United States Patent

Miles

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[54] **METHOD FOR DRILLING AND COMPLETING A WELL AND A PACKER FLUID THEREFOR**

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[58] **Field of Search**.....166/DIG. 1, 57; 252/8.55 R; 175/65

[56] **References Cited**

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[57] **ABSTRACT**

A method for drilling and/or producing a well through a permafrost zone which employs a thermally insulated packer fluid which contains at least one of hollow shapes such as glass spheres, halogenated ethane, or halogenated ethylene.

20 Claims, No Drawings

METHOD FOR DRILLING AND COMPLETING A WELL AND A PACKER FLUID THEREFOR

BACKGROUND OF THE INVENTION

Packer fluids are liquids which are pumped into annuli between a casing and the wellbore wall or between adjacent, concentric strings of pipe extending into a wellbore, e.g. the annuli between 9 ⅝ inch and 13 ⅜ inch casing, between 7 inch casing and 4 ½ inch tubing, and the like. Generally, depending upon the conditions, oil base or water base fluid weighted with barite have been employed.

However, in situations where the wellbore penetrates a permafrost zone these conventional packer fluids are unacceptable primarily because they are good thermal conductors, particularly when the fluid is weighted with conventional weighting agents such as barite, barium carbonate, calcium carbonate, lead sulfide, mixtures thereof, and the like.

It is also important that the liquid base of the packer fluid have a freezing point below the temperatures normally prevailing in a permafrost zone, i.e. below the temperature range of from about 14° to about 32° F.

SUMMARY OF THE INVENTION

It has now been found that packer fluids which do not freeze at permafrost temperatures and which have excellent thermal insulating characteristics as well as the capability of being weighted without destroying these thermal insulating characteristics are obtained by employing a hydrocarbonaceous oil base which has a freezing point below 14° F. and incorporating therein an effective thermal insulating and/or weighting amount of at least one of hollow shapes of glass and/or plastic and halogenated ethane and/or halogenated ethylene as hereinafter described.

The hollow shapes of this invention are, for example, glass spheres with air in their hollow interior. The spheres are of very small size, i.e. from about 10 to about 250 microns in diameter and are therefore readily dispersible in the packer fluid. When so dispersed in the packer fluid they decrease its density and greatly decrease the thermal conductivity of the hydrocarbonaceous oil base thereby producing a thermally insulated well packer fluid.

The halogenated ethane and ethylene have two salient advantages in that, when added to a hydrocarbonaceous oil base, they not only have a thermal insulating effect due to their low thermal conductivity but additionally have a weighting effect since they are relatively dense liquids. T-us, the halogenated hydrocarbonas have the distinct advantage of imparting thermal insulation while at the same time adding weight to the packer fluid so that when a weighted packer fluid is needed for permafrost zones, these halogenated hydrocarbons can be used in lieu of barite and the like, which increases thermal conductivity of the packer fluid.

Thus, these halogenated hydrocarbons can be employed as a weighting agent if it is desired to add density to a packer fluid such as a packer fluid employing the hollow shapes of this invention and not only is weighting achieved when these halogenated hydrocarbons are added, but at the same time the packer fluid is rendered even more thermally insulating.

Accordingly, it is an object of this invention to provide a new and improved method for drilling and/or producing a well through a permafrost zone. It is another object to provide a new and improved method for employing thermally insulating and/or weighted packer fluids in permafrost zones. It is another object to provide a new and improved well packer fluid. It is another object to provide a new and improved packer fluid useful in permafrost zones. It is another object to provide a new and improved thermally insulating weighted packer fluid.

Other aspects, objects, and advantages of this invention will be apparent to those skilled in the art from this disclosure and the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

According to one aspect of this invention, a thermal insulating packer fluid is provided by employing a hydrocarbonaceous oil base and incorporating in that base an effective thermal insulating amount of hollow shapes of at least one of glass and plastic, the shapes passing through a 50 mesh sieve, preferably being no less than about 10 microns, said shapes having a grain density (average density of one shape) of from about 0.2 to about 0.4 grams per cubic centimeter, said shapes also having a thermal conductivity in bulk form of no greater than about 0.08 Btu of heat transfer over a square foot area with a temperature gradient in ° F. per foot of thickness, i.e., Btu/hour sq. foot ° F./foot.

