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(54) Titre : ADDITIF POUR BOUES DE FORAGE A BASE DE PETROLE  
 (54) Title: ADDITIVE FOR OIL-BASED DRILLING FLUIDS

(57) **Abrégé/Abstract:**

A method and product is disclosed which provides emulsion stability and filtration control to invert emulsion drilling fluids. The product comprises a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles, preferably carboxylic acids, polycarboxylic acids, acid anhydrides, or combinations or mixes thereof, with a mixture of fatty acids and resin acids. The product is extremely effective, decreasing by about two-thirds the amount of emulsifier generally required to formulate an effective drilling fluid. The product also greatly reduces and in many cases eliminates the need for conventional fluid loss additives, and additionally provides electrical stability. Moreover, the product has a pour point as low as about 20 degrees Fahrenheit with minimal solvents, thereby eliminating the need to ship large amounts of inert material for use, and may be transported in a highly active state.

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(54) Title: ADDITIVE FOR OIL-BASED DRILLING FLUIDS

(57) Abstract: A method and product is disclosed which provides emulsion stability and filtration control to invert emulsion drilling fluids. The product comprises a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles, preferably carboxylic acids, polycarboxylic acids, acid anhydrides, or combinations or mixes thereof, with a mixture of fatty acids and resin acids. The product is extremely effective, decreasing by about two-thirds the amount of emulsifier generally required to formulate an effective drilling fluid. The product also greatly reduces and in many cases eliminates the need for conventional fluid loss additives, and additionally provides electrical stability. Moreover, the product has a pour point as low as about 20 degrees Fahrenheit with minimal solvents, thereby eliminating the need to ship large amounts of inert material for use, and may be transported in a highly active state.

**ADDITIVE FOR OIL-BASED DRILLING FLUIDS****BACKGROUND OF THE INVENTION****1. Field of the Invention**

5 The present invention relates to methods for drilling boreholes in subterranean formations, particularly hydrocarbon bearing formations, and to drilling fluids for use in such drilling operations. More particularly, the present invention relates to oil or synthetic based drilling fluids, fluids comprising invert emulsions, and more particularly drilling fluid additives that facilitate or enhance emulsification, electrical stability or filtration properties of the drilling fluid.

**10 2. Description of Relevant Art**

A drilling fluid or mud is a specially designed fluid that is circulated through a wellbore as the wellbore is being drilled to facilitate the drilling operation. The various functions of a drilling fluid include removing drill cuttings from the wellbore, cooling and lubricating the drill bit, aiding in support of the drill pipe and drill bit, and providing a hydrostatic head to maintain the integrity of the wellbore walls and prevent well blowouts. Specific drilling fluid systems are selected to optimize a drilling operation in accordance with the characteristics of a particular geological formation.

Oil or synthetic-based muds, or invert emulsions, are normally used to drill swelling or sloughing shales, salt, gypsum, anhydrite or other evaporite formations, hydrogen sulfide-containing formations, and hot (greater than about 300 degrees Fahrenheit) holes, but may be used in other holes penetrating a subterranean formation as well. These non-aqueous based drilling fluids typically contain oil or a synthetic oil or other synthetic material or synthetic fluid ("synthetic") as the continuous phase and may also contain water which is dispersed in the continuous phase by emulsification so that there is no distinct layer of water in the fluid. The term "oil mud" or "oil or synthetic-based mud" typically means an invert oil mud emulsion or invert emulsion. An all oil mud simply comprises 100% oil by volume as the liquid phase; that is, there is no aqueous internal phase. An invert emulsion drilling fluid may commonly comprise between about 50:50 to 95:5 by volume oil phase to water phase.

Most commonly, invert emulsions used in drilling typically comprise: a base oil or synthetic fluid for the external phase; a saline, aqueous solution for the internal phase (typically a solution comprising about 30% calcium chloride); and other agents or additives for suspension, fluid loss, density, oil-wetting, emulsification, filtration, and rheology control. With space at some well sites limited, such as on offshore platforms, and with increasing costs of transport of materials to a wellsite, there is industry-wide interest in, and on-going need for, more efficient and

concentrated drilling fluid additives and for drilling fluids which can be formulated and maintained with minimal or fewer additives than common with prior art drilling fluids.

### **SUMMARY OF THE INVENTION**

5 An improved and more efficient material or product and method is disclosed for providing emulsion stability and filtration control to invert emulsions and other oil or synthetic based drilling fluids for use in drilling boreholes in subterranean formations, particularly hydrocarbon bearing formations.

10 The product of the invention has the advantage of a pour point at temperatures as low as about 20 degrees Fahrenheit with minimal solvent. Thus, the product of the invention may be transported in a highly (about 90% to about 100%) active state, which reduces the need to inventory products containing different solvents for compatibility with the drilling fluid. This advantage further eliminates the need for shipping large amounts of inert material. Moreover, the product of the invention has the further advantage of providing high levels of filtration control to a drilling fluid made with conventional emulsifiers, especially at temperatures up to about 250°F. 15 Still further, the product of this invention, when added to drilling fluids, reduces or eliminates the need for conventional fluid loss additives.

The product of this invention comprises two primary components or parts. One part is a carboxylic acid-terminated polyamide and the other part is itself a mixture produced by the Diels-Alder reaction of dienophiles, preferably carboxylic acids, polycarboxylic acids, acid anhydrides, 20 or combinations or mixes thereof, with a mixture of fatty acids and resin acids. These two components or parts are blended or mixed and further reacted with cations to form soaps. This saponification reaction may be achieved in the manufacturing process or it may be effected "in situ" by the presence of or addition of cations to the drilling fluid. As used herein, the term "in situ" shall be understood to mean in the drilling fluid. Typically, such saponification reaction will occur in the drilling fluid when the drilling fluid is being prepared for use as a drilling fluid or when the drilling fluid is in use as a drilling fluid in drilling a borehole in a subterranean formation. Drilling fluids commonly comprise cations. Sources of such cations include, without limitation, lime, quicklime, and calcium chloride, among others. Further, drilling fluids may incorporate cations contacted in or available from the subterranean formation itself. The method 25 of the invention employs the product of the invention for improved drilling fluids and improved drilling of boreholes in subterranean formations.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a graph comparing the electrical stability of a synthetic based drilling fluid

containing the product of the invention with the same synthetic based drilling fluid containing conventional emulsifiers instead of the product of the invention, using data from Tables 1 and 2.

Figure 2 is a graph comparing HTHP filtration of a synthetic based drilling fluid containing the product of the invention with the same synthetic based drilling fluid containing conventional emulsifiers instead of the product of the invention, using data from Tables 3 and 4.

#### **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

The product of the invention comprises a blend, mixture, or a combination (hereinafter "blend") of a carboxylic acid-terminated polyamide (Component A) and a mixture (Component B) produced by the Diels-Alder reaction of dienophiles, preferably carboxylic acids, polycarboxylic acids, and anhydrides, or combinations or mixes thereof, with a mixture of fatty acids and resin acids. According to one example, the dienophiles are maleic anhydrides. Component B has a ratio of fatty acids to resin acids preferably ranging from about 4:1 to about 1:1 and a most preferred ratio of about 2:1 and is preferably comprised of fatty acids and resin acids derived from the distillation of crude tall oil.

Component A is preferably concentrated (i.e., about 90% active), and typically made from the condensation reaction between fatty acids and polyamines. The fatty acids and polyamines are reacted in such proportion as to create a "partial amide" intermediate product having a mole ratio of the reactive acid sites to amine sites ranges from about 0.5:1 to about 0.75:1 and most preferably about 0.6:1. This partial amide intermediate product is diluted with a minimum amount of solvent, as needed for further processing, and the remaining amine sites are further reacted with an acid anhydride or polycarboxylic acid to produce the carboxylic acid-terminated polyamide. A most preferred carboxylic acid-terminated fatty polyamide for use in the invention is EZ-MUL<sup>®</sup>NT CONCENTRATE, the active constituent of EZ-MUL<sup>®</sup>NT available from Halliburton Energy Services, Inc. in Houston, Texas, although other carboxylic acid terminated fatty polyamides are believed to be useable.

