A SPECIAL SEALANT PROCESS FOR SUBSURFACE WATER

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ABSTRACT

Each year production is lost due to water influx from naturally occurring or induced channels or fractures. A special sealant process has been developed to help control subsurface water movement. The process consists of two individual states separated by a water spacer. Multiple treatments may be applied to control more severe downhole conditions. The first stage consists of about 200 gal/ft of a solids-free, non-Newtonian fluid with a viscosity of approximately 200 cp for matrix penetration. As much as ten pounds of solids per gallon may be added to this fluid for channels or fractures. This stage forms a very stiff gel when it contacts synthetic or formation brine. In fresh water zones where little salt is present, a preflush of concentrated brine is injected ahead of the first stage. The second stage consists of 10 to 30 sks/ft of low water-loss,[1] accelerated cement slurry. This cement slurry is used to complete the special sealant process by forming a permanent, high-strength plug. To fit specific well conditions, solids may be added to the cement slurry. Successful sealant treatments have been performed in West Texas and New Mexico to correct subsurface water movement in producing wells. Most applications have been in naturally occurring or induced channels or fractures creating undesirable water flow. Sealant treatments up to 8,000 gal of first-stage fluid followed with 600 sacks of cement have been used.

INTRODUCTION

A special sealant process has been developed and field tested to control underground water movement in subsurface formations and/or bottom water and to seal lost circulation zones in limestone, dolomite, and sandstone formations. In this study underground water movement problems were more prevalent in older producing wells than in newly drilled producers. Fewer, but very severe, problems with underground water flow or lost circulation were encountered during drilling.

PROBLEMS ENCOUNTERED

Underground Water Movement Behind Casing

Underground moving water may be fresh, briney, or corrosive water located above the pay zone. This water may damage tubular goods, channel down behind the casing curtailing production, or channel up to the surface producing undesirable water. Conventional materials[3,4] and procedures to control such water movement have had limited success. The special sealant process has had improved success in controlling underground water movement in recent applications.

Bottom Water Production

Bottom water is usually produced with oil. It may or may not originate from the pay zone. In either case, the production of water may affect the rate and total volume of crude produced. Water production usually increases during the life of the well, causing problems such as possible corrosion or a requirement for larger lifting equipment. The source of this increase in water production is not usually well defined. Water may be produced through fractures (natural or induced) or fissures in the formation or through flow channels (formed during primary production) near the wellbore. Water-producing oil wells that are not properly treated, soon "water out." (WOR increases until the well is uneconomical to produce.)

A variety of very good conventional water-control materials and procedures such as organic and inorganic gels[1,2,3,5] has been used to achieve deep penetration into zone to control matrix water production. The special sealant process described in this paper is applicable for water production from both the formation matrix and fractures or channels.

Lost Circulation

Many hours of drilling time may be lost due to lost circulation problem intervals in a single well. Severe lost circulation problems may require thousands of pounds of special materials plus days of pumping to regain circulation in order to continue drilling. Such materials as cotton seed or walnut hulls and a variety of fast-setting cement slurries have been used to achieve recirculation in short lost-circulation intervals. The special sealant process may work in both short or long intervals to form a barrier with a fast-setting sealant that develops high strength very quickly.

WELL CONDITIONS FOR THE SPECIAL SEALANT PROCESS

One or more of the following conditions may be present requiring treating.

1. Drilling problems
   a. Communication to underground aquifers.
   b. Lost circulation intervals.
   c. High pressure water flow.
2. Poor well completion
   a. Partial or poor primary cement job.
   b. Completed in water zone (improperly located perforations).
3. Wellbore damage
   a. Numerous uncontrolled stimulation treatments such as acidizing or fracturing.
   b. Large fluid volumes produced at high rates.
4. Time factor
   a. Depletion phase of recovery.
   b. Deterioration of well (cement and casing).

PROCESS DESCRIPTION

The special sealant process is a relatively new process using a two-stage system designed specifically for controlling undesirable underground water movement. The uses for the special sealant process have been expanded to cover a variety of wellbore problems due to the unique characteristic of the sealant. Each stage is designed to react with the other to form a stiff gel very quickly in the problem zone.

The first stage (Chemical A) reacts with the formation water or brine preflush to form a gel. This gel reduces flow into the zone, allowing the second stage to override the small spacer and contact Chemical A, causing both chemicals to thicken at the interface. Chemical A is a colorless, solids-free, non-Newtonian fluid with an initial viscosity of approximately 200 cp. An arbitrary treating volume of concentrated Chemical A is 200 gal/ft of interval. This stage may be designed to carry sand up to 10 lb/gal. To obtain bridging and/or sealing under severe conditions, a combination of various sand sizes and special fillers may be added.

The second stage is an accelerated portland cement slurry pumped at an arbitrary treatment size of 10 to 30 sks/ft of formation interval. This stage may be designed with sand and/or special fillers at a slurry weight up to 18 lb/gal.