This packer fluid can have added thereto an effective insulating and/or weighting amount of at least one of ethane and ethylene having from 3 to 6, inclusive, halogen atoms per molecule and which is a liquid at 200° F. under pressure of at least 200 psig, has a weight in said liquid state of at least about 7 pounds per gallon, and has a thermal conductivity in said liquid state of no greater than about 0.08 Btu/hour sq. foot ° F./foot.

The addition of the hollow shapes of this invention to a base liquid can lighten the total liquid which is acceptable in some situations. However, in situations where a heavier packer fluid is desirable the halogenated hydrocarbons of this invention can be added to that packer fluid containing the hollow shapes of this invention to give that packer fluid the desired weight. A special advantage of this invention is that this weighting can be achieved with the halogenated hydrocarbon with the result that there is not sacrifice in thermal insulation, but rather an enhancement of the thermal insulating characteristics of the packer fluid.

According to another aspect of this invention, the hydrocarbonaceous oil base can have added thereto an effective insulating and/or weighting amount of at least one of the above halogenated hydrocarbons and without the use of the above hollow shapes and to provide a thermal insulating and weighted packer fluid.

The hydrocarbonaceous oil base can be one or more liquids. Suitable hydrocarbonaceous liquids have API gravities below about 30° and viscosities greater than about 25 SSF at 122° F. and can be crude petroleum oil or a distillate or residuum material therefrom. Heavy materials such as light tar, cracked residua, heavy extracts, and the like can also be employed. Diesel oil, fuel oil, gas oil, kerosine, heavier petroleum refinery liquid residues can be employed alone or in combination with heavier materials to lighten same. Mixtures of

two or more of these materials can be employed as desired. The base oil will be the major component of the packer fluid but can vary widely in the amount present depending upon what other additives are employed and the desired final characteristics of the packer fluid as a whole. Generally, at least about 50 weight percent of the packer fluid will be the hydrocarbonaceous oil base with the base generally being in the range of from about 50 to about 90 weight percent based on the total weight of the packer fluid.

The hollow shapes can be of any desired shape, but generally spherical and can be glass or plastic. Any glass or plastic can be employed so long as it is substantially inert to the base oil. The hollow shape should be completely closed so that the base oil can not penetrate the interior of the hollow shapes. Thus, the hollow shapes will be composed of glass or plastic which can be maintained in the base material for at least 20 years without deteriorating and without allowing the base liquid to penetrate the interior.

The hollow shapes can be dispersed in the base oil by simply mixing the shapes with the oil until an intimate dispersion is achieved. Because of the small size of the shapes they will stay in this dispersion for a matter of years.

However, in order to better maintain the dispersion of hollow shapes in the base oil for a long period of time, and also in order to thicken the dispersion so as to substantially prevent the formation of convection currents in the packer fluid after it is placed in the wellbore, one or more conventional emulsifiers can be employed in an effective thickening amount. The thickening amount will vary widely depending on the particular materials present and the degree of thickening desired, but generally from about 2 to about 10 weight percent of one or more gelling agents can be employed based on the total weight of the packer fluid. Suitable emulsifiers are fully and completely disclosed in "Composition and Properties of Oil Well Drilling Fluid" by W. F. Rogers, Third Edition, Gulf Publishing Company, Houston, Texas, 1963, page 565 et sic. Suitable emulsifiers include alkaline metal soap or alkaline earth metal soap of heavy metal (e.g., group IV b, V B, VI b, VII B, VIII B of the Periodic Table, Handbook of Chemistry and Physics, Chemical Rubber Company, 45 Edition, 1964, page B–2 (Soaps), of tall oil, resin oil, fatty acids, disproportionated rosin as fully and completely disclosed in U.S. Pat. No. 2,678,697, the disclosure of which is incorporated herein by reference, and the like. The emulsifier should be soluble in the oil base. Suitable fatty acids are saturated, unsaturated, or mixtures thereof such as capric, isocapric, lauric, pentadeconoic, palmitic, stearic, oleic, linoleic, dehenic, tetracofanoic, cerotic, and fatty acid mixtures obtained from vegetables and animals, e.g., tall oil, cotten seed, corn, coconut oil, soya, fish oil, animal fat, and the like.

