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DEVELOPMENT OF DRILLING FOAMS FOR GEOTHERMAL APPLICATIONS*

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Finally, the interest and efforts of Cliff Carwile of the Department of Energy, Division of Geothermal Energy, is gratefully acknowledged. For under such leadership it is believed that technology for bet.er and cheaper geothermal drilling will be developed.

ABSTRACT

This report, prepared at the request and under contract to Sandia Laboratories, addresses the use of foam drilling fluids in geothermal applications. The initial three chapters provide a description of foams--what they are, how they are used, their properties, equipment required to use them, the advantages and disadvantages of foams, etc.

Geothermal applications are discussed. Results of industry interviews presented indicate significant potential for foams, but also indicate significant technical problems to be solved to achieve this potential. Testing procedures and results of tests on represenative foams provide a basis for work to develop high-temperature foams. A seven year directed effort to develop the needed materials and equipment is presented.

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SUMMARY

Problems resulting from inadequate drilling fluids are the most frequently quoted reason for high geothermal drilling costs. Severe corrosion and erosion are common when air drilling; yet slow drilling rates, filtration control or loss of circulation, and mud gelation often occur when using muds. In order to ascertain how drilling foams might be utilized in geothermal drilling to solve some of these problems (hence reducing geothermal well costs) Sandia Laboratories contacted with Maurer Engineering to evaluate drilling foams for geothermal applications and to recommend a program for developing geothermal drilling foams.

Drilling foams are potentially applicable in air drilling situations namely where well control is not a problem. Foams offer advantages over air in their increased lifting capacity, reduced compression requirements, higher bottom hole densities, and improved borehole stabilization. A broad survey of industry personnel indicates that geothermal drilling could use foams up to 80% of the time. Use of foams could increase drilling rate, decrease downtime, decrease corrosion/erosion effects, help control lost circulation, and help alleviate other geothermal drilling problems. Yet many technical problems must be overcome to accomplish these things.

Temperature and salt stable foams must be developed. Handling equipment must be improved including developing processes for breaking, cleaning, and reusing foam materials.

Corrosion characteristics must be improved through the use of inert gases or chemical additives, and other technical problems must be addressed. Results of this study also indiates that wide use of foams will require informing operators and contractors about foams and their use and will require much greater availablility of equipment than present.

Numerous laboratory procedures were considered for testing foams; all have some usefullness, yet all have limitations. Probably the single most descriptive test is a modified Chevron test after high-temperature static aging. Although present procedures are useful screening tools better test equipment and procedures (such as a high-temperature flow simulator for foams) should be developed. Test of representative foams give insight into anticipated behavior of families of materials and the performance which can be expected from field drilling foams. These tests indicate that completely new materials will have to be developed in order to satisfy geothermal applications.

A proposed program for developing geothermal drilling foams recommends a 7-year development period with expenditures anticipated at $1.9 million. Technical goals should be achievable in 5-years with remaining 2-years to complete testing, demonstration, and technology transfer. It is anticipated that significant industry cost sharing will augment the $1.9 million of DOE funds.

CONCLUSIONS AND RECOMMENDATIONS

The following is an enumeration of conclusions regarding geothermal drilling foams. These conclusions are based on 1) extensive discussions with geothermal drilling and operating personnel, 2) literature review, 3) testing of candidate materials, 4) recommendations of manufacturers and suppliers, and 5) consultation with academic authorities.

The major conclusions are:

- There are severe technical problems with geothermal drilling foams relating stability, contamination, handling and costs.
- Improved foams can have major impact on geothermal well costs, saving from $30,000 to $300,000 per well.
- A major federal initiative is needed to develop the required technology. This role is strongly urged and supported by industry.

Detailed conclusions drawn and supported by this study are below:

Applicability of Geothermal Foams

1. Foams would be used in up to 80% of geothermal drilling if technical problems with foams can be solved.
2. Foams potentially could solve or alleviate the following important problems.
   A. Corrosion/Erosion
   B. Mud Gelation
   C. Filtration Control/Formation Damage
   D. Lost Circulation
   E. High Mud Maintenance Costs
3. Foams will be excellent for cementing and workover procedures.
4. Conservatively estimated, foams can reduce overall geothermal well cost from 3 to 30%.

4. Reduced fishing, presently averaging (with air drilling) 4 jobs/rig/year at $250,000 /job. Estimated savings $100,000-$200,00 per well.

5. Improved drilling rate $20,000-$30,000 per well saving in rig time.

Total economic benefits range from $30,000 to $300,000 per well, or approximately 3% to 30% of total well costs.

Testing

1. Numerous lab tests are available. Most definitive in common use is a test developed by Chevron and modified slightly to include Chevron static high-temperature aging.
2. Improved lab procedures are needed. In particular a flow loop for testing foams should be developed.
3. A catalog of foams giving composition and lab performance should be developed.
4. A field test facility is needed.
5. High-temperature performance of foams is not predictable from low-temperature performance.

Development Program

1. A majority of interviewees strongly supported federal R&D effort to develop foam fluids for geothermal drilling.
2. Benefits from even a partial solution to the problems are great and a program should be initiated immediately.
3. Total program cost is estimated to be $1.9 million. Development time totals 7-years with all major goals expected to be achieved in 5-years.
4. Technology transfer should be a major effort to assure implementation of accomplishments.

Technical Problems

1. Present foams are not stable under a range of temperature, pressure, and salinity of conditions.

   A. pH can suddenly change with thermal degradation

   B. Foam quality (air/water ratio) can be seriously impaired by hydrocarbon impurities and brine influx.

2. Foams built with air are corrosive. An economic method of building foams with inert gas must be found. Stable, economic chemical corrosion inhibitors may solve near-term problems.

3. Systems to break, clean, and reuse foam materials must be developed for foams to be economic and to avoid disposal problems.