In comprising the product of the invention, the preferred ratio of Component A to Component B is about 1:5 to about 1:1. Ratios of Component A to Component B of about 1:2 to about 1:3 are most preferred. The exact ratio of these two components or parts may vary greatly depending on the exact desired characteristics of the product. Preferably, however, the quantity of Component B will exceed the quantity of Component A.

The blend comprising the product of the invention is preferably made by blending, mixing, or combining these two components - the polyamide and the modified fatty acid/resin acid mixture - together. After blending, the polyamide and fatty acid/resin acid components are

reacted with cations to form soaps. Such reaction or saponification may be achieved as part of the manufacturing process of the product of the invention or may be effected in situ the drilling fluid

by the presence or addition of cations to the drilling fluid. Calcium cations are preferred and may be obtained, for example, by reacting the polyamide and modified fatty acid/resin acid components with lime, quicklime, or calcium chloride.

5 Tall oil is a commonly known product made from acid treatment of alkaline liquors obtained from the manufacture of wood pulp, and tall oil and its derivatives have previously been used in oil-well drilling muds. However, the modified fatty acid/resin acid component of the blend of the product of the invention alone is not effective for achieving the advantages of the invention. EZ-MUL® is known to have utility as an emulsifier for oil based drilling fluids. However, carboxylic acid- terminated fatty polyamides alone cannot achieve all of the advantages of the  
10 invention. In the combination disclosed, however, the blend (or mixture) comprising the product of the invention provides a marked advance in the art.

The product of the invention is a powerfully efficient additive for oil or synthetic based drilling fluids, affording or effecting enhanced emulsification, and improved electrical stability and fluid loss control, with significantly less volume of additive than previously known or  
15 available with prior art drilling fluid additives. The product effects or helps facilitate emulsification typically in amounts of about one-third the quantity commonly needed for emulsification of oil or synthetic based fluids with prior art emulsifiers. That is, amounts of about three pounds to about five pounds of the product of the invention per barrel of drilling fluid can be effective for emulsification. Even lower quantities can improve the electrical stability and  
20 filtration control of drilling fluids, even if already emulsified with other emulsifiers.

The product of the invention does not rely on a carrier. The material comprising the product is highly active and is believed to be useful with all or substantially all synthetic and oil-based systems known to be effective for drilling fluids. The product of the invention may also add viscosity to the drilling fluid and thus is preferably added to the base drilling fluid before any  
25 weighting agents such as barite, for example, are added.

The product of this invention is stable even at temperatures up to (and including) about 250 degrees Fahrenheit without filtration additives and up to about 300 to about 350 degrees Fahrenheit with filtration additives. Adding wetting agents along with the product of the invention in an emulsifier package may improve the oil-wetting nature of the drilling fluid in some base oils  
30 but will not be needed in others. Wetting agents may also improve the rheological stability at temperatures up to about 300°F. The addition of wetting agents to drilling fluids comprising the product of the invention may also further enhance performance of some fluid systems.

The product of the invention has a high acid value. Consequently, improved results may be seen when a neutralizer or neutralizing agent is added to the drilling fluid. For example, a

minimum of about eight pounds of lime (or similar saponifying agent) might favorably be added per barrel of drilling fluid when about three pounds per barrel of the product of the invention are used in the drilling fluid. Additional lime (or similar saponifying agent) may be helpful or needed with larger quantities of product of the invention for optimum results, although satisfactory results might also be obtained with less.

Care is recommended when using the product of this invention to avoid over-treating. Excess emulsifiers (i.e., more than needed to effect emulsification) in drilling fluids can contribute to high fluid viscosity at cold temperatures (i.e., temperatures less than about 45 degrees Fahrenheit). For deepwater operations (i.e., use of drilling fluids at depths of water greater than about 500 feet and at temperatures less than about 45 degrees Fahrenheit), wetting agents may preferably be added to help maintain low riser viscosities as drill solids are incorporated in or become carried by the drilling fluid.

The method of the invention comprises adding the product of the invention to an oil or synthetic based drilling fluid or employing a drilling fluid comprising the product of the invention in drilling a borehole in a subterranean formation. In another embodiment, the method of the invention comprises adding the product of the invention to an oil or synthetic based drilling fluid to facilitate emulsification of the drilling fluid or the formation of invert emulsions.

Experiments were conducted that demonstrate or exemplify the invention. Several formulations of synthetic or oil-based drilling fluids were prepared, typical of those used in the field, and all of which comprised invert emulsions. Specifically, samples of drilling fluids were prepared comprising a synthetic or diesel oil base, to which additives were added, including the product of the invention or a known emulsifier for comparison, as indicated in Tables 1-12 below. The different samples were subjected to different conditions, such as high temperatures or hot rolling, or further additives or contaminants, for example, simulated drill solids or salt water, for comparison of performance and properties. The results of tests tabulated in Tables 1-4 are graphed in Figures 1 and 2.

As used in the tables, the following compounds or products have the meanings indicated below:

SF BASE™ is a synthetic oil base for drilling fluids typically used in drilling mud systems such as PETROFREE®SF, available from Halliburton Energy Services, Inc. in Houston Texas;  
LE BASE™ is a synthetic oil base for drilling fluids typically used in drilling mud systems such as PETROFREE® LE;  
GELTONE® II, is an organoclay for improving viscosity characteristics;

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SUSPENTONE® is an organoclay for improving the ability of a drilling fluid to suspend drill cuttings;

INVERMUL® is an emulsifier;

EZ MUL® is an emulsifier;

5 LE SUPERMUL® is an emulsifier;

LE MUL® is an emulsifier;

DRILTREAT™ is a wetting agent;

DEEP-TREAT™ is a wetting agent;

BAROID® is barite, a weighting agent;

10 DURATONE® HT is a filtration control agent; and

BDF-258™ is the product of the invention.

All trademarks are the property of Halliburton Energy Services, Inc. and the products are available from Halliburton Energy Services, Inc. in Houston, Texas.

TABLE 1

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**

| Sample Mark   | A (7.33 lb/bbl Active emulsifier content) |           |            |           |            |                 |            |
|---|---|-----------|------------|-----------|------------|-----------------|------------|
| SF BASE, bbl  | 0.516                                     |           |            |           |            |                 |            |
| Freshwater, bbl   | 0.181                                     |           |            |           |            |                 |            |
| GELTONE® II, lb   | 3   |           |            |           |            |                 |            |
| SUSPENTONE™, lb   | 1   |           |            |           |            |                 |            |
| LE™ MUL, lb   | 4   |           |            |           |            |                 |            |
| LE™ SUPERMUL, lb  | 6   |           |            |           |            |                 |            |
| Lime, lb  | 5   |           |            |           |            |                 |            |
| DURATONE® HT, lb  | 7   |           |            |           |            |                 |            |
| BAROID®, lb   | 330                                       |           |            |           |            |                 |            |
| Calcium chloride, lb  | 21.9                                      |           |            |           |            |                 |            |
| DEEP-TREAT™, lb   | 3   |           |            |           |            |                 |            |
| Mixed 15 minutes at 7000 rpm on a Silverson LART before testing; mixed 10 minutes after rolling |   |           |            |           |            |                 |            |
| Rev Dust, lb  | —   |           | 45         |           | —          |                 |            |
| 15% NaCl Brine Added, % vol   | —   |           | —          |           | 33         |                 |            |
| Hot rolled @250°F, hr   | —   | 16        |            | 16        |            | 16              |            |
| <i>Temperature, °F</i>  | <i>120</i>                                | <i>40</i> | <i>120</i> | <i>40</i> | <i>120</i> | <i>40</i>       | <i>120</i> |
| Plastic viscosity, cP   | 23  | 80        | 24         | 112       | 37         | 108             | 38         |
| Yield point, lb/100 ft <sup>2</sup>   | 15  | 18        | 8          | 19        | 8          | 26              | 11         |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 8   | 7         | 6          | 10        | 7          | 9               | 6          |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 9   | 11        | 8          | 18        | 10         | 12              | 10         |
| Electrical stability, v   | 690                                       | 235       |            | 488       |            | 77              |            |
| HTHP filtrate @250°F, ml  | 2.4                                       | 2.4       |            | 10.4      |            | 7.6 (0.5 water) |            |
| Fann 35 dial readings   |   |           |            |           |            |                 |            |
| 600 rpm   | 61  | 178       | 56         | 243       | 82         | 242             | 87         |
| 300 rpm   | 38  | 98        | 32         | 131       | 45         | 134             | 49         |
| 200 rpm   | 29  | 69        | 24         | 91        | 33         | 94              | 36         |
| 100 rpm   | 20  | 38        | 15         | 51        | 20         | 53              | 23         |
| 6 rpm   | 7   | 7         | 5          | 10        | 5          | 10              | 7          |
| 3 rpm   | 6   | 6         | 4          | 9         | 4          | 8               | 6          |