The final squeeze step is designed to mix, blend, or commingle the two stages. Chemical A should partially gel upon contact with brine. The second stage may be squeezed into the unreacted portion of the first stage to flash set the cement slurry, locking up the special sealant very quickly in place. More than one treatment may be necessary for very severe problems. A second or third application may follow immediately if a pressure increase is not observed at the end of the first treatment. Conventional sealants usually require an overnight cure time following the treatment.

PLACEMENT PROCEDURE

Three placement procedures for treating a well for underground water movement behind casing, bottom water production, and lost circulation are described below. Surface equipment normally used for the process is shown in Figure 1. Techniques for strategically placing the special sealant treatment are depicted in Figures 2 through 4. Graphical representations of these three categories of problems are shown in Figures 5 through 15.

Underground Water Movement Behind Casing

1. Locate the water flow zone. If necessary, perforate the water zone.
2. Isolate the interval.
3. Pump a brine preflush.
4. Pump 200 gallons of Chemical A per foot of formation interval. Do not reach theoretical fracturing pressure.

5. Pump 10 to 30 sacks of low water-loss cement per foot of formation interval.
6. If pressure has not increased by the time the second stage has been displaced to the zone, prepare for another treatment.
7. Continue this procedure until a five minute standing or holding pressure (when pressure does not bleed off) is maintained.

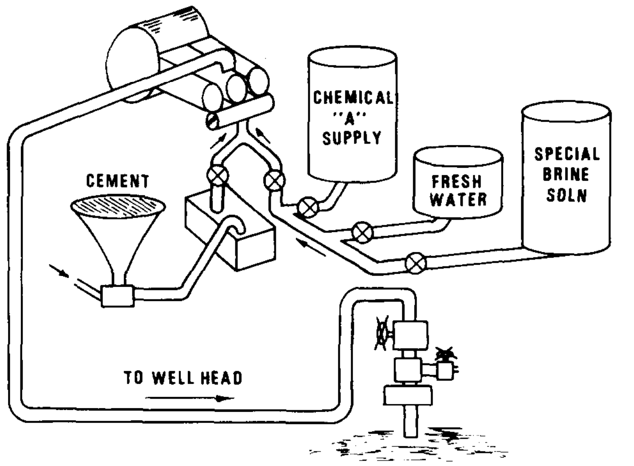


FIGURE 1—JOB SCHEMATIC FOR SPECIAL SEALANT PREPARATION

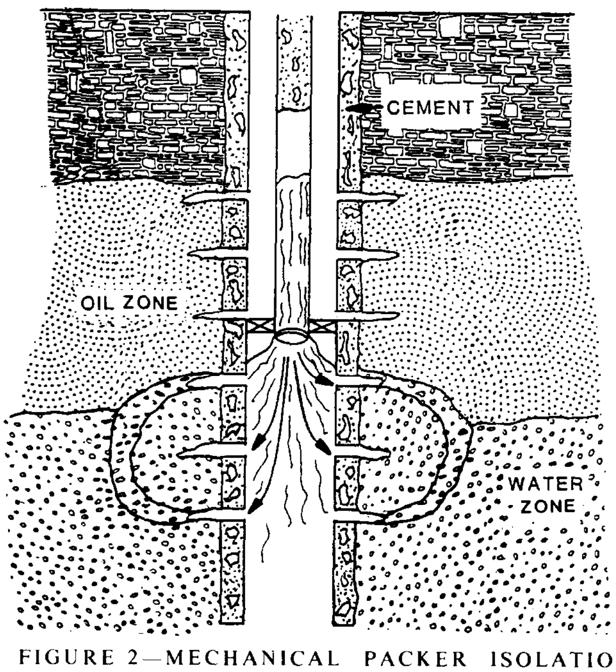


FIGURE 2—MECHANICAL PACKER ISOLATION TECHNIQUE. THE USE OF MECHANICAL PACKERS IS THE MOST WIDELY USED ISOLATION PLACEMENT TECHNIQUE. PACKERS OPERATE VERY WELL TO ISOLATE THE TREATING INTERVAL IN LONG INTERVALS WHERE THEY CAN BE SET ABOVE, BELOW, OR BETWEEN PERFORATIONS.