4. Borehole stability is a major problem. Methods of prediction and control must be developed.

5. Bit life with foams is low and bit cleaning is not as good as with air or mud.

6. Present material costs are high and yields are often much lower than lab predictions.

7. Foam quality, density, and carrying capacity vary with depth; predictive methods are not good.

8. Impact of low thermal conductivity and low heat capacity of foams (allowing higher borehole temperature during drilling) is unknown.

Economic Benefits

1. Reduced equipment costs over air drilling; possible savings of \$1,500-\$2,000 /day (\$50,000-\$100,000 per well).

2. Reduced drill pipe corrosion/erosion allowing estimated 40-fold improvements in drill pipe life. Estimated savings of \$30,000-\$40,000 per well.

3. Reduced hard banding costs and pipe inspection costs saving \$2,000-\$4,000 per well.

I INTRODUCTION

Drilling with air instead of mud as a circulating fluid was first used in the oil fields in the 1930's. In some shallow drilling in hard dry rock, air drilling worked well and drilled faster than mud. In other areas, air drilling was severely limited because of large influxes of formation fluids into the wellbore and because of hole sloughing problems.

The obvious approach to this was to combine air and drilling mud into aerated mud. This was done as early as the late 1940's but usually the results were disappointing. The foam was generally too expensive, and the system too unstable. Nevertheless, since that time there has been considerable work done with aerated muds, and given close supervision under the proper hole conditions they have performed well in many areas.

AEC Stiff Foams

A major development in the use of foams was made in 1965 by the A.E.C. on their test sites at Frenchman's Flat and Piute Mesa, Nevada. In this area the rhyolite rock of the test sites had been pulverized by the shock of the explosions or was extensively fractured. Drilling muds caused lost returns, yet there was too much water in the rock for air drilling. Also, the pulverized rock caved into the hole when drilling with air.

Faced with this problem, the test site engineers developed the "stiff foam" drilling fluid. The material was a drilling mud which contained a large quantity of entrained air. The resulting mixture looked like aerosol shaving foam, but was very stable and persistent as shown in Figure 1.1. It had good lifting capacity, was lighter than water and helped support the walls of the hole.

Figure 1.1. Stiff foam coming from blooie line. Notice the barrel in the foreground showing shaving cream like consistency (Anderson).

The system was stable enough to prevent formation fluids from flowing into the wellbore and yet not lose circulation. The only problem encountered was that the foam was so stable that it could not be broken and reused. In fact, five years later the pits of used foam were still too wet to cover as shown in Figure 1.2.

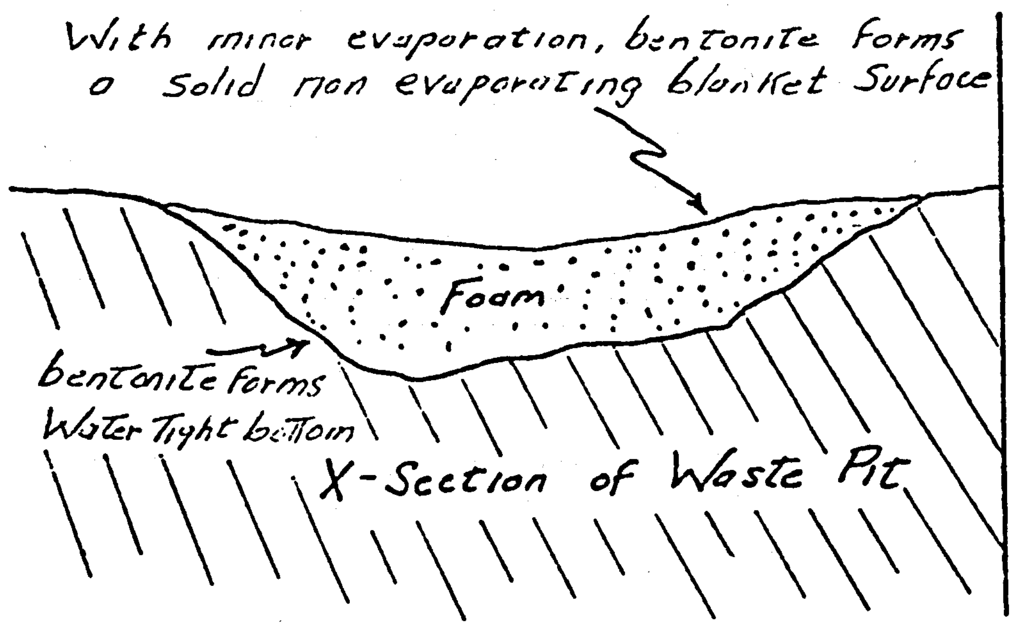


Figure 1.2. The Stabilizing and Persistent Effect of the Bentonite in Stiff Foam Discards.

Depleted Reservoirs

Since foams exert less bottom-hole pressure than water, they make excellent fluids for drilling depleted reservoirs for secondary and tertiary recovery. Standard Oil of California uses them in the workover and recompletion of the "Huff and Puff" steam flooding of the Taft Field as well as in other California fields. The fluid pressures in these depleted fields are very low (Figure 1.3).

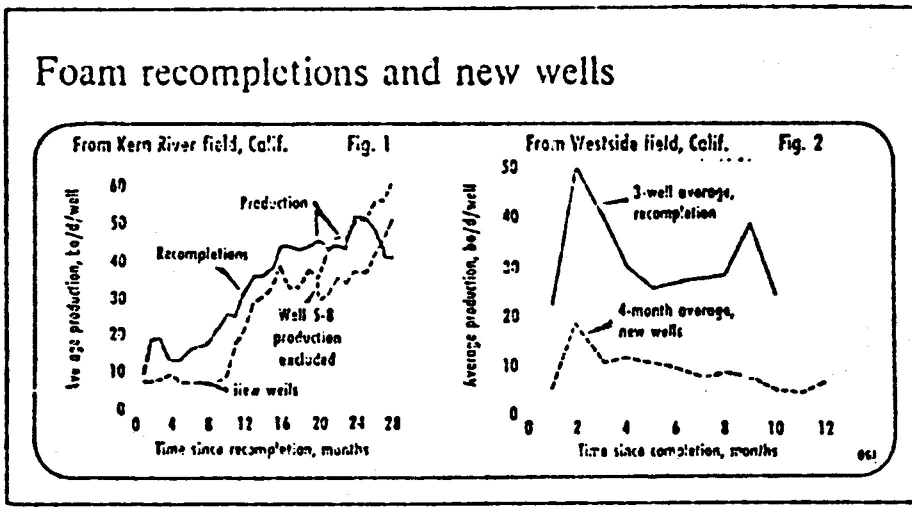


Figure 1.3. Effectiveness of Foam as a Workover and Drilling Fluid (Hutchinson).