Note: Contaminated samples were made up with mud already hot rolled 16 hr.@250°F

TABLE 2

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**

| Sample Mark   | H3    |     |     |     |     |     |     |     |     |     |
|---|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SF BASE, bbl  | 0.516 |     |     |     |     |     |     |     |     |     |
| Freshwater, bbl   | 0.181 |     |     |     |     |     |     |     |     |     |
| GELTONE® II, lb   | 3     |     |     |     |     |     |     |     |     |     |
| SUSPENTONE™, lb   | 1     |     |     |     |     |     |     |     |     |     |
| BDF-258, lb   | 3     |     |     |     |     |     |     |     |     |     |
| Lime, lb  | 8     |     |     |     |     |     |     |     |     |     |
| DURATONE® HT, lb  | 7     |     |     |     |     |     |     |     |     |     |
| BAROID®, lb   | 330   |     |     |     |     |     |     |     |     |     |
| Calcium chloride, lb  | 21.9  |     |     |     |     |     |     |     |     |     |
| DEEP-TREAT™, lb   | 3     |     |     |     |     |     |     |     |     |     |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |       |     |     |     |     |     |     |     |     |     |
| Rev Dust, lb  | —     |     |     |     |     |     |     |     |     |     |
| 15% NaCl Brine Added, % vol   | —     |     |     |     |     |     |     |     |     |     |
| Hot rolled @250°F, hr   | 16    |     |     |     |     |     |     |     |     |     |
| <b>Temperature, °F</b>  | 120   | 40  | 120 | 40  | 120 | 40  | 120 | 40  | 120 | 40  |
| Plastic viscosity, cP   | 29    | 78  | 27  | 72  | 26  | N/A | 49  | 113 | 43  | 43  |
| Yield point, lb/100 ft <sup>2</sup>   | 16    | 33  | 14  | 24  | 12  | N/A | 24  | 43  | 20  | 20  |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 8     | 15  | 7   | 13  | 7   | 27  | 16  | 19  | 13  | 13  |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 10    | 17  | 9   | 15  | 9   | 57  | 36  | 20  | 13  | 13  |
| Electrical stability, v   | 638   |     |     |     |     |     |     |     |     |     |
| HTHP filtrate @250°F, ml  | 669   |     |     |     |     |     |     |     |     |     |
| Fann 35 dial readings   | 2.0   |     |     |     |     |     |     |     |     |     |
| 600 rpm   | 74    | 189 | 68  | 168 | 64  | O/S | 122 | 269 | 106 | 106 |
| 300 rpm   | 45    | 111 | 41  | 96  | 38  | 186 | 73  | 156 | 63  | 63  |
| 200 rpm   | 35    | 82  | 32  | 72  | 30  | 139 | 56  | 116 | 48  | 48  |
| 100 rpm   | 24    | 53  | 22  | 45  | 20  | 88  | 38  | 72  | 32  | 32  |
| 6 rpm   | 9     | 17  | 8   | 14  | 8   | 29  | 15  | 21  | 12  | 12  |
| 3 rpm   | 8     | 15  | 7   | 12  | 7   | 26  | 14  | 19  | 11  | 11  |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already rolled 16 hr @250°F

TABLE 3

**PETROFREE® LE**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**

| <i>Sample Mark</i>  | <b>C</b>             |                     |
|---|----------------------|---------------------|
| LE BASE, bbl  | 0.5094               |                     |
| Freshwater, bbl   | 0.1793               |                     |
| GELTONE® II, lb   | 3.5                  |                     |
| SUSPENTONE™, lb   | 2                    |                     |
| LE™ MUL, lb   | 7                    |                     |
| LE™ SUPERMUL, lb  | 4                    |                     |
| Lime, lb  | 7                    |                     |
| DURATONE® HT, lb  | 6                    |                     |
| Calcium chloride, lb  | 21.8                 |                     |
| BAROID®, lb   | 332.3                |                     |
| DEEP-TREAT™, lb   | 3.5                  |                     |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |                      |                     |
| Rev Dust, lb  | —                    | 45                  |
| 15% NaCl Brine Added, % vol   | —                    | 33                  |
| Hot rolled @250°F, hr   | —                    | 16                  |
| <i>Temperature, °F</i>  | 40 120 40 120 40 120 | 40 120 40 120       |
| Plastic viscosity, cP   | 23 94 22 77 23 82    | 32 87 35            |
| Yield point, lb/100 ft <sup>2</sup>   | 12 51 9 18 6 12      | 5 14 4              |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 6 17 6 9 5 8         | 5 7 5               |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 9 21 8 15 7 15       | 8 10 6              |
| Electrical stability, v   | 737 676 474          | 545 230             |
| HTHP filtrate @250°F, ml  | 4.4 2.0              | 10.0 12.0-1.1 emul. |
| Fann 35 dial readings   |                      |                     |
| 600 rpm   | 58 239 53 172 52 176 | 69 188 74           |
| 300 rpm   | 35 145 31 95 29 94   | 37 101 39           |
| 200 rpm   | 26 108 24 67 22 66   | 28 70 29            |
| 100 rpm   | 17 66 16 38 13 37    | 17 38 17            |
| 6 rpm   | 6 19 5 9 4 8         | 4 7 5               |
| 3 rpm   | 5 17 4 8 3 7         | 3 6 4               |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already hot rolled 16 hr @250°F

TABLE 4

**PETROFREE® LE**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**

| Sample Mark   | B2     |     |     |     |     |     |     |     |     |    |     |    |     |
|---|--------|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|----|-----|
| LE BASE, bbl  | 0.5163 |     |     |     |     |     |     |     |     |    |     |    |     |
| Freshwater, bbl   | 0.1796 |     |     |     |     |     |     |     |     |    |     |    |     |
| GELTONE® II, lb   | 3      |     |     |     |     |     |     |     |     |    |     |    |     |
| SUSPENTONE™, lb   | 2      |     |     |     |     |     |     |     |     |    |     |    |     |
| BDF-258, lb   | 3      |     |     |     |     |     |     |     |     |    |     |    |     |
| Lime, lb  | 7      |     |     |     |     |     |     |     |     |    |     |    |     |
| DURATONE® HT, lb  | 6      |     |     |     |     |     |     |     |     |    |     |    |     |
| Calcium chloride, lb  | 21.8   |     |     |     |     |     |     |     |     |    |     |    |     |
| BAROID®, lb   | 333.2  |     |     |     |     |     |     |     |     |    |     |    |     |
| DEEP-TREAT™, lb   | 3.3    |     |     |     |     |     |     |     |     |    |     |    |     |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |        |     |     |     |     |     |     |     |     |    |     |    |     |
| Rev Dust, lb  | 45     |     |     |     |     |     |     |     |     |    |     |    |     |
| 15% NaCl Brine Added, % vol   | 33     |     |     |     |     |     |     |     |     |    |     |    |     |
| Hot rolled @250°F, hr   | 16     |     |     |     |     |     |     |     |     |    |     |    |     |
| <b>Temperature, °F</b>  | 120    | 40  | 120 | 40  | 120 | 40  | 120 | 40  | 120 | 40 | 120 | 40 | 120 |
| Plastic viscosity, cP   | 26     | 72  | 23  | 64  | 23  | 98  | 34  | 96  | 36  | 36 | 36  | 36 | 36  |
| Yield point, lb/100 ft <sup>2</sup>   | 12     | 29  | 9   | 16  | 7   | 26  | 6   | 32  | 11  | 11 | 11  | 11 | 11  |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 7      | 14  | 6   | 12  | 6   | 13  | 6   | 16  | 10  | 10 | 10  | 10 | 10  |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 9      | 18  | 8   | 16  | 9   | 28  | 8   | 21  | 9   | 9  | 9   | 9  | 9   |
| Electrical stability, v   | 574    |     |     |     |     |     |     |     |     |    |     |    |     |
| HTHP filtrate @250°F, ml  | 3.0    |     |     |     |     |     |     |     |     |    |     |    |     |
| Fann 35 dial readings   |        |     |     |     |     |     |     |     |     |    |     |    |     |
| 600 rpm   | 64     | 173 | 55  | 144 | 53  | 222 | 74  | 224 | 83  | 83 | 83  | 83 | 83  |
| 300 rpm   | 38     | 101 | 32  | 80  | 30  | 124 | 40  | 128 | 47  | 47 | 47  | 47 | 47  |
| 200 rpm   | 29     | 75  | 25  | 58  | 23  | 89  | 29  | 94  | 36  | 36 | 36  | 36 | 36  |
| 100 rpm   | 20     | 47  | 17  | 35  | 15  | 52  | 18  | 58  | 23  | 23 | 23  | 23 | 23  |
| 6 rpm   | 7      | 15  | 6   | 10  | 6   | 13  | 4   | 16  | 8   | 8  | 8   | 8  | 8   |
| 3 rpm   | 6      | 14  | 5   | 9   | 5   | 11  | 3   | 14  | 7   | 7  | 7   | 7  | 7   |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already hot rolled 16 hr @250°F