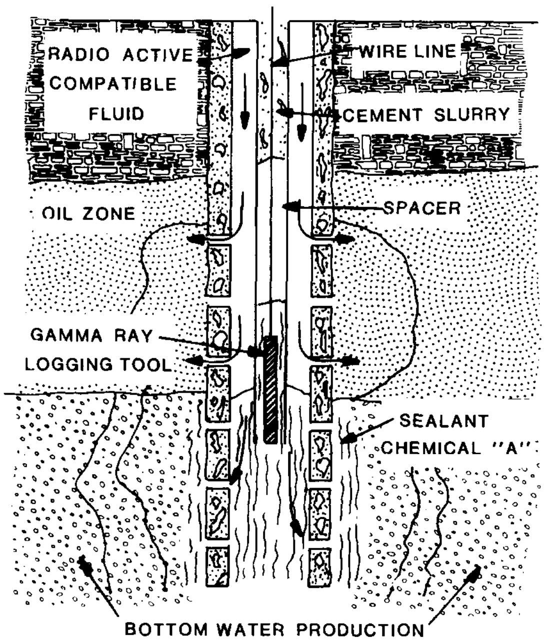


FIGURE 3—CONTROLLED INTERFACE PLACEMENT TECHNIQUE. CONTROLLED INTERFACE PLACEMENT TECHNIQUE IS USED PRIMARILY IN VERY SHORT INTERVALS WHERE PACKERS WOULD BE SET IN PERFORATIONS. THIS TECHNIQUE REQUIRES A TWO-DETECTOR RADIOACTIVE LOGGING TOOL, A TRACER MATERIAL AND THE WELL HEAD DESIGNED TO PUMP DOWN THE TUBING AND ANNULUS SIMULTANEOUSLY.

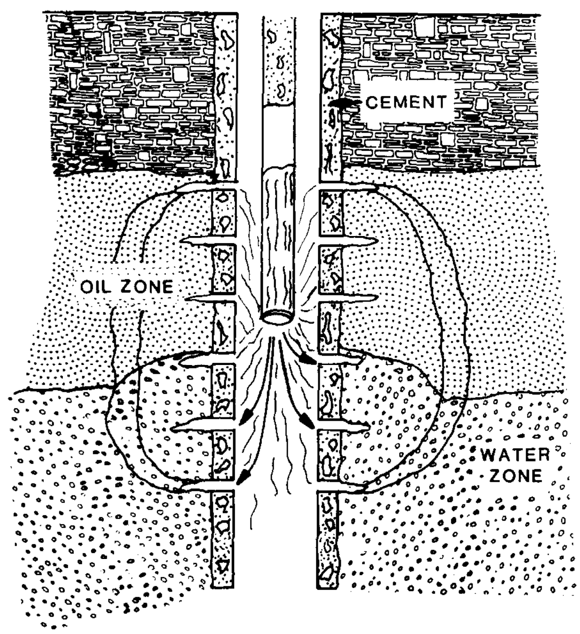
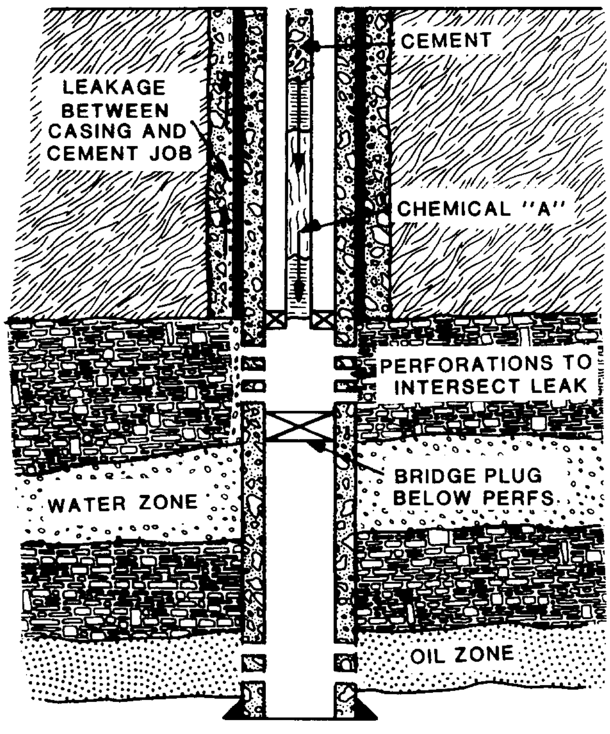


FIGURE 4—BULLHEAD PLACEMENT TECHNIQUE. THE BULLHEAD PLACEMENT IS PRIMARILY USED IN LOST CIRCULATION TYPE APPLICATIONS. THIS TECHNIQUE MAY PLUG THE ENTIRE PRODUCTION INTERVAL.



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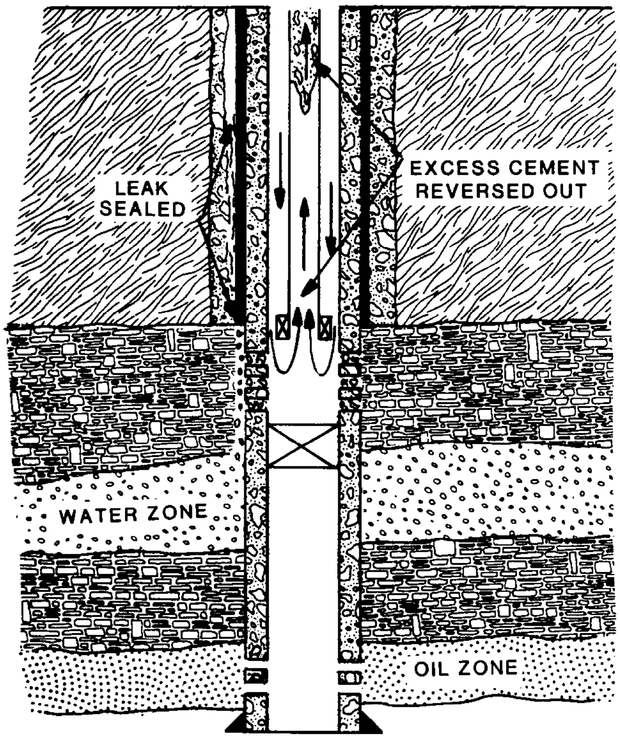