As desired, weighting agents which do not substantially adversely affect the thermal insulating characteristics of the packer fluid, viscosifiers such as asphalt, bentonite, or other clay, and the like, surfactants to render the hollow shaped oil wet, and the like can be employed in the packer fluid of this invention so long as the materials are substantially inert as to the base oil and hollow shapes and do not substantially adversely affect the thermal insulating characteristics of the packer fluid.

The hollow shapes are present in the packer fluid in an amount to give the packer fluid a thermal insulating characteristic which is better than the thermal insulating properties of the base oil itself. Generally, at least about 12 weight percent hollow shapes will be employed based on the total weight of the packer fluid. To put it another way, sufficient hollow shapes can be employed to give the packer fluid a thermal conductivity no greater than about 0.08 Btu/hour sq. foot ° F./foot.

There can also be present in the hollow shape containing packer fluid one or more halogenated hydrocarbons as above described, the halogenated hydrocarbons being present in an effective insulating and/or weighting amount depending upon whether the material is added primarily as an insulating agent or a weighting agent, the material having beneficial effects on both functions. Generally, any halogenated ethane or ethylene meeting the above described requirements can be employed. Suitable specific materials include trichlorotrifluoroethane, dichlorotetrofluoroethane and trichloroethylene these materials can be employed in effective finite amounts up to about 50 weight percent based upon the total weight of the packer fluid to give the packer fluid a weight of at least about 7 pounds per gallon and a thermal conductivity no greater than about 0.08 Btu/hour sq. foot ° F./foot.

The halogenated hydrocarbons of this invention can be employed with the hydrocarbonaceous base oil in the absence of any hollow shapes and when the base oil and halogenated hydrocarbons are thus mixed a thermally insulating and weighted packer fluid is produced in its own right. Therefore, a thermal insulating weighted packer fluid according to this invention can contain an effective insulating and/or weighting amount of at least one halogenated hydrocarbon as above defined, the remainder being essentially the hydrocarbonaceous base oil as above defined.

In addition, additives can be employed in the halogenated hydrocarbon/base oil packer fluid which, include the above hollow shapes, weighting agents, viscosifiers, surfactants, oil wetting surfactants, and the like so long as the thermal insulating and weighting characteristics of the packer fluid are not substantially adversely affected.

All of the packer fluids of this invention can be prepared by simple mixing of the ingredients under ambient conditions of temperature and pressure for a time sufficient to provide a homogeneous mixture of all ingredients.

The method of this invention involves using during at least one of drilling and/or producing of the well through the permafrost zone, one or more of the packer fluids as above described, the packer fluid being used in the wellbore at least through the permafrost zone by substantially filling at least one annulus zone between two concentric pipes in the wellbore with at least one packer fluid of this invention.

The halogenated hydrocarbons useful in this invention are desirable additives other than their high weight and low thermal conductivities because they have substantially no corrosivity in steel, stainless steel, nickel based alloys, aluminum, and tin. Consequently they have good stability in contact with steel such as that

steel from which drilling pipe and casing is made. Halogenated hydrocarbons also have low toxicity, e.g., a threshold limit value of 7,600 milligrams per cubic meter for trichlorotrifluoroethane, high flash points e.g., above 900° F. for trichlorotrifluoroethane, and generally have a flash surpressing effect on liquids such as hydrocarbons with which they are mixed. Thus, these halogenated hydrocarbons are well suited for addition to a packer fluid and will perform well under the conditions of operation for a packer fluid.

EXAMPLE 1

Various packer fluids were prepared using diesel oil having an API gravity of about 38.8° and a viscosity of about 1.73 centistokes at 100° F., a weight of 6.7 pounds per gallon at 100° F. and a thermal conductivity of 0.08 Btu/hour sq. foot ° F./foot. In packer fluid 1 trichlorotrifluoroethane (CClhd 2F—$CC1F_2$) having a weight of 12.8 pounds per gallon at 100° F. and a thermal conductivity of 0.05 Btu/hour sq. foot ° F./foot at 100° F. was mixed at about 75° F. with residual fuel oil having a API gravity of about 16.9° at 60° F. and a viscosity of about 150 SSF at 122° F. and an emulsifier of the calcium salt of disproportionated rosin as fully and completely disclosed in U.S. Pat. No. 2,678,697. In packer fluid 1 the halogenated hydrocarbon was employed in an amount of 80 volume percent, the residual fuel oil in the amount of 10 volume percent and the emulsifier in the volume of 10 volume percent. The resulting packer fluid at 100° F. has a weight of 11.9 pounds per gallon and a thermal conductivity of 0.055. A packer fluid of this high a weight with such a low thermal conductivity is highly desirable for use in permafrost applications.

