore. This reduces the pressure even more, causing a blowout hazard or, at least, gas cut cement.

Separation of drilling mud and cement when these problems are present is provided by a spacer. A spacer is a thickened fluid which displaces the mud in a piston-like manner due to a combination of viscosity characteristics and weight differential between the spacer and the mud. Spacers should also have other characteristics for use in cementing. They should be easily mixed in common field cementing equipment, should not be adversely affected by downhole conditions of heat and pressure, and in most cases, should have controlled fluid loss.

LABORATORY DATA

Chemical Wash — Tests were conducted to determine the mud removal ability of different materials used as chemical washes. These tests were conducted by packing gas columns with shale cuttings coated with water-based drilling mud. These were field samples of cuttings with the drilling mud left on them. Equivalent volumes of different chemical washes were forced through the column and the amount of drilling mud removal was determined. Commonly used mud thinners tested averaged about 36 percent mud solids removed. Chemical wash A removed 72 percent of the mud solids (Table 1). Chemical wash A was effective in removing all types of drilling muds, while individual mud thinners are generally effective against only one type of mud each.

TABLE 1—MUD REMOVAL BY CHEMICAL WASH SOLUTION

Active Ingredient	Concentration lb/bbl	% Mud Solids Removed
SAPP	2.0	36
Ferrochrome lignosulfonate	4.0	32
Tannin	4.0	39
Chemical Wash A	-	72

Glass column packed with 50 gm mud coated shale cuttings and flushed with 200 ml wash.

TABLE 2—FLUID LOSS OF CHEMICAL WASHES

Active Ingredient	Fluid Loss cc/30 min.
SAPP	+ 500
Ferrochrome lignosulfonate	+ 500
Tannin	+ 500
Low fluid loss wash	36

Fluid loss measured against a 1" x 1" Berea sandstone core in a Baroid Fluid Loss Tester adapted for cores. Test pressure was 1000 psi at 80°F.

Low Fluid Loss Wash — Low fluid loss wash has fluid loss control for use in cementing through highly permeable zones. Tests were conducted to determine the fluid loss of various wash solutions. These tests were conducted against a Berea sandstone core 1-inch x 1-inch with a permeability of 50-75 md. Test pressure was 1000 psi. Common wash solutions had very high fluid-loss rates. Low fluid-loss wash, a wash solution similar to cehmical wash A but with fluid-loss control, had low fluid loss (Table 2).

Water-Base Spacer Fluid—Water-base spacer fluid was tested with a cement system and a drilling mud which was incompatible with the cement. As soon as they were mixed together, the cement and mud were no longer pumpable. All combinations of the spacer with cement and with mud were pumpable and remained so at least as long as the cement slurry itself. Table 3 shows this data. The water-base spacer fluid also has rheology favorable for efficient mud removal. Rheological data is

TABLE 3—PUMPABILITY OF WATER-BASE SPACER FLUID

Pumpability Test - API Schedule 30-204°F. BHCT	Pumping Time (Hr:Min)
18.2 ppg Cement	+5:00
18.0 ppg Water-Base Spacer	+5:00
50:50 Mud (18.0 ppg): Cement	0:00
Spacer: Cement (all ratios)	+5:00
Spacer: Mud (all ratios)	+5:00

presented in Table 4. Fluid loss of the water-base spacer fluid is about 150 cc/30 min in a standard API fluid loss test as specified in API RP 10B, *Recommended Practice for Testing Oil-Well Cement and Cement Additives*. Test conditions are 140°F and 1000 psi.