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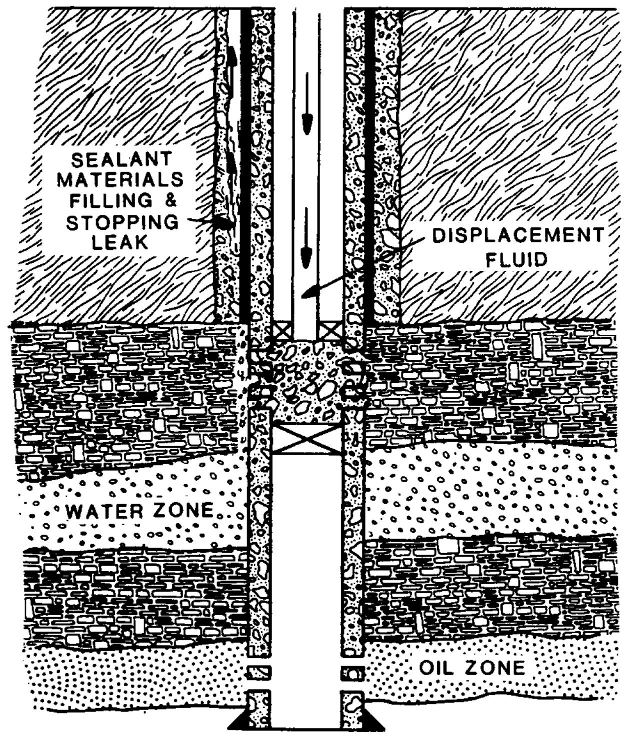

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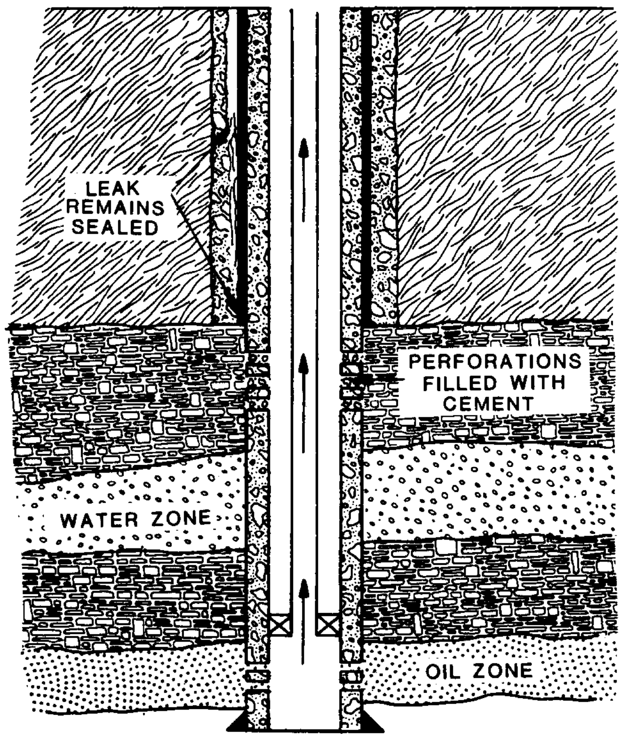

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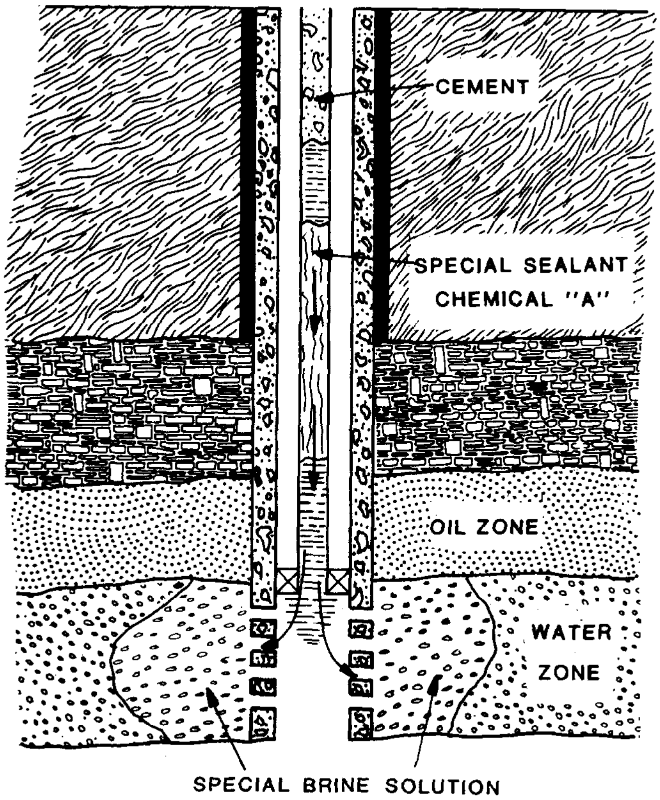

