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METHOD OF PACKING OFF THE ANNULAS BETWEEN THE CASING AND TUBING IN A WELL WITH A PACKER FLUID

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This invention relates to a novel packer fluid to be employed in wells, particularly when producing oil or gas from said wells. In another aspect it relates to a method of packing off the annulus between a casing and a tubing suspended therein in a well, so as to protect said casing and tubing against leakage, collapse and corrosion.

In drilling a well, it is often necessary to "pack off" the annulus between the production tubing and the casing, for example, when producing the oil or gas from the well. This is accomplished by placing a packer in the annulus and leaving some type of fluid in the annulus above the packer. The purpose of this packer fluid is to effect the pressure differential across the packer and the casing, thereby preventing leakage from the tubing or from the formation into the casing, and preventing collapse of the casing. High density drilling muds are commonly employed as packer fluids but these muds are often unsatisfactory due to solidification, settling of the suspended solids, etc. Consequently, the removal of the packer or production tubing is often very difficult and necessarily entails expensive and time-consuming work-over operations. These high density drilling muds are unsatisfactory as packer fluid because of the high concentration of solids, such as drilled clay or shale solids, and mud reagents; they are also unsatisfactory because of the high amount of soluble contaminating materials, such as lime or calcium compounds. The solids in the high density muds tend to settle out and deposit above the packer. Solidification of the high density mud can result by reaction, for example, of the dissolved solids in the liquid phase with the solid phase. Contaminants in the mud often cause corrosion of the casing and tubing. Since it is prohibitively expensive to replace the high density mud with a cleaner, high density mud, in order to circumvent these difficulties, it is generally not done.

Accordingly, an object of my invention is to provide a novel packer fluid. Another object is to provide a novel packer fluid having a relatively high density. A further object is to provide a packer fluid the components of which will not settle after standing. A further object is to provide a novel packer fluid characterized by its non-corrosiveness, the almost complete absence of inorganic suspended solids such as drilled clay solids, and its non-solidifying properties. A further object is to provide an improved method of packing off the annulus between a casing and tubing suspended therein, in such a manner as to protect said casing and tubing against leakage, collapse, and corrosion.

Other objects and advantages of my invention will become apparent, to those skilled in the art, from the accompanying discussion and appended claims.

The packer fluids of this invention comprise aqueous solutions of water soluble alkali metal silicates, such as, sodium silicates and potassium silicates. In making up these silicate solutions, either fresh water or salt water (e.g., sea water or field brine) can be used, and the term

"aqueous" is used in its inclusive sense generically covering both fresh water and salt water, unless otherwise specified. These packer fluids are alkaline in nature and have relatively high densities, generally in the range of from 9 to 14 pounds per gallon. These packer fluids are non-corrosive and will not be affected by the relatively high pressures or temperatures encountered in a well. They are true solutions and as such are relatively solids-free and will be able to stand in the well indefinitely without solidification, settling of solids, corrosion, etc. Should it be necessary to complete or rework a well packed off with the novel packer fluid of this invention, for example by drilling out or pulling the packer, these packer fluids will not cause the swelling of clays such as bentonite should the packer fluid escape or come into contact with the formation.

By convention, alkali metal silicates, which are often products of indefinite composition, are often specified in terms of the molecular ratio of silica, SiO_2, to alkali, Na_2O or K_2O. The silicates useful in preparing the packer fluids of this invention can have silica/alkali molecular ratios varying over a wide range, generally between 1.60/1 to 3.90/1. Representative sodium silicates useful in preparing packer fluids of this invention include sodium orthosilicate, sodium metasilicate, sodium disilicate, sodium sesquisilicate, and the like.

A number of commercially available aqueous solutions of sodium silicate, useful in preparing the packer fluids of this invention, are set forth in Table I. A particularly useful commercially available sodium silicate solution is one having a density of 11.5 lb./gal., a silica/alkali ratio of 3.2/1, and 40° Baumé.