TABLE 5

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**

| Sample Mark   | H2    |     |     |     |     |     |     |     |     |     |
|---|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SF BASE, bbl  | 0.516 |     |     |     |     |     |     |     |     |     |
| Freshwater, bbl   | 0.181 |     |     |     |     |     |     |     |     |     |
| GELTONE® II, lb   | 3     |     |     |     |     |     |     |     |     |     |
| SUSPENTONE™, lb   | 1     |     |     |     |     |     |     |     |     |     |
| BDF-258, lb   | 3     |     |     |     |     |     |     |     |     |     |
| Lime, lb  | 8     |     |     |     |     |     |     |     |     |     |
| DURATONE® HT, lb  | 7     |     |     |     |     |     |     |     |     |     |
| BAROID®, lb   | 330   |     |     |     |     |     |     |     |     |     |
| Calcium chloride, lb  | 21.9  |     |     |     |     |     |     |     |     |     |
| DEEP-TREAT™, lb   | 3     |     |     |     |     |     |     |     |     |     |
| DRILTREAT®, lb  | 1     |     |     |     |     |     |     |     |     |     |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |       |     |     |     |     |     |     |     |     |     |
| Rev Dust, lb  | —     |     |     |     |     |     |     |     |     |     |
| 15% NaCl Brine Added, % vol   | —     |     |     |     |     |     |     |     |     |     |
| Hot rolled @250°F, hr   | 16    |     |     |     |     |     |     |     |     |     |
| Temperature, °F   | 120   | 40  | 120 | 40  | 120 | 40  | 120 | 40  | 120 | 40  |
|   | 28    | 82  | 25  | 86  | 25  | N/A | 46  | 116 | 41  | 120 |
| Plastic viscosity, cP   | 14    | 36  | 16  | 29  | 14  | N/A | 22  | 45  | 22  | 22  |
|   | 7     | 17  | 7   | 14  | 8   | 28  | 18  | 19  | 12  | 12  |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 10    | 20  | 9   | 18  | 10  | 60  | 31  | 21  | 12  | 12  |
|   | 603   | 694 | 684 | 846 | 409 | 1.6 | 4.0 | 1.6 | 1.6 | 1.6 |
| Electrical stability, v   | 846   |     |     |     |     |     |     |     |     |     |
| HTHP filtrate @250°F, ml  | 4.0   |     |     |     |     |     |     |     |     |     |
| Fann 35 dial readings   |       |     |     |     |     |     |     |     |     |     |
| 600 rpm   | 70    | 200 | 66  | 201 | 64  | O/S | 114 | 277 | 104 | 104 |
| 300 rpm   | 42    | 118 | 41  | 115 | 39  | 201 | 68  | 161 | 63  | 63  |
| 200 rpm   | 33    | 89  | 32  | 84  | 30  | 149 | 52  | 119 | 48  | 48  |
| 100 rpm   | 22    | 57  | 22  | 51  | 21  | 93  | 34  | 74  | 33  | 33  |
| 6 rpm   | 8     | 19  | 8   | 15  | 8   | 28  | 13  | 22  | 13  | 13  |
| 3 rpm   | 7     | 17  | 7   | 14  | 7   | 24  | 12  | 19  | 12  | 12  |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already rolled 16 hr @250°F

TABLE 6

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**  
**NO DURATONE® HT**

| Sample Mark   | O     |     |           |     |     |     |     |      |     |     |
|---|-------|-----|-----------|-----|-----|-----|-----|------|-----|-----|
| SF BASE, lb   | 0.516 |     |           |     |     |     |     |      |     |     |
| Freshwater, bbl   | 0.181 |     |           |     |     |     |     |      |     |     |
| GELTONE® II, lb   | 4     |     |           |     |     |     |     |      |     |     |
| SUSPENTONET™, lb  | 1     |     |           |     |     |     |     |      |     |     |
| BDF-258, lb   | 3     |     |           |     |     |     |     |      |     |     |
| Lime, lb  | 9     |     |           |     |     |     |     |      |     |     |
| Calcium chloride, lb  | 21.9  |     |           |     |     |     |     |      |     |     |
| BAROID®, lb   | 330   |     |           |     |     |     |     |      |     |     |
| DRILTREAT®, lb  | 1     |     |           |     |     |     |     |      |     |     |
| DEEP-TREAT™, lb   | 3     |     |           |     |     |     |     |      |     |     |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |       |     |           |     |     |     |     |      |     |     |
| Hot rolled @250°F, hr   | —     | —   | —         | 16  | 16  | 16  | 16  | 16   | 16  | 16  |
| Rev Dust, lb  | —     | —   | —         | —   | —   | —   | 45  | —    | —   | —   |
| 15% NaCl brine, % vol   | —     | —   | —         | —   | —   | —   | —   | —    | —   | 33  |
| Temperature, °F   | 120   | 40  | 120       | 40  | 120 | 40  | 120 | 40   | 120 | 120 |
| Plastic viscosity, cP   | 28    | 88  | 33        | 85  | 29  | N/A | 50  | N/A  | 69  | 69  |
| Yield point, lb/100 ft <sup>2</sup>   | 5     | 19  | 8         | 20  | 8   | N/A | 5   | N/A  | 45  | 45  |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 5     | 10  | 7         | 9   | 5   | 5   | 3   | 48   | 25  | 25  |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 8     | 14  | 9         | 13  | 7   | 14  | 10  | > 60 | 62  | 62  |
| Electrical stability @120°F, v  | 471   | 519 | 496 / 230 | 218 | 285 | 285 | 285 | 285  | 285 | 285 |
| HTHP filtrate @250°F, ml  | 1.6   |     |           |     |     |     |     |      |     |     |
| Fann 35 dial readings   |       |     |           |     |     |     |     |      |     |     |
| 600 rpm   | 61    | 195 | 74        | 190 | 66  | 105 | 105 | O/S  | 183 | 183 |
| 300 rpm   | 33    | 107 | 41        | 105 | 37  | 173 | 55  | O/S  | 114 | 114 |
| 200 rpm   | 25    | 75  | 31        | 75  | 27  | 123 | 39  | 256  | 87  | 87  |
| 100 rpm   | 16    | 43  | 20        | 44  | 17  | 68  | 21  | 163  | 57  | 57  |
| 6 rpm   | 5     | 10  | 7         | 10  | 5   | 7   | 3   | 45   | 26  | 26  |
| 3 rpm   | 4     | 8   | 6         | 8   | 4   | 5   | 2   | 40   | 24  | 24  |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already rolled 16 hr @250°F