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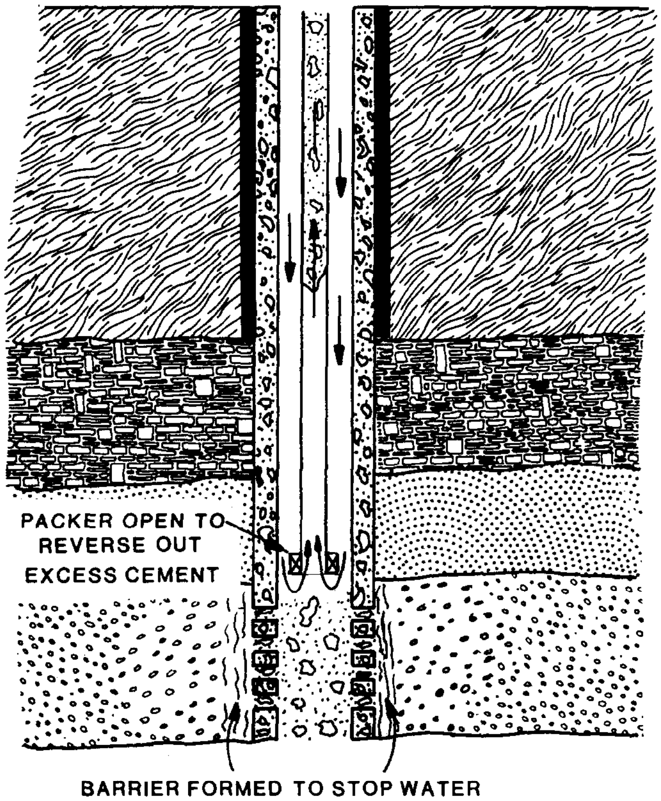
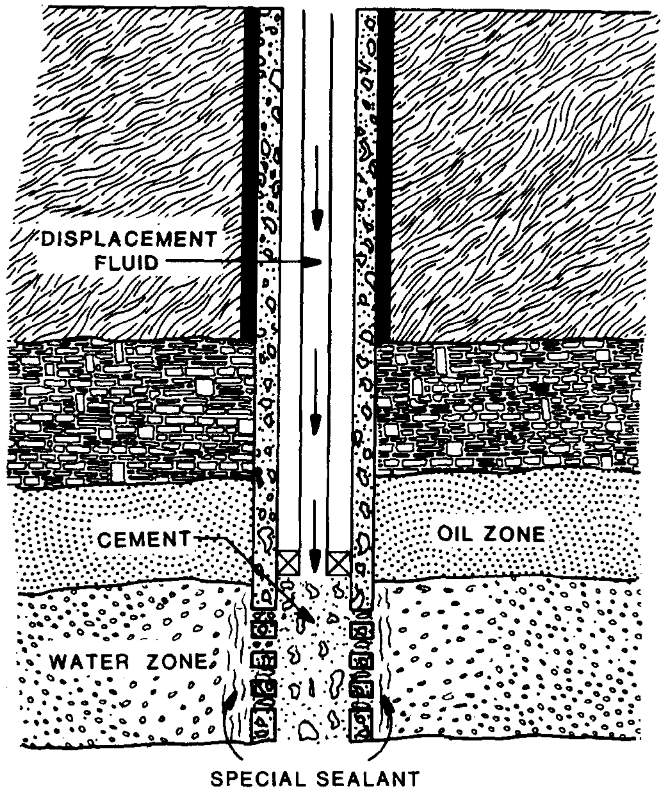