Packer fluid 2 was formed by mixing at 75° F., diesel oil as above described with the halogenated hydrocarbon of packer fluid 1, the residual fuel oil of packer fluid 1, and the emulsifier of packer fluid 1. The materials were mixed in the amounts of 31.4 volume percent diesel oil, 10 volume percent residual fuel oil, 10 volume percent emulsifier, and 48.6 volume halogenated hydrocarbon. The resulting packer fluid had at 100° F. a weight of 10 pounds per gallon and a thermal conductivity of 0.075. This packer fluid also has an exceptional combination of weight and thermal conductivity as can be seen by comparison with packer fluid 3.

Packer fluid 3 was composed of 86.4 volume percent residual fuel oil of packer fluid 1, and 30.4 weight percent barite, the barite having a density of 4.3 grams per cubic centimeter and a thermal conductivity of 1.25. The resulting packer fluid at 100° F. had a weight of 10 pounds per gallon and a thermal conductivity of 0.1.

It can be seen from packer fluid 3 that although an equivalently weighted packer fluid was achieved, the packer fluid did not have sufficient thermal insulating characteristics with the thermal conductivity of 0.1 and therefore was not desirable for use in permafrost applications.

Packer fluids 1 and 2 are mixed at the drill site and just prior to introduction of these fluids into the wellbore, about 10 pounds of calcium oxide per barrel of packer fluid is added. The packer fluid displaces the drilling mud in the annulus in the wellbore by first passing down the interior of the drill pipe and then upwards into the annulus. In about 3 hours the packer fluid has formed a grease like gel in the drilling fluid by way of reaction of the calcium oxide with the packer fluid. It is preferred that the packer fluid be gelled or otherwise viscosified somewhat to help prevent the formation of convection currents within the fluid after emplacement in the annulus.

EXAMPLE 2

The residual fuel oil of Example 1 is employed as a base oil in the amount of 62 volume percent to which is added 14.7 weight percent of hollow glass spheres in the size range of from about 10 to about 250 microns, the glass being of a borosilicate composition, the spheres being filled with air and the hollow interior closed off from the exterior. The glass spheres had a grain density of about 0.26 grams per cubic centimeter, a thermal conductivity in bulk of about 0.03 Btu/hour sq. foot ° F./foot. The glass spheres are commercially available from Emerson and Cuming, Inc. and Minnesota Mining and Manufacturing Company.

The spheres were mixed with the base oil at 75° F. until an homogeneous mixture was formed.

The resulting packer fluid had a weight of 5.95 pounds per gallon and a thermal conductivity of 0.07 Btu/hour sq. foot ° F./foot.

This packer fluid can also be thickened by the addition thereto of 6 volume percent of the emulsifier of Example 1.

Reasonable variations and modifications are possible within the scope of this disclosure without departing from the spirit and scope of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a method for drilling a well through a permafrost zone, the improvement comprising providing at least one annulus zone in said wellbore, said annulus zone extending at least through said permafrost zone, and substantially filling said at least one annulus zone during at least part of the drilling of said well with a thermal insulating well packer fluid consisting essentially of an effective thermal insulating amount of hollow shapes of a material selected from the group consisting of glass and plastic, said shapes passing through a 50 mesh sieve, said shapes having a grain density of from about 0.2 to about 0.4 grams/cubic centimeter, said shapes having a thermal conductivity in bulk of no greater than about 0.08 Btu/hour sq. foot ° F./foot, the remainder being essentially a hydrocarbonaceous oil.

