RADIOACTIVE PLACEMENT TECHNIQUE FOR WELL STIMULATION

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With the shortage of oil, rising prices, and the increased difficulty and expense in finding new reserves, it has become more important than ever to recover maximum reserves from current producing wells. One of the most important means of improving recovery is the use of stimulation. With the introduction of acidizing and then later hydraulic fracturing, the recovery of in-place reserves has increased several-fold. The decline of production, coupled with the greater demand for oil, made it imperative to investigate means of further stimulation.

It was realized that the conventional method of placing acid and frac fluids in wellbores with long openhole sections and poor cement jobs was resulting in the stimulation of only the more permeable zones. Many of the lower permeability zones, which could possibily contribute to a greater degree, were not being stimulated. Several useful methods such as temperature surveys, straddle packers, and sanding-off when possible, have been used with varying degrees of success in stimulating these less permeable zones.

In an effort to find a method of placement of acids and frac fluids that could be used in holes where packers were not usable and where the point of entry of the fluids would be known immediately, development work was initiated on the use of radioactive tracers. The need for a new placement technique was magnified after fracturing some wells into an underlying water zone, and not realizing it until the frac job was completed. Once the fracture was propped, nothing could be done to correct the situation. It appeared that if some method was available to detect immediately if the point of fluid entry was into a water or other undesirable zone, then the job could be stopped and the fracture would be allowed to heal without proppant. With the cooperation and advice of a local wireline company and a treating company, a placement technique utilizing radioactive fluids was developed.

METHOD OF PLACEMENT

Radioactive fluids have primarily been used when placement of the fluid is critical due to proximity of a water-bearing zone. A well is normally equipped with tubing set approximately 2 ft from total depth as shown in Fig. 1. Two and one-half inch tubing may be run on bottom of the string to allow greater pump rates. Two trucks are used, one pumping into the tubing and the other into the tubing-casing annulus. All pad and stimulating fluids are made radioactive. The tracing tool which has two gamma detectors spaced five feet apart, is run to bottom. Radioactive pad fluid is then pumped down the annulus and nonradioactive fluid is pumped down the tubing. An interface between the fluids is established and maintained between the gamma detectors, one detecting radiation and one the absence of radiation.

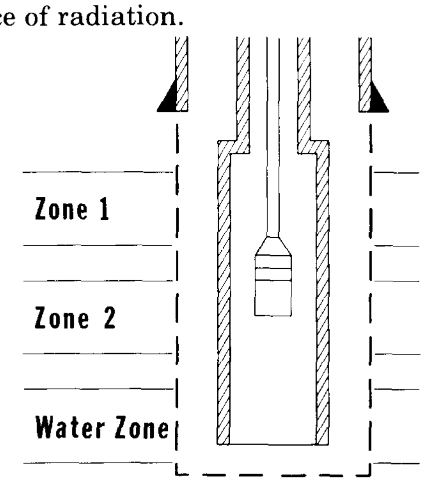

FIG. 1—DOWNHOLE EQUIPMENT SETUP FOR PLACEMENT TECHNIQUE

The primary consideration is the amount of fluid leaving the wellbore above the desired point of entry. This can be closely determined by moving the interface up and down the wellbore, by varying pump rates on the tubing and annulus. For instance, follow the schedule below and check the interface with each rate. This procedure will give a good indication of fluid entry into each particular zone:

Tubing Rate (BPM)	Annulus Rate (BPM)
1	5
2	4
3	3
4	2
5	1

After this determination, if fluid entry down the annulus is at the desired point and at a sufficient rate to stimulate, this zone is then treated while maintaining the interface by pumping down the tubing (see Fig. 2).

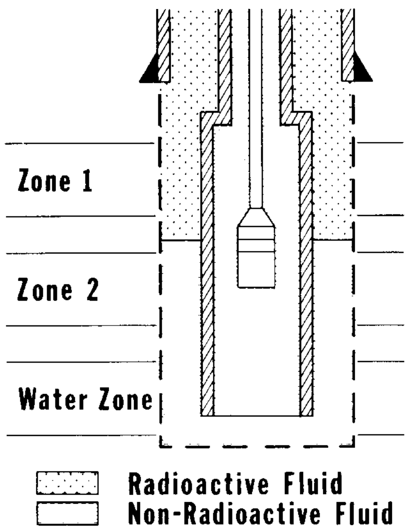

FIG. 2

If the loss of fluid to zones above the desired point of entry is unsatisfactory, then maintain an interface above this point and place a blocking agent, such as rock salt, moth balls, or benzoic acid flakes to reduce the loss.