TABLE I

SiO_2/Na_2O, Ratio by Wt.	Total Solids, Wt. Percent	Specific Gravity, d_{20}^{20}	Vis. at 20° C. Abs., poises
1.60	50.9	1.68	70
2.00	54.0	1.69	700
2.50	36.9	1.41	0.5
2.90	43.0	1.48	9.6
3.22	37.6	1.39	1.8
3.75	32.1	1.32	2.2

The packer fluids of this invention can be prepared by any convenient manner, for example, by dissolving the solid sodium silicates in either hot or cold fresh water or salt water. Where commercially available silicate solutions are used, such as those set forth in Table I, these solutions can be employed as such, or, preferably, can be diluted with fresh or salt water to the desired concentration and density. If desired, the solution can be heated to increase the rate of solution of the silicates and increase the solubility of the silicates. Either cold or hot silicate solutions can be pumped into the annulus of the well where thermal equilibrium can be attained.

The density of the packer fluid to be employed in any particular instance will, of course, also depend upon such considerations as the depth of the well and the pressure in the well where the packer fluid is employed. Generally the density of the packer fluid will be greater than about 9 lbs./gal. and the term "high density" as employed herein and in the appended claims is to be understood as being a density of at least about 9 lbs./gal. The

packer fluids of my invention having a density in the range between about 9 and 14 lbs./gal. will be satisfactory in the great majority of wells being drilled and produced at the present time.

The packer fluid can be placed in the well according to well known procedures. For example, after drilling is completed and the well is conditioned by cleaning out the cuttings and circulating drilling mud, the drill stem is pulled from the well and the casing is run into the well and cemented. The production tubing and packer are then put into the well. The packer fluid is introduced into the well following a slug of clean water or other cleaning fluid if desired. The packer can be set by turning the tubing or raising or lowering the same, and the annular space between the tubing and casing sealed to prevent evaporation of the packer fluid. The casing can be perforated below the packer either before or after the placing of the packer fluid. Surface equipment can then be installed and the well completed because the packer fluid of this invention does not contain any solid components or other material which will settle out during standing; the packer will not be frozen in place even after prolonged standing. Moreover, since the packer fluid of this invention is non-corrosive, no corrosion problems will be encountered.

The following examples are set forth to illustrate the objects and advantages of this invention, but it should be understood that the relative concentrations, densities, etc., set forth in these examples represent preferred embodiments of this invention and they should not be construed to unduly limit this invention.

Example I

A number of sodium silicate packer fluids were prepared from a commercially available sodium silicate solution having a density of 14 pounds per gallon, a specific gravity of 1.68, and a SiO_2/Na_2O mole ratio of about 2/1.

Table II sets forth the relative amounts of this commercially available silicate solution and either fresh or salt water necessary to obtain packer fluids having desirable densities.

TABLE II

Commercial Sodium Silicate Solution, Wt. percent	Saturated Salt Water, Wt. percent	Density, lbs./gal.	Apparent Viscosity, cps.	Plastic Viscosity, cps.	Yield Point lbs./100 Ft.²	Fann Gels, lbs./100 Ft.²	pH
100	0	14.0	6,800	6,800	0	74-74	11.5
80	20	13.0	295	295	0	4-4	11.1
60	40	12.1	27.5	27.0	1.0	3-3	11.2
40	60	11.3	8.5	8.0	1.0	1-1	11.4
20	80	10.65	4.0	3.5	1.0	1-1	11.0
0	100	10.00	2.5	2.0	1.0	1-1	9.3

Commercial Sodium Silicate Solution, Wt. percent	Fresh Water, Wt. percent	Density, lbs./gal.	Apparent Viscosity, cps.	Plastic Viscosity, cps.	Yield Point, lbs./100 Ft.²	Fann Gels, lbs./100 Ft.²	pH
100	0	14.0	6,800	6,810	0	74-74	11.5
80	20	12.6	111.75	110.5	2.5	2-3	11.2
60	40	11.3	12.75	12.5	0.5	1-1	11.3
40	60	10.1	3.50	3.0	1.0	1-1	11.4
20	80	9.1	1.50	1.0	1.0	1-1	11.65
0	100	8.33	1.00	1.0	0	1-1	10.2

Example II

As mentioned hereinbefore, the packer fluids of this invention, should they come into contact with formations, such as bentonitic formations, will not cause the swelling thereof. This property of the packer fluids was demonstrated by the following procedure.