2. A method according to claim 1 wherein said material is glass.

3. A method according to claim 1 wherein there is additionally present an effective insulating amount of at least one agent selected from the group consisting of ethane and ethylene having from 3 to 6, inclusive, halogen atoms per molecule and which is liquid at 200° F. under a pressure of at least 200 psig, has a weight in said liquid state of at least about 7 pounds/gallon, and a thermal conductivity in said liquid state of no greater than about 0.08 Btu/hour sq. foot ° F./foot.

4. A method according to claim 3 wherein said additional insulating agent is selected from the group consisting of trichlorotrifluoroethane, dichlorotetrafluoroethane, and trichloroethylene.

5. A method according to claim 1 wherein there is additionally present an effective weighting amount of at least one agent selected from the group consisting of ethane and ethylene having from 3 to 6, inclusive, halogen atoms per molecule and which is liquid at 200° F. under a pressure of at least 200 psig, has a weight in said liquid state of at least about 7 pounds/gallon, and a thermal conductivity in said liquid state of no greater than about 0.08 Btu/hour sq. foot ° F./foot.

6. A method according to claim 5 wherein said additional weighting agent is selected from the group consisting of trichlorotrifluoroethane, dichlorotetrafluoroethane, and trichloroethylene present in an amount sufficient to give the packer fluid a weight of at least about 7 pounds/gallon.

7. A method according to claim 1 wherein said shapes are present in amounts of at least about 12 weight percent based on the total weight of the packer fluid.

8. A method according to claim 1 wherein said shapes are spherical and have a diameter range such that they will pass through a 50 mesh sieve but are no less than about 10 microns in diameter.

9. In a method for producing a well through a permafrost zone, the improvement comprising providing at least one annulus zone in said wellbore, said annulus zone extending at least through said permafrost zone, and substantially filling said at least one annulus zone during at least part of the producing of said well with a thermal insulating well packer fluid consisting essentially of an effective thermal insulating amount of hollow shapes of a material selected from the group consisting of glass and plastic, said shapes passing through a 50 mesh sieve, said shapes having a grain density of from about 0.2 to about 0.4 grams/cubic centimeter, said shapes having a thermal conductivity in bulk of no greater than about 0.08 Btu/hour sq. foot ° F./foot, the remainder being essentially a hydrocarbonaceous oil.

10. A method according to claim 9 wherein said material is glass.

11. A method according to claim 9 wherein there is additionally present an effective insulating amount of at least one agent selected from the group consisting of ethane and ethylene having from 3 to 6, inclusive, halogen atoms per molecule and which is liquid at 200° F. under a pressure of at least 200 psig, has a weight in said liquid state of at least about 7 pounds/gallon, and a thermal conductivity in said liquid state of no greater than about 0.08 Btu/hour sq. foot ° F./foot.

12. A method according to claim 11 wherein said additional insulating agent is selected from the group consisting of trichlorotrifluoroethane, dichlorotetrafluoroethane, and trichloroethylene.

13. A method according to claim 9 wherein there is additionally present an effective weighting amount of at least one agent selected from the group consisting of ethane and ethylene having from 3 to 6, inclusive, halogen atoms per molecule and which is liquid at 200° F. under a pressure of at least 200 psig, has a weight in said liquid state of at least about 7 pounds/gallon, and a thermal conductivity in said liquid state of no greater than about 0.08 Btu/hour sq. foot ° F./foot.

14. A method according to claim 13 wherein said additional weighting agent is selected from the group consisting of trichlorotrifluoroethane, dichlorotetrafluoroethane, and trichloroethylene present in an amount sufficient to give the packer fluid a weight of at least about 7 pounds/gallon.

15. A method according to claim 9 wherein said shapes are present in amounts of at least about 12 weight percent based on the total weight of the packer fluid.

16. A method according to claim 9 wherein said shapes are spherical and have a diameter range such that they will pass through a 50 mesh sieve but are no less than about 10 microns in diameter.

17. A method according to claim 9 wherein there is additionally present an effective thickening amount of at least one gelling agent.

18. A method according to claim 17 wherein said gelling agent is present in an amount of from about 2 to about 10 weight percent based on the total weight of the packer fluid.

19. A method according to claim 9 wherein there is additionally present an effective amount of at least one material selected from the group consisting of weighting agent and viscosifier.

20. A method according to claim 9 wherein said hydrocarbonaceous oil is Diesel oil.

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