Stiff foam is commonly used in high mesa or mountain country where lost circulation is a serious problem. A large stiff foam project is operated by the Italian National Oil Company (AGIP) in the folded zone of the Zargos Mountains in Iran. The mixtures and techniques they use are similar to those used by the A.E.C. (Figure 1.4).

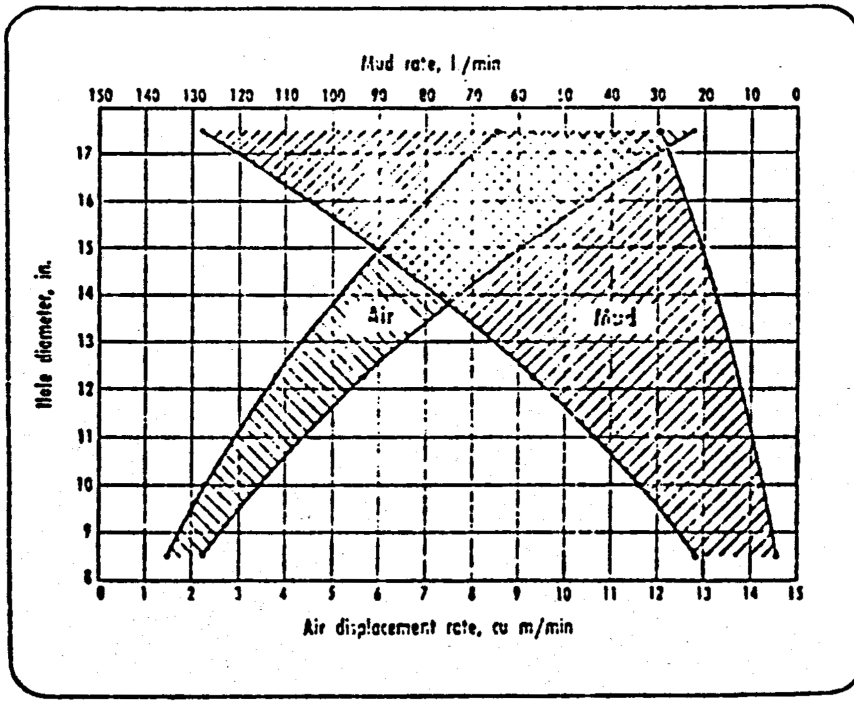


Figure 1.4. Air/Mud Ratios on Foam used by AGIP in Iran (Garavini).

One common use of foams is in drilling very large mine shafts because of its high lifting capacity.

Permafrost Drilling

Probably the most unique use of stiff foam has been to drill gauge hole through the permafrost on the North Slope of Alaska (Figure 1.5). In this application, the insulating properties of the foam are particularly helpful.

Figure 1.5. Frozen foam piles up in the sump. The 12-inch blooie line was frozen internally to an effective diameter of only 3-inches (Anderson).

Fracturing and Completions

As a completion and workover fluid the lifting capacity of the foam in laminar flow is very high. This allows the large fragments of rock and waste to be circulated up to the surface with a low circulation rate and hence a low back pressure or circulating density against the reservoir formations. The net effect of this has been that less fluid was put back into the reservoir rock and so there is a significant reduction in skin damage.

Foam mixtures have also been used as fracturing agents because of the high lifting capacity but also because of the stored energy in the fluid. The foam expands after the fracing treatment and unloads the hole without swabbing or pumping.

Geothermal Application

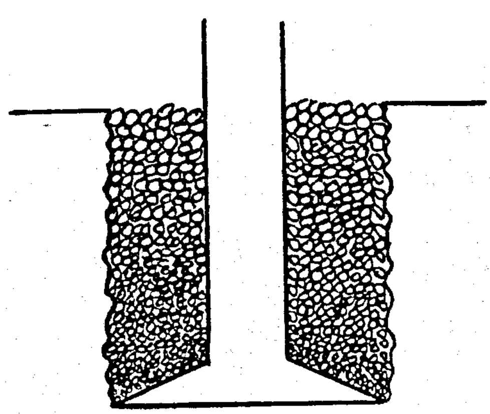
Potentially foams could be used in many geothermal applications. In fact they are not commonly used, primarily because of 1) cleaning and disposal problems, and 2) corrosion. The inability to break, clean, and reuse foams significantly increases material costs.

Several companies, particularly Union and Chevron, have studied foams and have continuing projects to develop materials, procedures, and equipment for utilizing foams in high-temperature applications.

II REVIEW OF FOAM DRILLING

Foam drilling uses a drilling fluid that resembles foamed shaving cream. The foam is made up at the surface by injecting a nonionic foaming agent into a water that has been treated with lime and corrosion inhibitors The mixture as it is pumped down the hole by the mud pump is a nonfoamed water. When the mixture passes through the bit jets, it starts to expand. The expansion is governed by the downhole pressure and at the bit, the foam is essentially water. At the surface, the foam is fully expanded and contains 90% to 95% air and 5% to 10% water. Most of the expansion takes place in the upper 500' to 1,000' of the hole.

The advantage of foam drilling is that it produces a drilling fluid column with a variable density that can be adjusted so as to control water influx while avoiding lost returns. The density effects are shown in Figure 2.1.