Sodium silicate packer fluids were made up by diluting the commercially available sodium silicate solution mentioned in Example I with either fresh water or salt water, each of these packer fluids containing 3 weight percent bentonite. The physical properties of the samples were measured immediately after preparing the packer fluids and after aging the same for 24 hours. The results, tabulated in Table III, demonstrate that these packer fluids do not cause the swelling of dry bentonitic solids.

TABLE III

UNAGED SAMPLES

Commercial Sodium Silicate Solution, Wt. Percent	Saturated Salt Water, Wt. Percent	Bentonite, Wt. Percent	Density, lbs./gal.	Apparent Viscosity, cps.	Plastic Viscosity, cps.	Yield Value, lbs./ 100 Ft.²	Fann Gels, lbs./ 100 Ft.²	pH
60	40	3	12.15	29.75	29.5	0.5	1-1	10.7
40	60	3	11.40	9.25	8.5	1.5	1-2	10.7
	Fresh Water, Wt. Percent							
60	40	3	11.45	14.75	14.5	0.5	2-2	11.4
40	60	3	10.35	4.50	4.0	1.0	1-1	11.5

TABLE III—Continued

AGED SAMPLES

[24 Hours at 80° C.]

Commercial Sodium Silicate Solution, Wt. Percent	Saturated Salt Water, Wt. Percent	Bentonite, Wt. Percent	Density, lbs./gal.	Apparent Viscosity, cps.	Plastic Viscosity, cps.	Yield Value, lbs./100 Ft.²	Fann Gels, lbs./100 Ft.²	pH
60	40	3	12.15	31	30	2.0	1-2	10.9
40	60	3	11.40	9.25	9.0	0.5	1-1	10.7
	Fresh Water, Wt. Percent							
60	40	3	11.45	15.75	15.5	0.5	1-2	11.4
40	60	3	10.35	4.50	4.0	1.0	1-2	11.6

Various modifications and alterations of this invention will become apparent to those skilled in the art from the foregoing discussion, and it should be understood that this invention should not be unduly limited to that set forth herein for illustrative purposes.

I claim:

1. In a well comprising a casing and a tubing annularly disposed within said casing, a method which comprises packing off the annulus between said casing and tubing with a packer fluid consisting essentially of a solids-free aqueous solution of a water soluble alkali metal silicate, said solution having a density of at least 9 pounds per gallon.

2. In a well comprising a casing and a production tubing annularly disposed within said casing, a method of protecting said casing and tubing against leakage, collapse and corrosion, which method comprises packing off the annulus between said casing and tubing and filling said annulus with a packer fluid consisting essentially of a solids-free aqueous solution of a water soluble alkali metal silicate, said solution having a density of at least 9 pounds per gallon.

3. The method according to claim 2 wherein said alkali metal silicate has a silica to alkali molecular ratio in the range of 1.60/1 to 3.90/1.

4. The method according to claim 2 wherein said aqueous solution is made up with fresh water.

5. The method according to claim 2 wherein said aqueous solution is made up with salt water.

6. The method according to claim 2 wherein said density is in the range of 10 to 14 pounds per gallon.

7. The method according to claim 2 wherein said alkali metal silicate is potassium silicate.

8. The method according to claim 2 wherein said alkali metal silicate is sodium silicate.

9. The method according to claim 2 wherein the silica to alkali molecular ratio of said sodium silicate is about 2/1.

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