FIGURE 11



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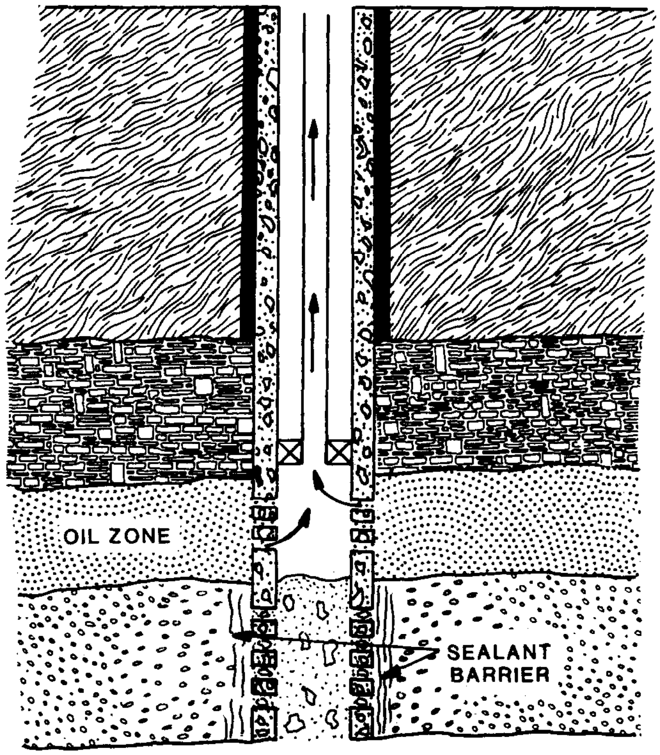

FIGURE 12

Bottom Water Production

1. Locate the water flow zone. If necessary perforate below the water flow interval.
2. Isolate the interval using a controlled placement technique.
3. Rig the wellhead to reverse circulate the excess cement slurry.
4. Pump the prepared volume of Chemical A, 200 gal/ft of formation.
5. Pump 10 to 30 sacks of low water-loss cement slurry per ft of formation.
6. If pressure has not increased by the time the second stage has been displaced into the zone, prepare for another treatment.
7. Continue this procedure until a five minute holding pressure is maintained.

Lost Circulation

1. Pump a preflush of brine.
2. Pump 200 gallons of Chemical A (with fillers as necessary) per foot of expected lost circulation zone.
3. Pump 10 to 30 sacks of accelerated cement slurry containing sand and special fillers (slurry weight up to 18 lb/gal) per foot of formation.
4. Displace to the lost circulation zone with field brine. If pressure does not increase, repeat steps 2 and 3.
5. Continue this procedure until a five minute holding or standing pressure is maintained.
6. Continue drilling.

SUMMARY OF FIELD RESULTS

Field treatments using the special sealant process have been primarily performed in West Texas and Eastern New Mexico. These treatments were designed to correct the following well conditions.