FIELD DATA

Case History - Low Fluid-Loss Wash—Low fluid-loss wash has been used extensively in the San Juan Basin to improve cementing results. Wells in this area are frequently drilled through the productive interval with gas. Four and one-half inch liners are cemented in 6-1/4-inch hole. Cement is generally class B cement with 4 percent gel at 13.6 lb/gal to 14.6 lb/gal, or 50:50 fly ash class B cement with 6 percent gel at 12.6 lb/gal. Most of the cement contains fluid loss or lost circulation additives also. Prior to the introduction of low fluid-loss wash, a pre-flush of 30 bbls of water containing 300 lbs of bentonite was used ahead of the cement. Almost without exception, extremely high treating pressures were encountered, formations were broken down, and even though large excesses of cement were pumped, no cement was reversed out. Frequently, the plug was not even bumped, due to pressure limitations. These high treating pressures could have been due to partial dehydration of the pre-flush causing increasing viscosity or incompatibility with the cement. Another possibility could be bridging caused by a buildup of cuttings picked up by the leading ledge of the pre-flush.

The use of low fluid-loss wash in place of the pre-flush eliminated these problems. Where treatment pressures in the range of 2000-2500 psi were encountered in the past, pressures in the range of 100-1000 psi are the rule now. Generally, most of the excess cement is reversed out, along with most of the low fluid-loss wash.

Case History—Low Fluid Loss Wash With Water Base Spacer

In Western Pennsylvania, the Cooper, Tiona, and

TABLE 4—RHEOLOGICAL DATA OF WATER-BASE SPACER FLUID

Rheology at 190°F

	Fann 35 Reading @ RPM				10 Sec.	Bingham Plastic	
	600	300	200	100	Gel Str.	n	Ty
18.2 ppg Cement	215	95	61	25	2	.077	.005
18.0 ppg Drilling Mud	132	81	60	35	7	.038	.21
18.0 ppg Water-Base Spacer	140	82	63	43	34	.038	.25
10:90 Spacer Cement*	232	154	117	73	26	.062	.543
70:30 Spacer Mud*	203	155	132	109	99	.037	.999

* Thickest Mixture

Balltown formations, which occur between 1750 and 2075 feet, are drilled with gas. Three and one half inch casing is set in a 6-inch hole drilled from 450 feet to an average TD of 2900 feet. Cement used is 130 sacks of 65:35 fly ash class A cement plus 4 percent bentonite at 13.9 lb/gal plus 80 sacks of thixotropic cement. The cement is preceded by a pre-flush composed of 500 lbs of bentonite and 25 lbs of cellophane flake in 12 bbl of water. From the pressure charts, it was apparent that bridging was occurring in the annulus during these treatments. Surface pressures were also considerably higher than they should have been before cement was lifted behind the pipe (Figure 3). Since an amount of cement approximately equal to the calculated excess pumped was circulated, there was no indication of a thief or lost-circulation zone. On running cement bond logs on these wells, 20 percent of the wells were determined to have almost no bond (Figure 4). The rest of the wells had close to 100 percent bond based on the bond log. On those wells with poor bond logs, attempts were made to squeeze cement behind the pipe to get good zone isolation.

Stimulation treatments are staged fracturing treatments with 14,000 gallons of water and 10,000 pounds of sand. Gellant concentrations range from 3 pounds of a synthetic vinyl polymer to 10 pounds of cellulose derivative per 1000 gallons of water. Sand was started at 1/4 lb/gal and increased to 1 lb/gal. All wells were treated in essentially the same manner with the only variation being in the number of stages. The number of stages was dependent on the thickness of pay.

For the wells which the bond logs indicated had good cement bond, production was good following stimulation. Even though attempts were made to