TABLE 7

**INVERMUL®**  
14 lb/gal; 250,000 WPS

| Sample Mark                         | 1            | 2            | 3            | 4            | 5            |      |      |     |
|-------------------------------------|--------------|--------------|--------------|--------------|--------------|------|------|-----|
| Diesel, bbl                         | 0.5395       | 0.5234       | 0.5679       | 0.5743       | 0.5608       |      |      |     |
| Fresh water, bbl                    | 0.1814       | 0.1815       | 0.1449       | 0.1453       | 0.1454       |      |      |     |
| <i>Oil-to-Water Ratio</i>           | <i>75/25</i> | <i>75/25</i> | <i>80/20</i> | <i>80/20</i> | <i>80/20</i> |      |      |     |
| GELTONE® II, lb                     | 2            | 2            | 2            | 2            | 2            |      |      |     |
| SUSPENTONE™, lb                     | 1            | 1            | —            | —            | —            |      |      |     |
| BDF-258, lb                         | 3.5          | -            | 6            | 3            | —            |      |      |     |
| INVERMUL® NT, lb                    | —            | 3            | —            | —            | 3            |      |      |     |
| Lime, lb                            | 8            | 8            | 12           | 8            | 8            |      |      |     |
| DURATONE® HT, lb                    | 6            | 6            | 6            | 6            | 6            |      |      |     |
| EZ MUL® NT, lb                      | —            | 6            | —            | —            | 6            |      |      |     |
| Calcium chloride, lb                | 22.0         | 22.1         | 17.6         | 17.7         | 17.7         |      |      |     |
| BAROID®, lb                         | 302          | 301          | 307          | 310          | 309          |      |      |     |
| Rev Dust, lb                        | 20           | 20           | 20           | 20           | 20           |      |      |     |
| DRILTREAT®, lb                      | —            | —            | —            | 1.5          | —            |      |      |     |
| Hot rolled @300°F, hr               | —            | —            | —            | 16           | —            | 16   | —    | 16  |
| Plastic viscosity @150°F, cP        | 25           | 26           | 21           | 23           | 22           | 19   | 20   | 22  |
| Yield point, lb/100 ft <sup>2</sup> | 31           | 53           | 17           | 11           | 13           | 9    | 30   | 8   |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 26           | 32           | 12           | 14           | 8            | 8    | 16   | 8   |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 34           | 34           | 23           | 29           | 15           | 16   | 16   | 9   |
| Electrical stability, v             | 593          | 1140         | 923          | 1302         | 697          | 783  | 1404 | 766 |
| HTHP filtrate @300°F, ml            | 11.6*        | 3.8          | 6.2          | 16.4         | 5.6          | 10.0 | 5.4  | 7.6 |
| Fann 35 dial readings               |              |              |              |              |              |      |      |     |
| 600 rpm                             | 81           | 105          | 59           | 57           | 57           | 47   | 70   | 52  |
| 300 rpm                             | 56           | 79           | 38           | 34           | 35           | 28   | 50   | 30  |
| 200 rpm                             | 46           | 69           | 30           | 26           | 28           | 21   | 42   | 23  |
| 100 rpm                             | 36           | 56           | 22           | 17           | 19           | 14   | 32   | 16  |
| 6 rpm                               | 21           | 33           | 10           | 8            | 8            | 7    | 17   | 7   |
| 3 rpm                               | 20           | 32           | 9            | 7            | 7            | 6    | 16   | 6   |

\*Trace of water/emulsion was seen in the filtrate.

TABLE 8

**INVERMUL®**  
**14 lb/gal; 80/20 OWR with 250,000 WPS**

| Sample Mark                         | 10    |     | 11    |     |
|-------------------------------------|-------|-----|-------|-----|
| Diesel, bbl                         | 0.577 |     | 0.577 |     |
| Fresh water, bbl                    | 0.145 |     | 0.145 |     |
| GELTONE® II, lb                     | 6     |     | 6     |     |
| BDF-258, lb                         | 3     |     | 3     |     |
| Lime, lb                            | 8     |     | 8     |     |
| Calcium chloride, lb                | 17.6  |     | 17.6  |     |
| DEEP-TREAT™, lb                     | 1.5   |     | 1     |     |
| BAROID®, lb                         | 312   |     | 312   |     |
| Rev Dust, lb                        | 20    |     | 20    |     |
| DRILTREAT®, lb                      | —     |     | 1     |     |
|                                     |       |     |       |     |
| Hot rolled @150°F, hr               | 16    | —   | 16    | —   |
| Hot rolled @250°F, hr               | —     | 16  | —     | 16  |
| Plastic viscosity @150°F, cP        | 23    | 24  | 23    | 24  |
| Yield point, lb/100 ft <sup>2</sup> | 28    | 10  | 25    | 12  |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 17    | 10  | 18    | 11  |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 22    | 16  | 20    | 20  |
| Electrical stability, v             | 686   | 783 | 561   | 723 |
| HTHP filtrate @250°F, ml            | 5.6   | 6.8 | 6.6   | 9.4 |
| HTHP filt.cake thickness, 1/32"     | 4     | 3   | 5     | 5   |
| Fann 35 dial readings               |       |     |       |     |
| 600 rpm                             | 74    | 58  | 71    | 60  |
| 300 rpm                             | 51    | 34  | 48    | 36  |
| 200 rpm                             | 42    | 26  | 39    | 28  |
| 100 rpm                             | 32    | 17  | 30    | 19  |
| 6 rpm                               | 17    | 7   | 17    | 8   |
| 3 rpm                               | 16    | 6   | 17    | 8   |

*Note: 0.4 lb/bbl DEEP-TREAT™ was sufficient to wet in the barite and Rev Dust in mud 11. Additional product was added after the Rev Dust to total 1 lb/bbl.*

TABLE 9

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**  
**NO DURATONE® HT**

| Sample Mark   | I     |     |     |     |     |     |     |     |     |     |
|---|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SF BASE, bbl  | 0.516 |     |     |     |     |     |     |     |     |     |
| Freshwater, bbl   | 0.181 |     |     |     |     |     |     |     |     |     |
| GELTONE® II, lb   | 4     |     |     |     |     |     |     |     |     |     |
| SUSPENTONE™, lb   | 1     |     |     |     |     |     |     |     |     |     |
| BDF-258, lb   | 3.5   |     |     |     |     |     |     |     |     |     |
| Lime, lb  | 9     |     |     |     |     |     |     |     |     |     |
| DURATONE® HT, lb  | -     |     |     |     |     |     |     |     |     |     |
| Calcium chloride, lb  | 21.9  |     |     |     |     |     |     |     |     |     |
| DEEP-TREAT™, lb   | 3     |     |     |     |     |     |     |     |     |     |
| BAROID®, lb   | 330   |     |     |     |     |     |     |     |     |     |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |       |     |     |     |     |     |     |     |     |     |
| Hot rolled @250°F, hr   | —     | —   | —   | —   | 16  | 16  | 16  | 16  | 16  | 16  |
| Rev Dust, lb  | 45    |     |     |     |     |     |     |     |     |     |
| 15% NaCl Brine Added, % vol   | —     |     |     |     |     |     |     |     |     |     |
| Temperature, °F   | 120   | 40  | 120 | 40  | 120 | 40  | 120 | 40  | 120 | 58  |
| Plastic viscosity, cP   | 29    | 85  | 32  | 76  | 31  | N/A | 54  | N/A | 71  | 71  |
| Yield point, lb/100 ft <sup>2</sup>   | 9     | 17  | 9   | 15  | 6   | N/A | 7   | N/A | 53  | 53  |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 7     | 10  | 8   | 9   | 7   | 6   | 4   | 6   | 55  | 34  |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 8     | 15  | 11  | 10  | 7   | 13  | 8   | 8   | -   | 65  |
| Electrical stability, v   | 241   |     |     |     |     |     |     |     |     |     |
| HTHP filtrate @250°F, ml  | 482   | 529 |     | 241 |     | 234 |     | 293 |     | 293 |
| Fann 35 dial readings   | 1.6   |     |     |     |     |     |     |     |     |     |
|   | 2.8*  |     |     |     |     |     |     |     |     |     |
| 600 rpm   | 67    | 187 | 73  | 167 | 68  | O/S | 115 | O/S | 195 | 195 |
| 300 rpm   | 38    | 102 | 41  | 91  | 37  | 186 | 61  | 278 | 124 | 124 |
| 200 rpm   | 29    | 73  | 31  | 65  | 28  | 130 | 43  | 220 | 97  | 97  |
| 100 rpm   | 19    | 42  | 20  | 38  | 18  | 71  | 23  | 151 | 67  | 67  |
| 6 rpm   | 6     | 10  | 7   | 9   | 6   | 8   | 3   | 53  | 29  | 29  |
| 3 rpm   | 5     | 8   | 6   | 7   | 5   | 5   | 2   | 50  | 28  | 28  |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already rolled 16 hr @250°F