After the initial zone is stimulated and it is desired to treat a lower zone, then the same method can be used to move the interface down. If reduction of the rate on the tubing is not enough to move the interface down, (and with the upper zone stimulated, it probably will not be) then a blocking agent again can be used to reduce the fluid loss into the upper zones. This will move the interface down to the lower zone, (see Fig. 3), and the lower zone is treated down the annulus, as shown in Fig. 4. Obviously, it is much simpler if the lower zone stimulates first. If the lower zone does break first, then the amount of entry into that zone is determined by varying the pump rates. When it is determined that the majority of the fluid is entering the lower zone, it is stimulated by holding an interface near the bottom of the zone. Maintaining this interface assures that acid or a proppant does not enter the water-bearing zone. Should the water-bearing zone break during the job, the stimulation fluid can be circulated out of the wellbore. After the lower zone is treated, blocking agent can be spotted either down the tubing or annulus, and the interface moved up the wellbore to a point between the upper and lower zones. The upper zone can then be stimulated. It has been determined that it is much easier to block the lower zone and move the interface up than it is to block the upper zone after it has been stimulated and move the interface down. If all else fails, the tubing can be pulled up two joints and the bottom sanded off.

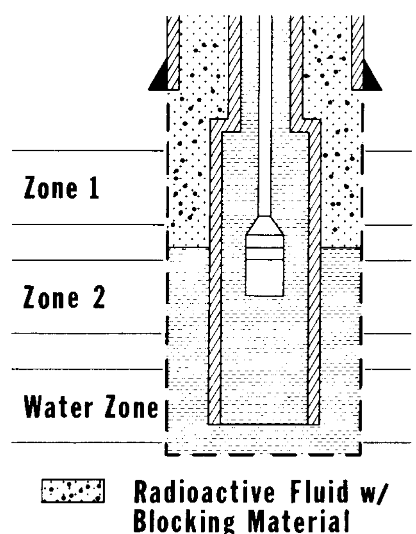

FIG. 3

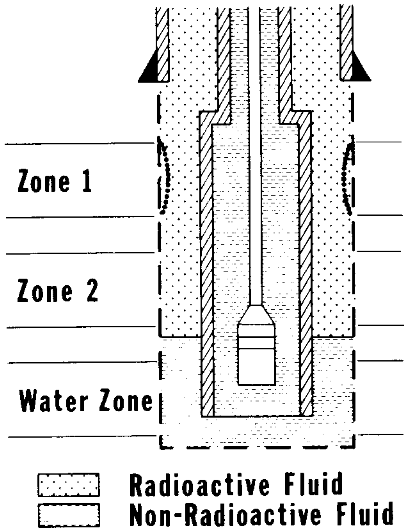

FIG. 4

The tubing can be moved two joints under pressure through the use of a wireline blanking plug and a flow nipple. The nipple can be made up in the string two joints down. After the first zone is stimulated, a blanking plug is run with the same wireline used for the tracer survey and set in the flow nipple. The pressure then can be bled off the top two joints, and these joints pulled with a double derrick pulling unit. The wireline lubricator is then replaced, the pressure equalized by one of the pump trucks, and the plug removed by the wireline. Since the plug is only 60 ft from the surface, this is a quick process. This removes the tubing from the bottom, and the well can be filled with sand.

It has been determined that if the zones to be stimulated have pore pressures which vary more than 300 psi, it is very difficult to change the interface through blocking materials. This problem can be minimized by pumping 1000 barrels of water into the wellbore prior to the stimulation job. This more nearly equalizes the pore pressures and gives greater backup for the blocking material.

If there is no fear of stimulating a water-bearing zone below the producing zones, then the process becomes much simpler. When using acid, establish the interface between the two zones to be treated. If the rates are sufficient down the tubing and annulus, then acidize the upper zone down the annulus using radioactive material in the acid, as shown in Fig. 5. Then acidize the bottom zone down the tubing using radioactive material in the fluid being pumped down the annulus to maintain the interface, Fig. 6. With inhibitor in the acid, there has been no problem acidizing with the wireline tool in the hole.

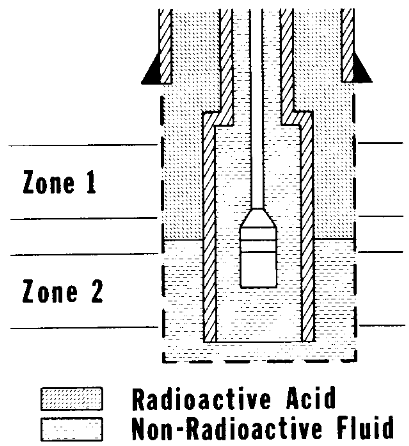

FIG. 5

Normally, the rate and sand quantity in the fluid preclude treating down the tubing with the wireline tool in the hole. The upper zone can be stimulated down the annulus with the tool monitoring the interface, then the rates and pressures can be established for treating down the tubing for the lower zone. Pull the tool and stimulate the lower zone down the tubing.