Depth (feet)	Pressure (psig)
0	0
1,000	130
2,000	420
3,000	780
4,000	1,160
5,000	1,560

Figure 2.1. Typical Foam Drilling Column

Another advantage of foam is that is provides a method of supporting the wall of the hole and significantly reduces sloughing of the hole. Under some conditions other additives can be put in the foam mixture that chemically helps reduce shale disintegration. These materials are often salts of potassium. The effective viscosity of the foam in the annulus is so high that the foam has an excellent lifting capacity and efficiently cleans the hole.

Foam used in Alaska to drill the permafrost has provided an excellent insulating effect. It might be postulated that in very hot holes, the insulating effect of the foam might tend to stabilize the mixture against high-temperature effects and thus reduce the problem of drilling in a very hot environment.

Foam Composition

"STIFF FOAM" is a mixture of water, bentonite, carboxymethyl cellulose, and foaming agent. The general compositions are:

	Fresh Water	Cost
Water	41 gal	
Bentonite	12 #/bbl	
CMC	1/2 #bbl	
Soda Ash	1 #/bbl	$6.00 /bbl
Foamer	1/2 gallon foamer	

	Salt Water	Cost
Water	41 gal	
Asbestos Fiber	10 #/bbl	
Cypan	1 #/bbl	$10.00 /bbl
Soda Ash	1 #/bbl	
Foamer	~~1/2 gallon~~	

The Effect of Foam

The problem of fracture pressures and lost circulation mandates that the density of the drilling fluid be variable. In the normal case of drilling fluids that are heavier than water, the weight of the fluid can be reduced and casing set to protect low pressure zones that will cause lost circulation. In the more fractured rocks and in areas of low water tables the average density of the drilling fluid column must be less than water to avoid lost returns. Air drilling is the ideal solution where water influx or an unstable wellbore does not preclude its use. Mist drilling, the addition of some water and detergent to the air stream extends the use of air into damp formations, but is not effective when water influx rises much above 10 gallons per minute, especially when the formations are sensitive to water wetting.

Foam provides an ideal solution in the area of water influx and sensitive formations since the foam column provides a variable density that can be controlled by the air injection rate or the backpressure on the hole.

Designing the Drilling Fluid

It is worthwhile to explain and define the effect of foam in the hole. The foamed mixture contains 5 to 10% drilling water and 90 to 95% air at the surface. The total amount of water that is used depends upon the amount of water required to clean the bit because below about 1,500' the air is compressed to the point where the air volume is less than one-tenth the surface volume.

Therefore, the first design parameter for foam is the amount of fluid required to clean the bit. This depends upon the rock drilled, the drilling rate, and the hole size. In a 7-7/8" hole drilled in sandstone at 10 min/ft the volume of water required would approach 200 gpm. There is no commonly accepted term to develop these fluid volumes.

The second design parameter for foam is the reduction in hydrostatic head required. The reduction in hydrostatic head of foam follows the equation[1]:

$$h = \frac{1}{D} [P + \frac{np}{100-n} \ln (\frac{P+p}{p})]$$

where

- h = depth, ft
- D = hydrostatic pressure, psi, of a column of fluid one foot high with no air in it
- P = pressure in atmospheres at depth h due to mud column only
- p = back pressure at wellhead, atmosphere
- $\frac{n}{100}$ = fraction by volume of gas in mud at wellhead at back pressure p

Details of the calculation and typical solutions are presented in Appendix I.

Figures 2.2 and 2.3 are graphic examples of the effect of foam on the hydrostatic pressure. In each of these cases, the assumption is made that the foam used will be the Stable Foam mixture and that the water will weigh 8.4 pounds per gallon, slightly more than pure water. Notice in the plots that the major reduction in hydrostatic pressure is in the very top of the hole. Below 1,500' to 2,000' in Figure 2.2, the foam is compressed to the point that the column is essentially a liquid column.