\*Some small water droplets were observed in the filtrate

TABLE 10

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**  
**NO DURATONE® HT**

| Sample Mark   | N     |     |     |     |     |     |     |     |     |    |     |    |
|---|-------|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|----|
| SF BASE, lb   | 0.516 |     |     |     |     |     |     |     |     |    |     |    |
| Freshwater, bbl   | 0.181 |     |     |     |     |     |     |     |     |    |     |    |
| GELTONE® II, lb   | 4     |     |     |     |     |     |     |     |     |    |     |    |
| SUSPENTONE™, lb   | 1     |     |     |     |     |     |     |     |     |    |     |    |
| BDF-258, lb   | 3.5   |     |     |     |     |     |     |     |     |    |     |    |
| Lime, lb  | 9     |     |     |     |     |     |     |     |     |    |     |    |
| Calcium chloride, lb  | 21.9  |     |     |     |     |     |     |     |     |    |     |    |
| DEEP-TREAT™, lb   | 4     |     |     |     |     |     |     |     |     |    |     |    |
| BAROID®, lb   | 330   |     |     |     |     |     |     |     |     |    |     |    |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |       |     |     |     |     |     |     |     |     |    |     |    |
| Hot rolled @250°F, hrs  | —     | —   | —   | 16  | 16  | 16  | 16  | 16  | 16  | 16 | 16  | 16 |
| Rev Dust, lb  | 45    |     |     |     |     |     |     |     |     |    |     |    |
| 15% NaCl brine, % vol   | —     |     |     |     |     |     |     |     |     |    |     |    |
| DEEP-TREAT™, lb   | 2     |     |     |     |     |     |     |     |     |    |     |    |
| <i>Temperature, °F</i>  | 120   | 40  | 120 | 40  | 120 | 40  | 120 | 40  | 120 | 40 | 120 | 40 |
| Plastic viscosity, cP   | 35    | 103 | 38  | 80  | 31  | 124 | 44  | N/A | 53  |    |     |    |
| Yield point, lb/100 ft <sup>2</sup>   | 11    | 18  | 11  | 16  | 6   | 22  | 5   | N/A | 10  |    |     |    |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 8     | 10  | 7   | 8   | 6   | 5   | 5   | 8   | 6   |    |     |    |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 14    | 16  | 11  | 9   | 7   | 8   | 7   | 10  | 7   |    |     |    |
| Electrical stability @120°F, v  | 503   | 527 | 209 | 275 | 156 |     |     |     |     |    |     |    |
| HTHP filtrate @250°F, ml  | 0.6   |     |     |     |     |     |     |     |     |    |     |    |
| Fann 35 dial readings   | 1.2   |     |     |     |     |     |     |     |     |    |     |    |
| 600 rpm   | 81    | 224 | 87  | 176 | 68  | 270 | 93  | O/S | 116 |    |     |    |
| 300 rpm   | 46    | 121 | 49  | 96  | 37  | 146 | 49  | 189 | 63  |    |     |    |
| 200 rpm   | 35    | 85  | 37  | 68  | 29  | 101 | 35  | 134 | 44  |    |     |    |
| 100 rpm   | 22    | 49  | 24  | 39  | 18  | 55  | 20  | 74  | 25  |    |     |    |
| 6 rpm   | 7     | 10  | 7   | 8   | 6   | 6   | 4   | 10  | 5   |    |     |    |
| 3 rpm   | 6     | 8   | 6   | 7   | 5   | 4   | 3   | 7   | 4   |    |     |    |

Note: O/S indicates an off-scale reading, or >300. Contaminated samples were made up with mud already rolled 16 hr @250°F

TABLE 11

**PETROFREE® SF**  
**14 lb/gal; 75/25 OWR with 250,000 ppm WPS**

| Sample Mark   | BB    |              |     |     |     |     |     |     |     |                 |
|---|-------|--------------|-----|-----|-----|-----|-----|-----|-----|-----------------|
| SF BASE, lb   | 0.516 |              |     |     |     |     |     |     |     |                 |
| Freshwater, bbl   | 0.181 |              |     |     |     |     |     |     |     |                 |
| GELTONE® II, lb   | 4     |              |     |     |     |     |     |     |     |                 |
| SUSPENTONE™, lb   | 1     |              |     |     |     |     |     |     |     |                 |
| BDF-258, lb   | 3.5   |              |     |     |     |     |     |     |     |                 |
| Lime, lb  | 9     |              |     |     |     |     |     |     |     |                 |
| Calcium chloride, lb  | 21.9  |              |     |     |     |     |     |     |     |                 |
| BD QUAT 2HT, lb   | 1     |              |     |     |     |     |     |     |     |                 |
| BAROID®, lb   | 330   |              |     |     |     |     |     |     |     |                 |
| DEEP-TREAT™, lb   | 3     |              |     |     |     |     |     |     |     |                 |
| Mixed 15 minutes at 7000 rpm on a Silverson L4RT before testing; mixed 10 minutes after rolling |       |              |     |     |     |     |     |     |     |                 |
| Hot rolled @250°F, hr   | —     | —            | —   | 16  | 16  | 16  | 16  | 16  | 16  | 16              |
| Rev Dust, lb  | —     | —            | —   | —   | —   | —   | 45  | —   | —   | —               |
| 15% NaCl brine, % vol   | —     | —            | —   | —   | —   | —   | —   | —   | —   | 25              |
| Temperature, °F   | 120   | 40           | 120 | 40  | 120 | 40  | 120 | 40  | 120 | 120             |
| Plastic viscosity, cP   | 29    | 76           | 30  | 75  | 28  | 119 | 40  | 119 | 43  | 43              |
| Yield point, lb/100 ft <sup>2</sup>   | 15    | 32           | 17  | 24  | 10  | 16  | 6   | 35  | 14  | 14              |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 8     | 14           | 8   | 11  | 7   | 7   | 5   | 15  | 8   | 8               |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 13    | 17           | 9   | 12  | 8   | 11  | 10  | 15  | 9   | 9               |
| Electrical stability @120°F, v  | 633   | *486 average |     |     | 333 | 576 |     |     | 223 |                 |
| HTHP filtrate @250°F, ml  | 2.2   |              |     | 5.4 |     |     | 4.0 |     |     | 3.0 - 0.2 emul. |
| Fann 35 dial readings   |       |              |     |     |     |     |     |     |     |                 |
| 600 rpm   | 73    | 184          | 77  | 174 | 66  | 254 | 86  | 273 | 100 |                 |
| 300 rpm   | 44    | 108          | 47  | 99  | 38  | 135 | 46  | 154 | 57  |                 |
| 200 rpm   | 34    | 81           | 36  | 73  | 30  | 93  | 33  | 111 | 42  |                 |
| 100 rpm   | 23    | 52           | 24  | 45  | 19  | 50  | 19  | 65  | 26  |                 |
| 6 rpm   | 8     | 16           | 8   | 13  | 7   | 7   | 4   | 15  | 8   |                 |
| 3 rpm   | 7     | 14           | 7   | 11  | 6   | 5   | 3   | 13  | 7   |                 |

Note: Contaminated samples were made up with mud already hot rolled 16 hr. @250°F

\*ES readings ranged from 347 to 656 volts.