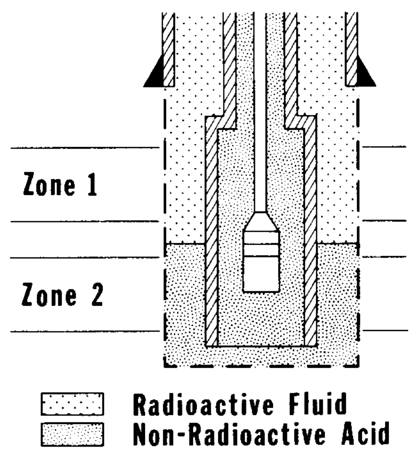

FIG. 6

PROBLEMS

The main problem that has been encountered with this technique is obtaining a blocking agent that will successfully divert the point of entry of the fluid. In particular, after a zone is stimulated, it is difficult to obtain a sufficient block of that zone to move the interface with sufficient rate to stimulate the other zone. This is more critical with a frac stimulation than with acid because of the rate limitation necessary to hold sand in suspension. Openhole completions have been much more difficult to divert than cased-hole completions even though communication between zones was present behind the pipe.

Another problem is determining the exact rate entering a lower zone when all stimulation is down the annulus. By changing the rates of the tubing and annulus, a close estimate of the rate can be determined prior to start of the stimulating fluid; but after the treatment is underway, some upper zone could break and unless it takes most of the fluid, it will not be known. This problem is eliminated when the fear of stimulating down is not present and the stimulation can be made down the tubing for the lower zones.

USES OF RADIOACTIVE PLACEMENT TECHNIQUE

Other use of this placement technique is possible. Thief zones in injection wells could be isolated, and plugging material placed without fear of plugging productive zones. Highly permeable zones in producing wells that may have watered-out in the middle of a pay section could be isolated, and this zone squeezed with a plugging material or cement. Also, lower perforations can be squeezed, even though communication exists between zones, without cement invading the upper perforations.

RESULTS

Getty Oil Company, in the Andrews Area, has performed frac jobs and acid jobs utilizing this technique. Most of these jobs were on the W.D. Johnson lease in the North Ward Estes Field, Ward County, Texas, and on the C.S. Dean "A" lease in the Slaughter Field, Cochran County, Texas.

The wells on the W.D. Johnson lease are approximately 2500 ft deep with an open hole or perforated interval of 40 ft. To stimulate the zone properly, due to variation in permeability, two or three stages are required. An abandoned watered-out zone lies immediately below this pay stringer, and if the frac fluid enters this zone, the well will produce 100% water and efforts to correct this situation have been unsuccessful. With this technique, no well has been treated into the water zone.

The wells on the C.S. Dean "A" lease are approximately 5000 ft deep, producing from the San Andres from two 30-ft intervals with 20 ft of separation between stringers. A third stringer is 20 ft below the lower producing stringer and produces 100% water. With this technique, no well has been acidized or any fracture propped into the water-bearing zone. In almost all cases, the water-bearing zone is fractured during the stimulation, but only with water; and the fracture heals to a large degree immediately and is completely healed in three months. Table 1 summarizes the results of the Slaughter Field jobs as well as those in the North Ward Estes Field.

TABLE 1—PRODUCTION BOPD/BWPD

Dean "A":	Date	Before	After	Jan. 1974	
#85	3-29-72	17/1	120/150	184/65	Frac
#90	5-25-72	25/4	20/250	61/21	Frac
#109	5-25-72	25/2	140/80	66/18	Frac
#87	5-26-72	30/1	70/30	157/3	Frac
#108	5-30-72	25/1	40/50	66/19	Frac
#67	8-28-72	15/7	40/60	72/6	Frac
#127	9-14-72	33/3	140/75	140/45	Frac Upper
#110	9-18-72	30/1	45/30	28/10	Frac Upper
#106	9-19-72	35/3	40/50	107/7	Frac
#112	7- 7-73	41/27	48/126	39/40	Frac Upper
#92	7- 8-73	29/29	46/185	39/85	Frac
#52	7-10-73	4/1	47/48	36/14	Frac
#153	7-12-73	21/9	18/35	22/12	Water Zone Broke No Stimulation
#145	7-15-73	35/22	66/78	62/33	Acid
Johnson:					
#50	9-23-71	New Comp.	31/10	7/5	Frac
#51	10-25-71	"	40/53	7/3	Frac
#28	12-28-71	"	8/15	4/3	Frac
#52	2- 8-72	"	5/6	9/1	Frac
#53	2- 8-72	"	59/157	17/28	Frac
#6-A	6-18-73	"	2/15	2/6	Frac

Note: All C. S. Dean "A" wells had been previously acidized with 6000 to 10,000 gallons 15 per cent HCl.

CONCLUSIONS

The radioactive placement technique is another valuable tool for stimulating selective zones without stimulating undesirable intervals.

Solid blocking or bridging agents such as rock salt, benzoic acid flakes and moth balls do not perform as needed to divert points of entry of the stimulating fluid, especially in open holes.

The cost of this technique is approximately 25% greater than the same stimulation with no effort to control point of entry, but results have proven this additional cost very minimal when the placement of stimulating fluid is critical.

ACKNOWLEDGMENTS

The author wishes to thank the management of Getty Oil Co. for permission to publish this paper. In addition, the author wishes to acknowledge W.E. Grolemund, Jr., Area Superintendent, Andrews Area, for the ideas and assistance in developing this technique.