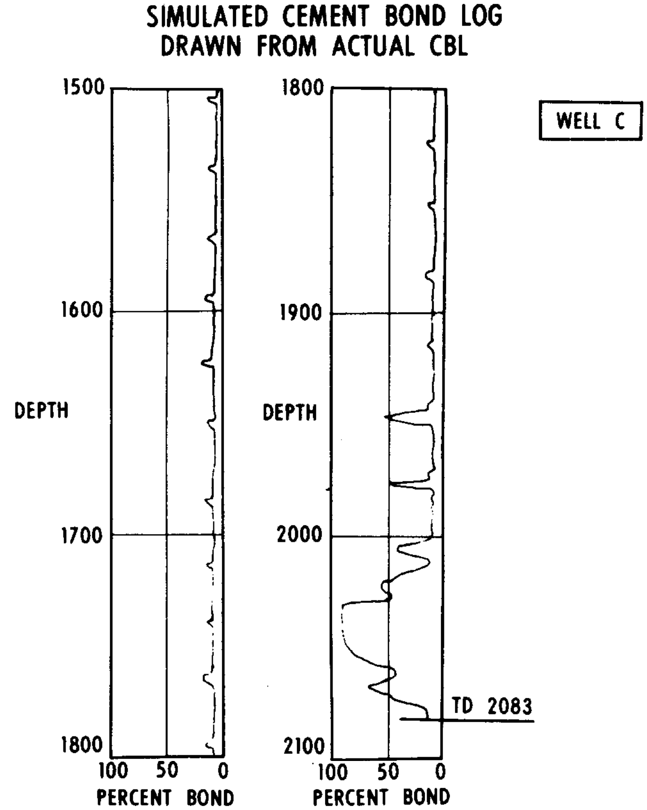

FIG. 4—CEMENT BOND LOG FOLLOWING CEMENT JOBS IN FIG. 3 SHOWED ALMOST NO BOND.

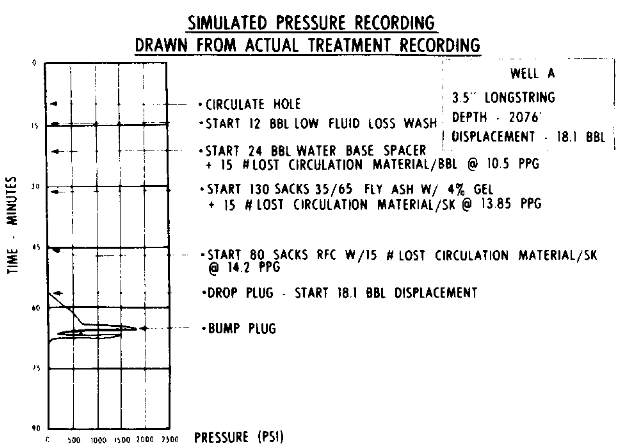

FIG. 3—PRESSURE RECORD OF CEMENT JOB USING BENTONITE PREFLUSH (WESTERN PA.) SHOWED EVIDENCE OF BRIDGING IN ANNULUS DURING DISPLACEMENT.

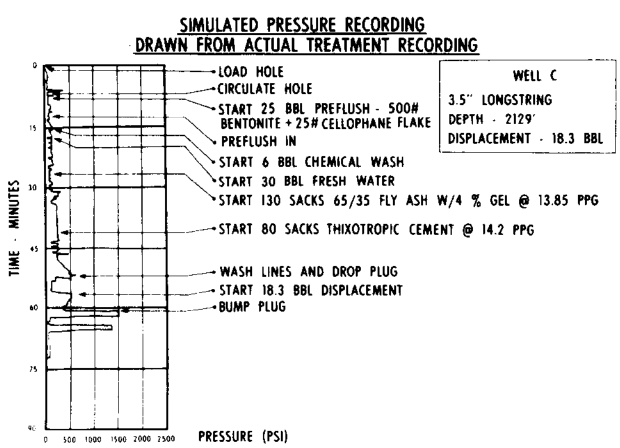

FIG. 5—CEMENT JOB USING LOW FLUID LOSS WASH AND WATER BASE SPACER ENCOUNTERED NO PRESSURE UNTIL CEMENT WAS BEING LIFTED BEHIND PIPE.