1. White, Robert J.: "Bottom-Hole Pressure Reduction Due to Gas-Cut Mud," AIME-SPE T.N. 4,301,957.

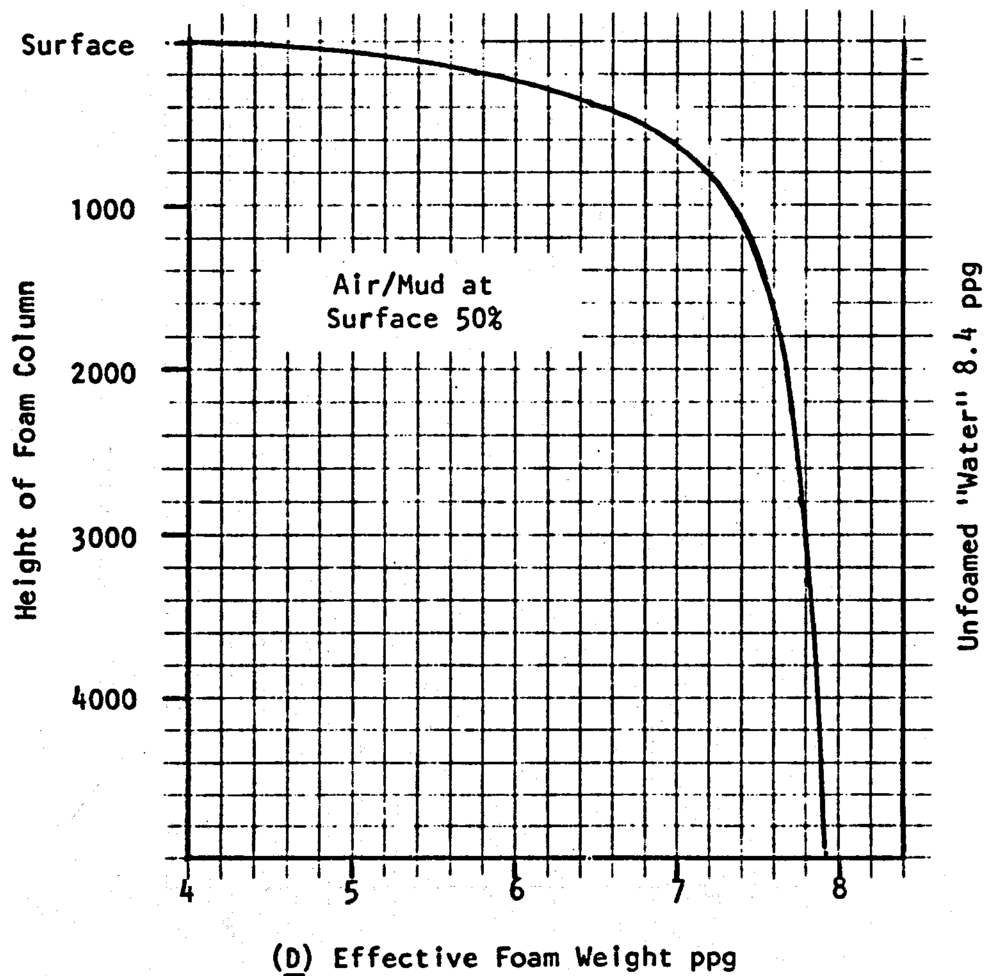


Figure 2.2. Foam Density vs Depth

In Figure 2.3, where the surface ratio of fluid to air is 1:10 the increase in pressure of the foam column is much slower than in the 1:2 ratio of Figure 2.2. This illustrates the use of fluid to air ratios in controlling pressures.

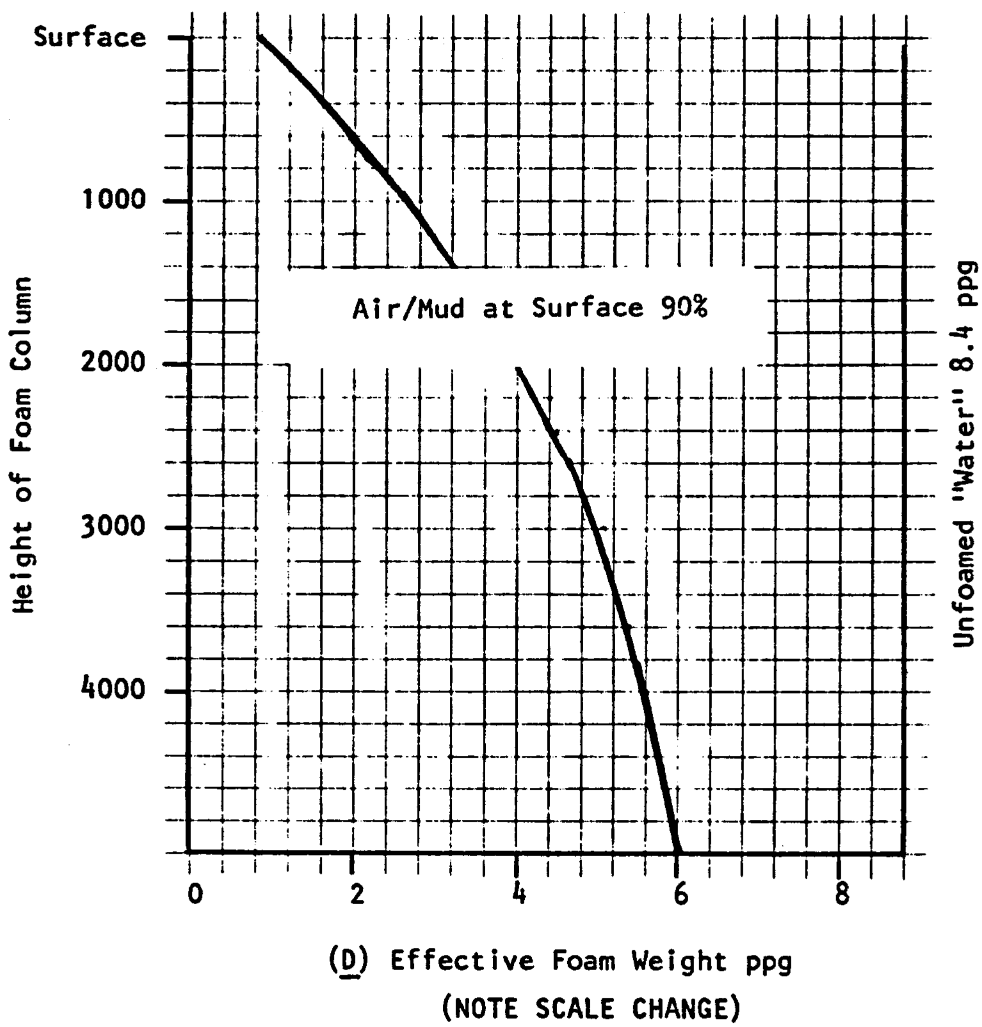


Figure 2.3. Foam Density vs Depth

Figure 2.4 shows the effect of backpressure on the wellbore. The 100 psi backpressure is extreme for foam drilling, but it illustrates how the fluid column pressure can be increased by the use of surface imposed pressure.