A. Eleven well treatments to control underground flowing water behind the casing.

B. Fifteen well treatments to control the production of bottom water from lower perforations.

C. Nine well treatments for casing leaks. These leaks were from splits or holes usually located below 2000 ft.

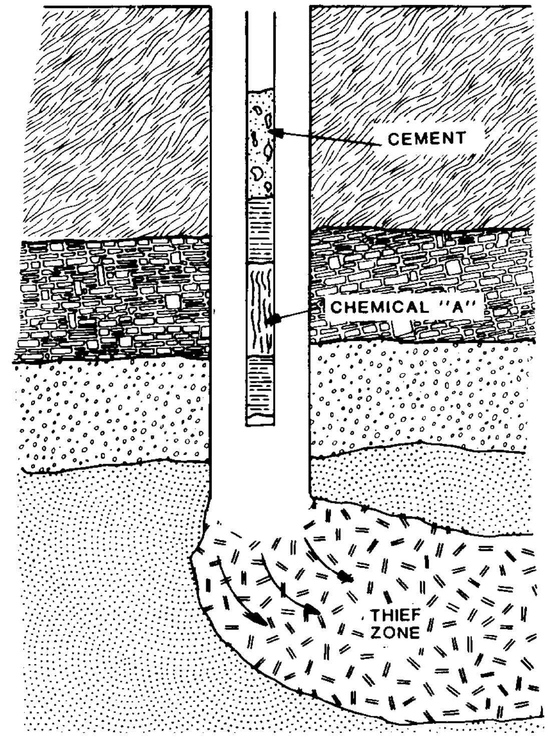

FIGURE 13—LOST CIRCULATION

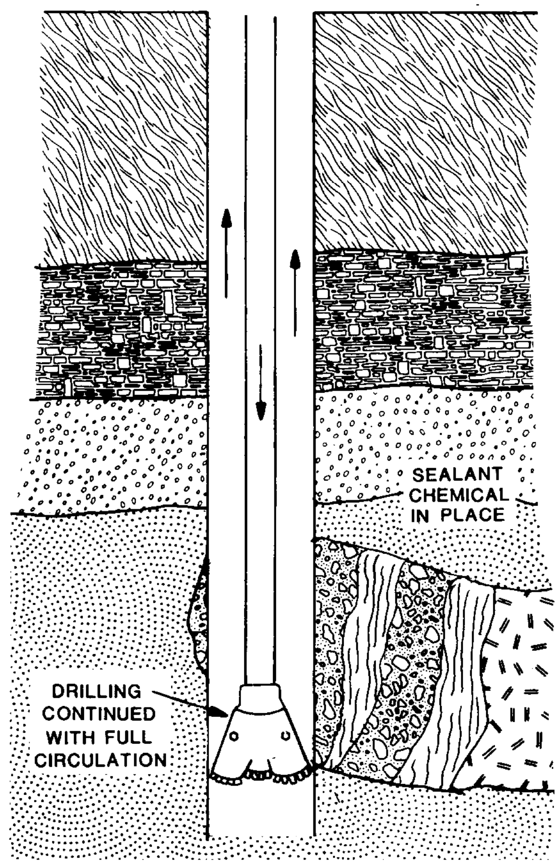

FIGURE 14

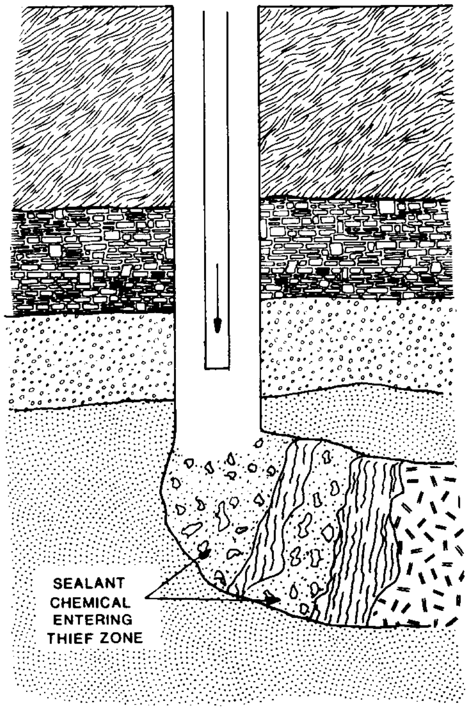

FIGURE 15

D. One well treatment to control flowing water encountered during drilling.
E. One well treatment to correct a lost circulation zone in a well to be plugged to abandon.

The first few special sealant jobs were performed in wells following unsuccessful conventional squeeze treatments. Individual job descriptions are listed in the Field Treatment Result's (in the Appendix).

Field results have indicated that, for controlling underground water movement (subsurface or bottom), the special sealant process exhibits the following advantages over conventional materials and methods presently in use.

1. The special sealant process is an economical method of squeezing off underground water movement and correcting lost circulation problems. Minimum volumes and reduced rig time are characteristics of the process due to the quick setting and fast strength development.
2. Due to the nature of Chemical A slurry, relatively large channels with high water flows may be sealed.
3. Slurries may be designed to cover a wide density range. Chemical A slurry densities may vary from 11.5 to 15 lb/gal. The density of the cement slurry may vary from 12.5 to 18 lb/gal.
4. The special sealant process materials may be used in limestone, dolomite, and sandstone formations.
5. The special sealant process may be used over a temperature range of 40 to 350°F.

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APPENDIX

TABLE 1—WATER MOVEMENT BEHIND CASING

Case No.	Location	Well Problem	Treatment	Results
1	Lea County, N.M.	Water flowing between 85/8 in & 5 1/2 in. casing.	One special sealant squeeze treatment.	Two conventional cement squeezes were unsuccessful. One special sealant squeeze controlled the water.
2	Lea County, N.M.	Water flowing between 85/8 in. & 5 1/2 in. casing.	One special sealant squeeze treatment with overnight shutin.	One special sealant squeeze controlled the water flow.
3	Lea County, N.M.	Water flow behind 95/8 in. casing.	One special sealant squeeze treatment.	One special sealant squeeze controlled the water flow.
4	Lea County, N.M.	Water flow between 85/8 in. & 51/2 in. casing.	Two special sealant squeeze treatments with three cement squeeze stages.	Two special sealant squeezes controlled the water flow.
5	Lea County, N.M.	Water flow behind 51/2 in. casing.	One special sealant squeeze treatment.	One special sealant squeeze controlled the water flow.
6	Lea County, N.M.	Water flow between surface peip & 7 in. casing.	Two special sealant squeeze treatments with three cement squeeze stages.	Two special sealant squeezes controlled the water flow.
7	Lea County, N.M.	Water flow behind 51/2 in. casing.	One special sealant squeeze treatment.	Pressure tested - no leak.
8	Santa Barbara County, Calif.	Water flow from casing at 1200 ft.	One special sealant squeeze treatment.	One special sealant squeeze treatment controlled the water flow.
9	Ventura County, Calif.	Water flow from casing at 300 ft.	One special sealant squeeze treatment.	One special sealant squeeze treatment controlled the water flow after four unsuccessful conventional squeeze cement jobs.
10	Lea County, N.M.	Water flow between 85/8 in. & 51/2 in. casing. Water contained high concentration of chlorides & magnesium. Surface water flow pressure on 85/8 in. casing 900 psi & 1300 psi on tubing.	One special sealant squeeze treatment.	The water flow was sealed off with the special sealant process technique.
11	Lea County, N.M.	Water flow between 85/8 in. & 51/2 in. casing. Water contained high concentration of chlorides & magnesium. Surface water flow pressure 800 psi.	Two special sealant squeeze treatments.	The flowing water was sealed off with special sealant process technique.