TABLE 12

**14.0 lb/gal PETROFREE® SF**  
**70/30 OWR; 250,000 ppm WPS**

| Sample Mark   | Base - D. Carbajal FLC Evaluation Data |            |           |            |           |            |
|---|--|------------|-----------|------------|-----------|------------|
| SF BASE, bbl  | 0.505                                  |            |           |            |           |            |
| Freshwater, bbl   | 0.220                                  |            |           |            |           |            |
| GELTONE® II, lb   | 3                                      |            |           |            |           |            |
| LE™ MUL, lb   | 3                                      |            |           |            |           |            |
| LE™ SUPERMUL, lb  | 3                                      |            |           |            |           |            |
| Lime, lb  | 5                                      |            |           |            |           |            |
| BAROID®, lb   | 330                                    |            |           |            |           |            |
| Calcium chloride, lb  | 27                                     |            |           |            |           |            |
| <i>A 3-gal. batch was mixed at low shear; then 30 min on a Silverson LART</i> |  |            |           |            |           |            |
| BDF-258, lb   | —                                      | 1.5        | 3         |            |           |            |
| <i>Samples were mixed, then hot rolled 16 hours at 150°F</i>                  |  |            |           |            |           |            |
| <b>Temperature, °F</b>  | <b>40</b>                              | <b>120</b> | <b>40</b> | <b>120</b> | <b>40</b> | <b>120</b> |
| Plastic viscosity, cP   | 75                                     | 26         | 90        | 30         | 97        | 32         |
| Yield point, lb/100 ft <sup>2</sup>   | 26                                     | 16         | 37        | 30         | 39        | 33         |
| 10 Sec gel, lb/100 ft <sup>2</sup>  | 17                                     | 10         | 30        | 17         | 32        | 19         |
| 10 Min gel, lb/100 ft <sup>2</sup>  | 18                                     | 12         | 30        | 20         | 33        | 24         |
| Electrical stability, volts   | 259                                    |            | 650       |            | 679       |            |
| HTHP filtrate @250°F, ml oil  | 11.8                                   |            | 3.2       |            | Trace     |            |
| HTHP filtrate @250°F, ml H <sub>2</sub> O                                     | 5.6                                    |            | —         |            | —         |            |
| Fann 35 dial readings   |  |            |           |            |           |            |
| 600 rpm   | 176                                    | 68         | 217       | 90         | 233       | 97         |
| 300 rpm   | 101                                    | 42         | 127       | 60         | 136       | 65         |
| 200 rpm   | 74                                     | 33         | 94        | 49         | 101       | 54         |
| 100 rpm   | 47                                     | 27         | 61        | 36         | 66        | 40         |
| 6 rpm   | 16                                     | 10         | 23        | 17         | 26        | 20         |
| 3 rpm   | 16                                     | 9          | 20        | 15         | 23        | 18         |

These experimental results show that the product of the invention has emulsion-forming capabilities comparable to or exceeding prior art emulsifiers at only about one-third the concentration and that the product of the invention improves the electrical stability of the drilling fluid, even after heat stress. These results also show that the product of the invention imparts very low filtration properties to the drilling fluids. Further, the product of the invention provides significantly better filtration control than conventional emulsifiers, especially when used with a wetting agent, even after solids and brine contamination. Still further, the tests showed that no fluid loss control additives were needed for the same filtration properties as prior art emulsifiers when the product of the invention was used. The tests also indicate that the product of the invention performs well with other emulsifying products, which should allow simpler maintenance treatments in oil or synthetic based fluids when using the product of the invention.

In the method of the invention, the product of the invention is added to an oil or synthetic based drilling fluid or a drilling fluid comprising an invert emulsion to improve or facilitate the emulsification of the oil or synthetic base fluid.

The foregoing description of the invention is intended to be a description of preferred embodiments. Various changes in the details of the described product and method can be made without departing from the intended scope of this invention as defined by the appended claims.

## WHAT IS CLAIMED IS:

1. A drilling fluid comprising an oil or synthetic base and further comprising a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles with a mixture of fatty acids and resin acids.
2. The drilling fluid of claim 1 wherein said dienophiles are selected from the group consisting of: carboxylic acids, polycarboxylic acids, acid anhydrides, and mixes thereof.
3. The drilling fluid of claim 1 wherein said mixture of fatty acids and resin acids are derived from the distillation of tall oil.
4. The drilling fluid of claim 1 wherein said dienophiles are maleic anhydrides.
5. The drilling fluid of claim 1 wherein said mixture has a ratio of fatty acids to resins acids ranging from about 4:1 to about 1:1.
6. The drilling fluid of claim 1 wherein said mixture has a ratio of fatty acids to resin acids of about 2:1.
7. The drilling fluid of claim 1 wherein the ratio of polyamide to said mixture is about 1:5 to about 1:1.
8. The drilling fluid of claim 1 wherein the ratio of said polyamide to said mixture is about 1:2 to about 1:3.
9. The drilling fluid of claim 1 wherein said blend is saponified.
10. The drilling fluid of claim 9 wherein said saponification is effected with calcium chloride, lime, quicklime, or other sources of calcium cations.
11. The drilling fluid of claim 9 wherein said saponification occurs in situ.
12. The drilling fluid of claim 9 wherein said saponification occurs before said blend is added to said drilling fluid.
13. The drilling fluid of claim 1 further comprising lime, calcium chloride, quicklime, or other saponifying agents.
14. The drilling fluid of claim 1 further comprising wetting agents.
15. The drilling fluid of claim 1 wherein said blend provides filtration control.
16. The drilling fluid of claim 1 wherein said blend provides emulsification.
17. The drilling fluid of claim 1 wherein said blend provides electrical stability.
18. An emulsifier comprising a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles selected from the group consisting of: carboxylic acids, polycarboxylic acids, and acid anhydrides, and

- combinations thereof, with a mixture of fatty acids and resin acids derived from the distillation of crude tall oil, wherein said mixture comprises a ratio of fatty acids to resin acids ranging from about 4:1 to about 1:1, and wherein the ratio of said polyamide to said mixture in said blend ranges from about 1:5 to about 1:1.
19. The emulsifier of claim 18 wherein said blend is saponified.
  20. The emulsifier of claim 19 wherein said saponification is effected by reaction of said blend with calcium cations.
  21. An additive for improving the properties of an invert emulsion comprising water or brine in an oil or synthetic based drilling fluid for use in drilling a borehole in a subterranean formation, said additive comprising a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles selected from the group consisting of: carboxylic acids, polycarboxylic acids, acid anhydrides, and combinations thereof, with a mixture of fatty acids and resin acids derived from the distillation of crude tall oil, wherein said acid mixture comprises a ratio of fatty acids to resin acids ranging from about 4:1 to about 1:1, and wherein the ratio of said polyamide to said mixture in said blend ranges from about 1:5 to about 1:1.
  22. The additive of claim 21 wherein said additive is saponified.
  23. The additive of claim 22 wherein said properties include emulsification.
  24. The additive of claim 22 wherein said properties include filtration control.
  25. The additive of claim 22 wherein said properties include electrical stability.
  26. A method for drilling a borehole in a subterranean formation, said method comprising employing an oil or synthetic based drilling fluid comprising an invert emulsion and an additive comprising a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles with a mixture of fatty acids and resin acids wherein said dienophiles are selected from the group consisting of: carboxylic acids, polycarboxylic acids, acid anhydrides and combinations thereof.
  27. The method of claim 26 wherein said acid mixture is comprised of fatty acids and resin acids derived from the distillation of tall oil.
  28. The method of claim 26 wherein said mixture has a ratio of fatty acids to resin acids ranging from about 4:1 to about 1:1.
  29. The method of claim 26 wherein said mixture has a ratio of fatty acids to resin acids of about 2:1.

30. The method of claim 26 wherein the ratio of said polyamide to said mixture is about 1:5 to about 1:1.
31. The method of claim 26 wherein the ratio of said polyamide to said mixture is about 1:2 to about 1:3.
32. The method of claim 26 wherein said blend is saponified.
33. The method of claim 32 wherein said blend is saponified with calcium chloride, lime, quicklime, or other sources of calcium cations.
34. The method of claim 32 wherein said saponification occurs in situ.
35. The method of claim 32 wherein said saponification occurs before said blend is added to said drilling fluid.
36. A method for improving or facilitating the emulsification of an oil or synthetic based drilling fluid or a drilling fluid comprising an invert emulsion, said method comprising adding to said drilling fluid a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles with a mixture of fatty acids and resin acids.
37. The method of claim 36 wherein said dienophiles are selected from the group consisting of: carboxylic acids, polycarboxylic acids, acid anhydrides, and combinations thereof.
38. A method for improving the filtration properties of an oil or synthetic based drilling fluid or a drilling fluid comprising an invert emulsion, said method employing adding to said drilling fluid a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles with a mixture of fatty acids and resin acids.
39. The method of claim 38 wherein said dienophiles are selected from the group consisting of: carboxylic acids, polycarboxylic acids, acid anhydrides, and combinations thereof.
40. A method for improving the electrical stability of an oil or synthetic based drilling fluid, or a drilling fluid comprising an invert emulsion, said method comprising adding to said fluid a blend of a carboxylic acid terminated polyamide and a mixture produced by the Diels-Alder reaction of dienophiles with a mixture of fatty acids and resin acids.
41. The method of claim 40 wherein said dienophiles are selected from the group consisting of: carboxylic acids, polycarboxylic acids, acid anhydrides, and combinations thereof.