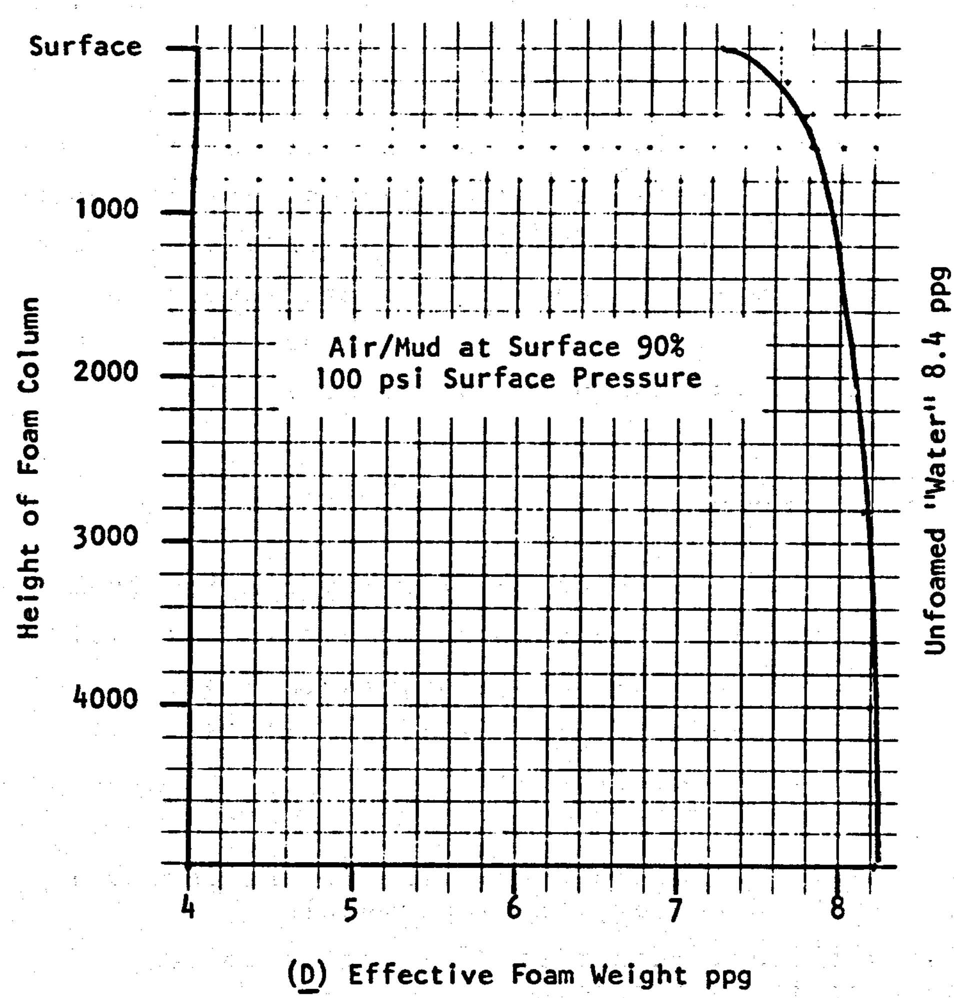


Figure 2.4. Foam Density vs Depth

In practical application, the limit of a true air/fluid emulsion is limited to about 10:1. (This is also the limit of foam shaving creams.) More air can be added to further reduce the fluid column pressure, but the addition of air beyond the 10:1 ratio causes some heading in the foam. In most cases there is some slippage of the air in the foam at high ratios and in large holes, so that additional air, up to 20:1 must be added and some heading of the foam column is accepted.

The heading of the foam column does not appear to cause significant downhole pressure surges because of the compression effect. The actual use of foam in the hole requires some practice. As the hole size becomes larger, some adjustment of foam chemicals, air volume, and water volume needs to be made to balance out the unknowns in the hole.

When Foams Can Be Used

Drilling fluids can be categorized by density from the very heavy muds to air. The use of any particular fluid depends upon the geological conditions in the hole being drilled. For a reasonable foam drilling decision, all alternatives should be considered.

- Air Drilling. Use air drilling if the interval is very hard and dry, or impermeable.
- Mist Drilling. Use mist drilling to solve dampness in an air hole.
- Foam Drilling. Use foam drilling where formation gradients are lower than 0.4 psi/ft, the hole is unstable due to fractured formations, and/or it is too wet for air drilling.
- Water is used as a drilling fluid when there is no need for the lifting capacity of viscosity, fluid loss control, or special mud weights, and the formations are not water sensitive or subject to easy erosion.

- Aerated muds are used to solve severe lost circulation problems when using mud. It may be preferable to switch to foam.

The above items typically grade into each other as sub systems of the basic air drilling or mud drilling system.

When to use foam is often a subjective decision because of lack of information. The following descriptions help provide the background for a foam decision.

Develop a Mud Type for Each Casing Point Interval

A. Check for air drilling intervals

1. Is the rock hard?
2. Is formation pressure gradient equal to or less than .43 psi/ft?
3. Is the rock dry?
4. If mist must be used because of damp rock, is the rock water-sensitive?
5. Steeply dipping formations drill better with a hammer because of the light bit weight required. Do formations dip steeply?
6. Is the hole to be directional?

If the answers for 1 through 4 are yes, consider air drilling. If the answer to five is yes, air is particularly competitive. If item 6 is yes, check with a directional drilling company before making a decision.

B. Be prepared for mist drilling intervals. Mist will be used if the hole becomes damp and there are no water-sensitive formations. Always have standby mist equipment available when air drilling.

C. Check for foam drilling intervals. Foam is an air drilling technique used when there is too much water influx to handle with mist and/or the hole is unstable. For foam use:

1. Hole is wet.
2. Pressure gradient is below .43 psi/ft

   or

2a. The rock is badly fractured and will not stand up and the pressure gradient is below .47 psi/ft.

Foam drilling can be overpowered by water flows, so the hydrostatic pressure needs to be balanced to avoid large influxes of water or else a mud must be used.

D. Check for conventional mud.

1. The pressure gradient is greater than .4 psi/ft.
2. The formation temperature at the bottom of the interval is less than 350°F

   or

2a. The formation temperature at the bottom of the interval is less than 300°F but the hole is directionally drilled, or using a packed hole assembly, or extensive testing is proposed.

E. Check for aerated mud.

1. Lost circulation occurs or may occur while drilling that cannot be solved by lost circulation material, cement plugs, or barite or gunk plugs.

2. Mud column in the hole falls less than 1,000' when returns are lost. If mud column falls more than 1,000' consider using foam, or setting plugs.

Air Drilling

Air drilling is used for a number of specific reasons.