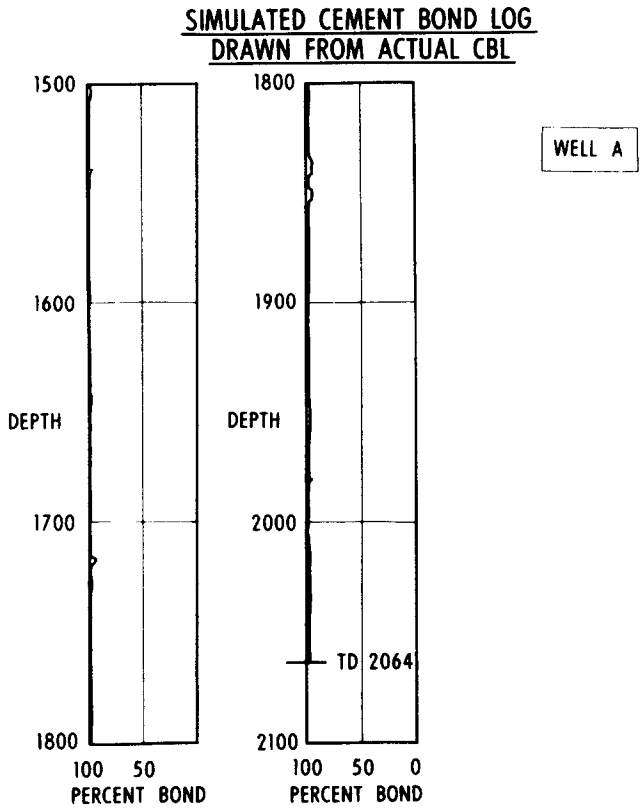

FIG. 6—BOND LOGS FOLLOWING JOBS AS IN FIG. 5 SHOWED EXCELLENT BOND THROUGHOUT DESIRED INTERVAL.

squeeze cement behind the pipe where bond logs indicated poor bond, production was limited to one or two zones out of three or four, and many of these wells had to be abandoned.

In an effort to improve his success ratio, the operator decided to run a combination of low fluid-loss wash followed by water-based spacer in place of the pre-flush. When this type treatment is used the pressure chart showed no indication of bridging in the annulus and no pressure until cement was being lifted behind the pipe (Figure 5). Bond logs on these wells show 100 percent bond through the entire interval (Figure 6). There have been no problems in stimulating or producing any of the wells treated with the combination of low fluid-loss wash and water-based spacer ahead of the cement.

Case History—Water-Based Spacer

In the Illinois Basin, operators were having a great deal of trouble getting decent cement jobs. Bond logs were run on all wells with very poor bonding indicated. These wells were drilled through the Salem formation at 2500-3500 feet. The wells were generally 7-7/8 inch hole drilled with a bentonite mud. Casing is 4-1/2 inch, set and cemented with 500 sacks of thixotropic cement. Normal stimulation consists of a fracturing treatment using 20,000 gallons of a 30 lb/gal water gel carrying 100,000 lb of 20-40 "frac" sand. Very high water-to-oil ratios were obtained with typical production being 5-15 BOPD and 30-40 BWPD. Frequent attempts to squeeze off the water zone with cement were unsuccessful and did not improve the production of oil or the water-to-oil ratio.

The operators requested something to improve the bond logs. A water-based spacer was used between the drilling mud and cement. On those wells where the spacer was used, superior bond logs have been obtained. Complete zone isolation is indicated by the improvement in production results. These wells were stimulated in precisely the same manner as the previous wells and are making better than 100 BOPD with no water (Table 5). These wells are offsets of the wells making small amounts of oil and high water-to-oil ratios.

TABLE 5—CASE HISTORY—WATER-BASE SPACER

Wells Treated Without Spacer	
Poor Bond Log	
Production	5-15 BOPD 30-40 BWPD
Well Treated With Spacer	
Excellent Bond Log	
Production	100 BOPD No Water

CONCLUSIONS

1. Low Fluid-Loss Wash is an excellent fluid for preparing air- or gas-drilled wells for cementing.
2. The use of spacers or washes eliminates the bridging which causes high treating pressures and subsequently, the possibility of breaking down the formation.
3. Channeling behind cement is reduced by the use of spacers and washes between the mud and cement, improving bond logs.
4. Where channeling has been eliminated, stimulation treatments are more effective applied and therefore production is improved.

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