1/1

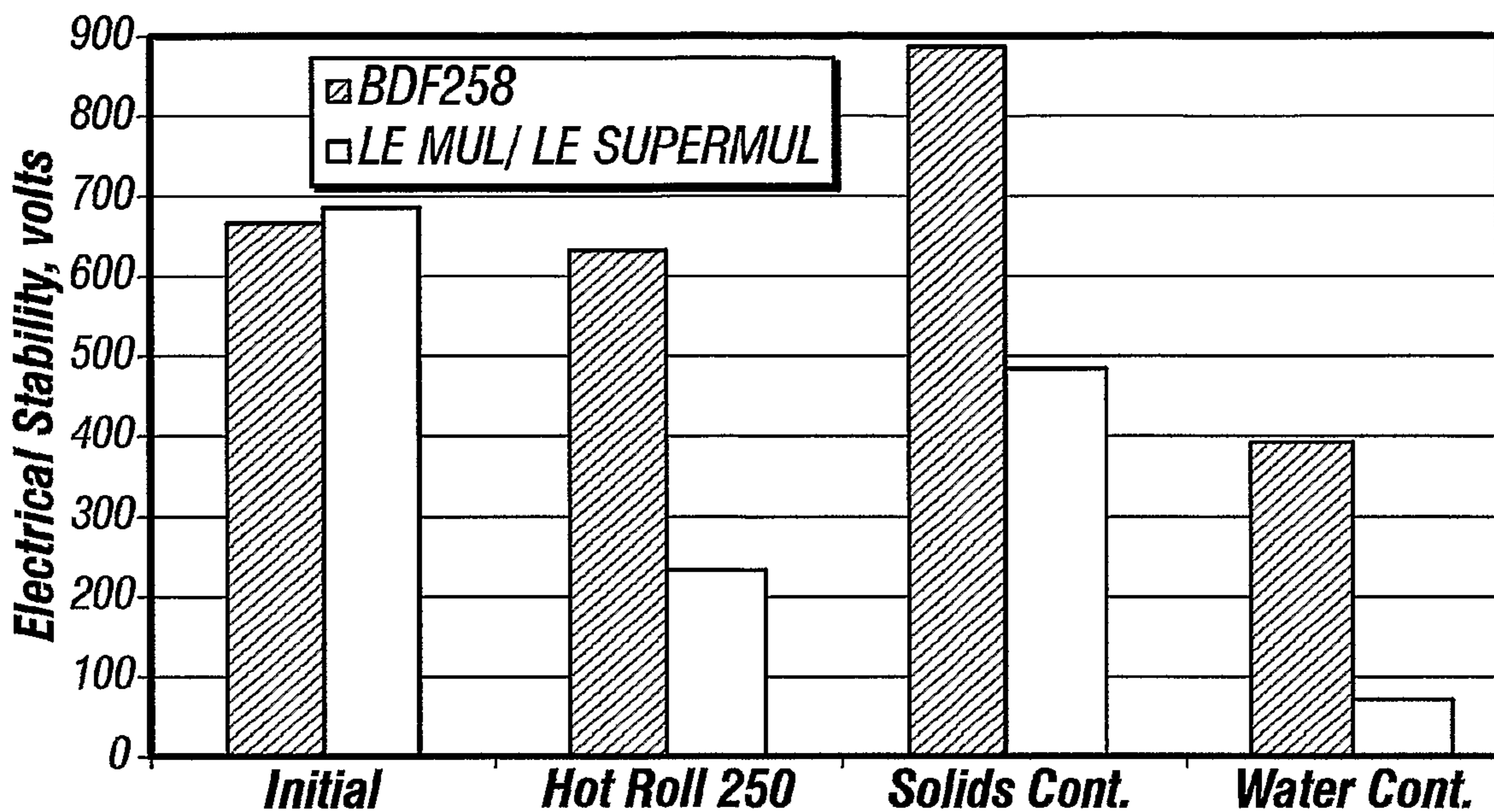


FIG. 1

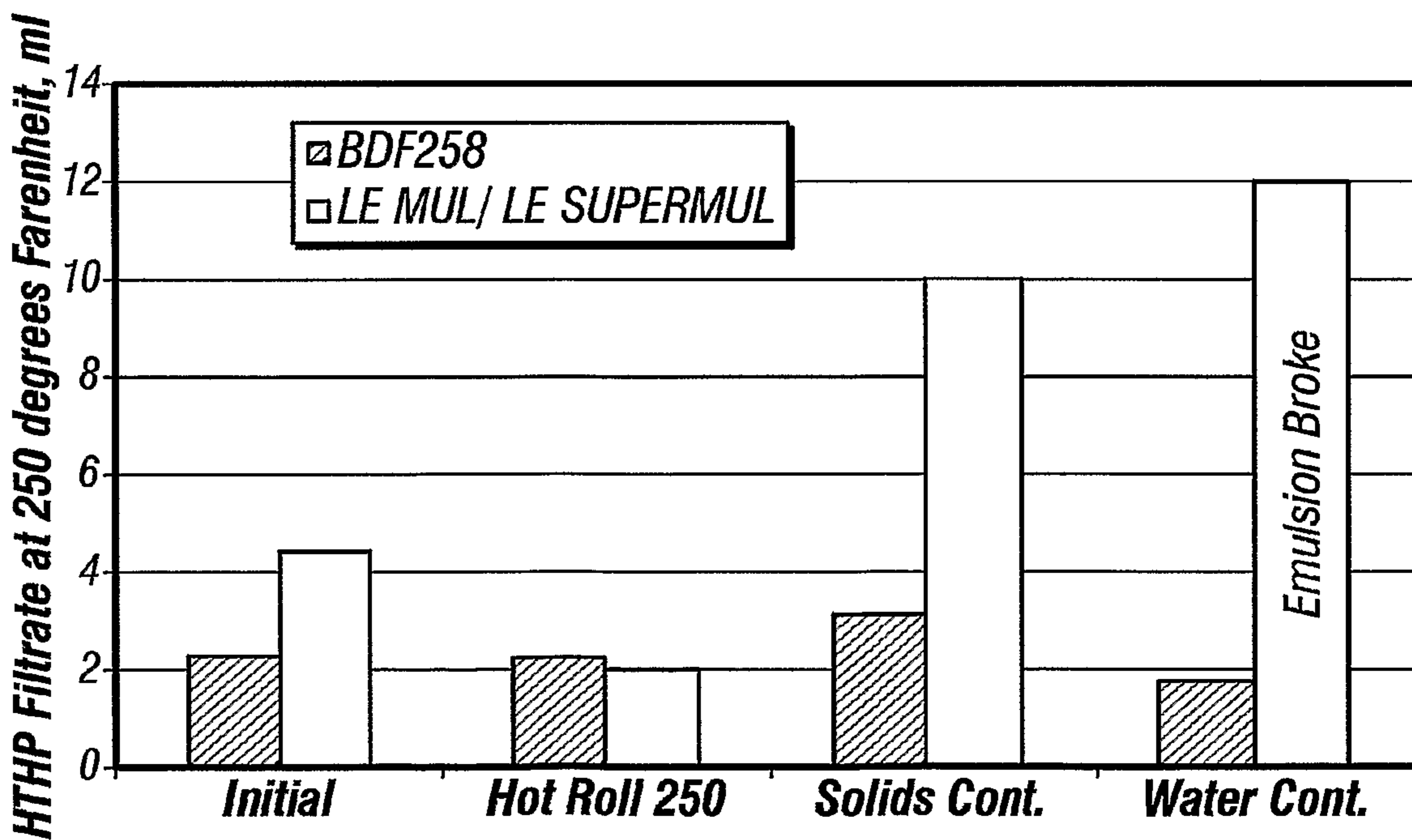


FIG. 2