1. The formations to be drilled are dry or impermeable hard rock.
2. The formations to be drilled are separated by casing from wet and/or permeable upper formations.
3. Drilling rate must be significantly faster than drilling with water and mud.
4. Lost circulation is a serious problem.
5. Reservoir damage may result from the use of water or muds.

As a general estimate, the following minimum air volumes are required for air drilling dry hole. Volume is listed as SCFM - standard cubic feet per minute.[2]

Hole Size (Inches)	Air Volume (SCFM)	Pressure
6-1/4	1,000	250
7-7/8	1,400	250
8-3/4	1,700	250
9-7/8	2,100	250

Air volume must be metered.

2. Angel, R. R.: "Volume Requirements for Air and Gas Drilling," Gulf Publishing Company, 1958.

Mist Drilling

Misting is an extension of air drilling used when damp formations are encountered. The same criteria as for air drilling justification are true, but in misting, detergent and water are injected into the air stream to keep damp drill cuttings from balling up or forming rings in the hole.

Air drilling costs are increased from 25% to 50% by the addition of mist because of increased air requirements, material cost, and lower penetration rate.

Lime must always be added .to the injection water to maintain a pH of 9.5 at the blooie line. One to two pounds of lime per barrel of injected water should be used in geothermal drilling.

An amine type filming corrosion inhibitor should also be used either in batch lots or in the injection water.

Foaming agents and inhibitors must be checked with the manufacturer for temperature suitability. Use the assumed formation temperature for the interval minus 100°F for the suitability temperature unless large quantities of steam are being produced. If steam is produced, use formation temperature. See API RP 46, "Recommended Practices for Testing Foaming Agents for Mist Drilling." Air volume must be metered.

Foam Drilling

Foam drilling is used when:

1. There is severe lost circulation that is difficult or impossible to control with conventional muds.

2. Air drilling is unsuitable because some hydrostatic pressure is required to stop fluid influx into the wellbore and/or fractured or broken formations make the wellbore unstable; or

3. The insulating properties of foam make it desirable.

Foams are not generally reusable and so costs for foam and air are generally quite high.

Special foamers are used for foam drilling. Two types of foam are used, "Stiff" and "Stable" foams.

Volume Requirements

Volume requirements for foam vary appreciably, but the following air volume and air pressures should be available.

Hole Size	Air Volume	Foam Mixture	Air Pressure
6-1/4"	350 cfm	15 bbl/hr	300 psi
7-7/8"	400 cfm	20 bbl/hr	300 psi
8-3/4"	450 cfm	25 bbl/hr	300 psi
9-7/8"	500 cfm	35 bbl/hr	300 psi

Based on the table above and the cost of foamers, a calculation can be made of foaming costs. Foam costs do not include the cost of water or such hardware items as drilling heads.

$$\text{Foaming Cost} = (A\$ + F\$) \times T$$

where

A$ = Air Cost per day
F$ = Foam Cost per day
T = Time to Drill Interval

$$F\$ = Fbbl \times (bbl/hr \times 18)$$

Fbbl = Foam Cost/bbl
bbl/hr = bbls per hour used

Equipment for Foam Drilling

The equipment required for foam drilling is a mixture of conventional mud drilling and air drilling equipment. Foam drilling is a compromise system that does not require the pump pressures used for mud drilling or the high volumes used in air drilling. This simplifies the equipment requirements and reduces some of the potential pollution aspects of air drilling.