TABLE 2A—BOTTOM WATER PRODUCTION

Case		Production			
		Before		After	
No.	Location	BWPD	BOPD	BWPD	BOPD
1	Brownfield, Texas	300	5	11	11
2	Odessa, Texas	1250	0	10	66
3	Odessa, Texas	700	2	20	50
4	Andrews, Texas	600	10	40	45
5	Odessa, Texas	700	5	30	40
6	Odessa, Texas	400	0	40	60
7	Odessa, Texas	900	0	1200	0
8	Worland, Wyoming	*			

*After well was put back on production the water production was 50% less with same oil production as before.

TABLE 2B BOTTOM WATER PRODUCTION

Case No.	Location	Well Problem	Treatment	Results
9	Howard County, Tx.	Squeeze lower perfs below 2584 ft.	One special sealant squeeze treatment.	Test squeeze held 1000 psi.
10	Howard County, Tx.	Squeeze perfs below 2486 ft, bottom set of perfs. 2413 - 2530 ft.	One special sealant with two cement squeeze stages.	Held squeeze pressure - no water production. squeeze treatment
11	Howard County, Tx.	Squeeze perfs below 1849 ft.	One special sealant squeeze treatment.	Held squeeze pressure - no water production.
13	Scurry County, Tx.	Squeeze perfs. at 3667 ft.	Two special sealant squeeze treatments.	Held squeeze pressure - no water production.
14	Scurry County, Tx.	Squeeze perfs at 3460 ft.	One special sealant squeeze treatment.	Held squeeze pressure.
15	Scurry County, Tx.	Squeeze perfs at 4270 ft.	One special sealant squeeze treatment.	Held squeeze pressure.
14	Scurry County, Tx.	Squeeze perfs at 3460 ft.	One special sealant squeeze treatment.	Held squeeze pressure.

TABLE 3—CASING LEAK

Case No.	Location	Well Problem	Treatment	Results
1	Scurry County, Tx.	Hole in 5 1/2 in. casing at 24000 ft.	One special sealant squeeze treatment.	One special sealant squeeze sealed the leak at 2400 ft.
2	Scurry County, Tx.	A 207 ft split in 7 in. casing from 2914 ft. to 3121 ft.	One special sealant squeeze treatment.	The split casing was sealed off with the special sealant squeeze process.
3	Scurry County, Tx.	A 21 ft split in 7 in. casing from 2658 ft to 2679 ft.	One special sealant squeeze treatment.	The split casing was sealed with the special sealant squeeze process.
4	Scurry County, Tx.	Casing leak in 7 in. casing.	One special sealant squeeze treatment.	The casing leak was sealed off using the special sealant process.
5	Scurry County, Tx.	Casing leak in 51/2 in. casing.	One special sealant squeeze treatment.	The casing leak was sealed off using the special sealant process.
6	Scurry County, Tx.	Casing leak in 5 1/2 in. casing between 5445 and 5569 ft.	One special sealant squeeze treatment.	Casing leak was sealed off using the special sealant process.
7	Scurry County, Tx.	Casing leak in 5 1/2 in. casing.	One special sealant squeeze treatment.	Casing leak was sealed off using the special sealant process.
8	Scurry County, Tx.	Casing leak in 7 in. casing between 6346 and 6567 ft.	One special sealant squeeze treatment.	Casing leak was sealed off using the special sealant process.
9	Scurry County, Tx.	Casing leak in 7 in. casing.	One special sealant squeeze treatment.	The casing leak was sealed off using the special sealant process after three conventional cement squeezes were not successful.

TABLE 4—FLOWING WATER DURING DRILLING

Case No.	Location	Problem
1	Lea County, New Mexico	Water Flow Rate 900 BPH

Discussion:

Surface pipe 8-5/8 in. was set to 365 ft. A 7-7/8 in. hole was drilled to 1840 ft where water flow was encountered. Drilling was continued to 2650 ft, and 7 in. casing was set.

Treating Sequence:

The 7 in. casing was perforated at 1840 ft. Three special sealant squeeze treatments followed with four cement stages were required through perforations.

Results:

The water flow at 1840 ft was shut off after three special sealant squeeze treatments.

TABLE 5—LOST CIRCULATION (PLUG TO ABANDON)

Case No.	Location	Problem
1	Lea County, New Mexico	Lost Circulation at 1700 ft

Discussion:

This well was an offset to a salt water disposal well. The casing and tubing in both wells were severely corroded. The lost circulation zone showed to be above the salt zone.

Treating Sequence:

Two special sealant squeeze treatments were required using a special placement technique.

Results:

The special sealant squeeze procedure corrected the lost circulataion interval with two treatments so that the wellbore could be plugged with regular cement.