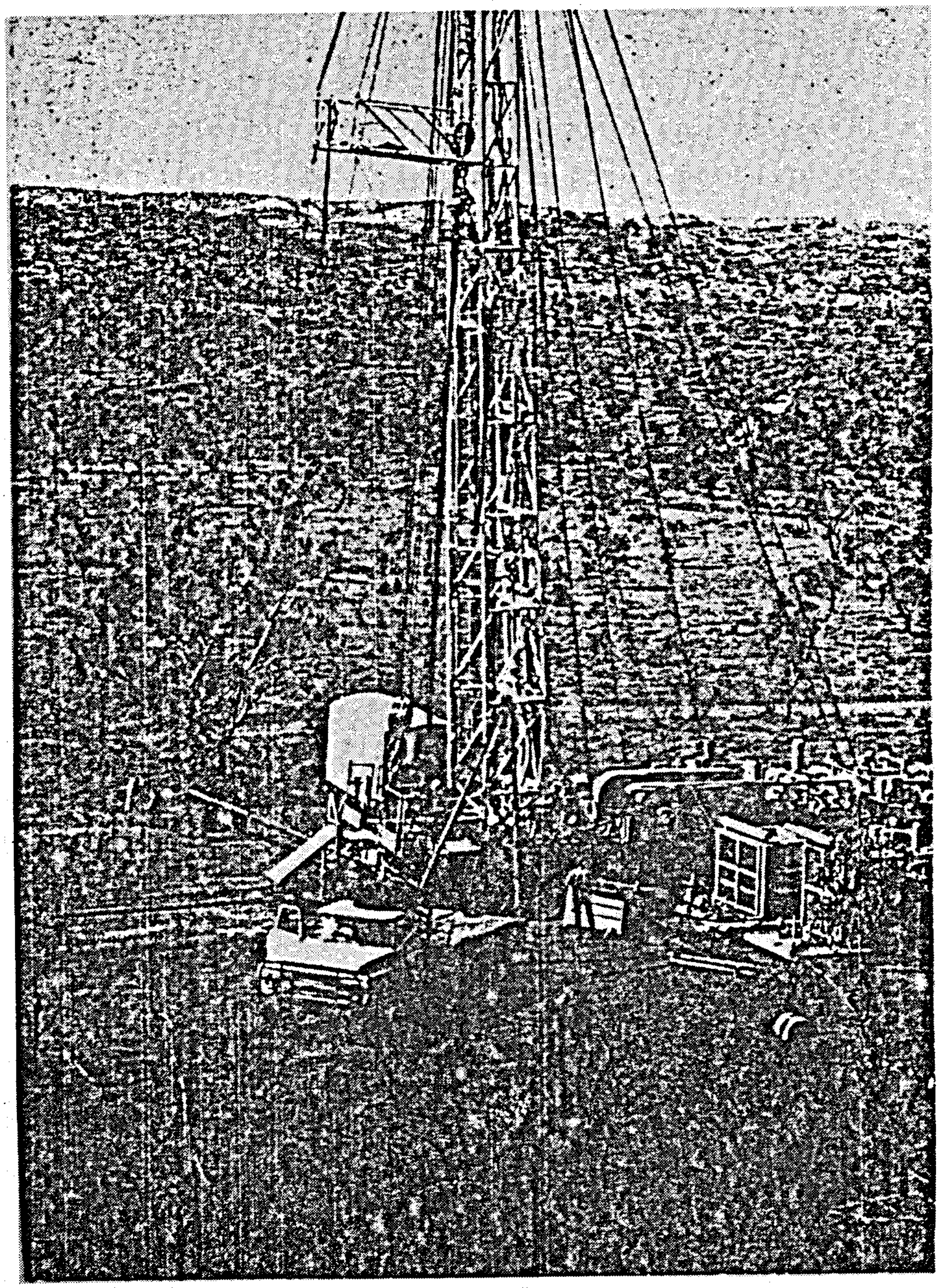


Figure 2.5. TYPICAL AIR DRILLING/FOAM DRILLING RIG (Courtesy: Interairdril.

Mud Pits

The mud pits used with foam drilling are principally used for mixing and storage since the system is not reused. A standard system would use one 200 bbl mud pit. The first pit section would be for mixing lime and inhibitors. The back end of the pit would be suction and storage.

Mud Pump

The mud pump would be a conventional rig mud pump. A mud pump of less than 500 HP would normally be the most satisfactory because it would run fast enough to give a reasonably smooth discharge.

Mixing Pump and Hopper

A mixing pump and hopper system need to be provided in the mixing tank. The mixing pump is generally a centrifugal pump and it should have enough capacity to operate the hopper and some mixing jets.

Drilling Head

Since foam drilling is done with low pressures and volumes, any of the commercially available drilling heads are satisfactory.

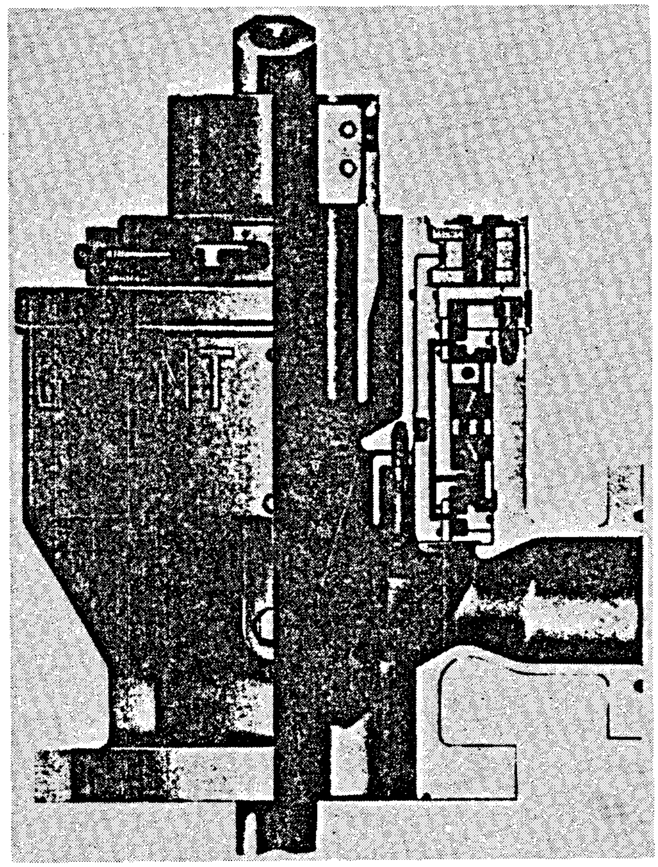


Figure 2.5. Typical Rotating Head.
Courtesy: Grant Tool Company

<u>String Float</u>

Foam drilling requires that a float be placed in the upper part of the drill pipe to keep the foam from expanding up the drill pipe when connections are made. A full opening float is generally the most satisfactory type since it allows the passage of wire line devices.

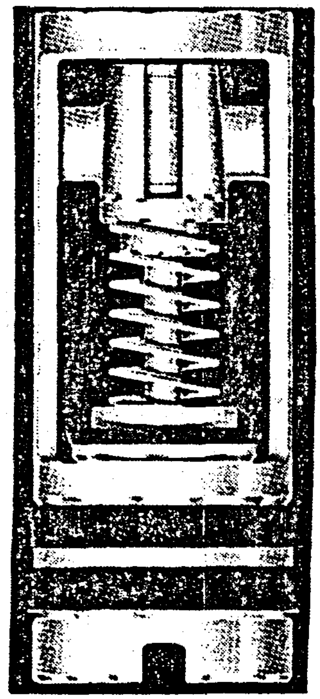


Figure 2.6. Baker Full Opening Float
Used as String Float.
Courtesy: Baker Tool Company

Air Compressors

The greatest reduction in air drilling costs with foam is the small volume of air required. Air volumes for foam generally are less than 500 cfm with pressures of less than 350 psi.

III PHYSICAL AND CHEMICAL PROPERTIES OF FOAMS

Physical Properties

Drilling foams are formed by mixtures of gas, water, and certain chemicals. They vary in density[1] from about .3 to .8 ppg depending on the amount of water present in the fluid. Other types of aerated drilling fluids would be air (0 ppg), mist (0 to 3 ppg), and aerated mud (.8 to 7 ppg). Figure 3.1 depicts the range of such fluids. As the density increases from 0 to 7 ppg more water and less air is combined to form a drilling fluid.

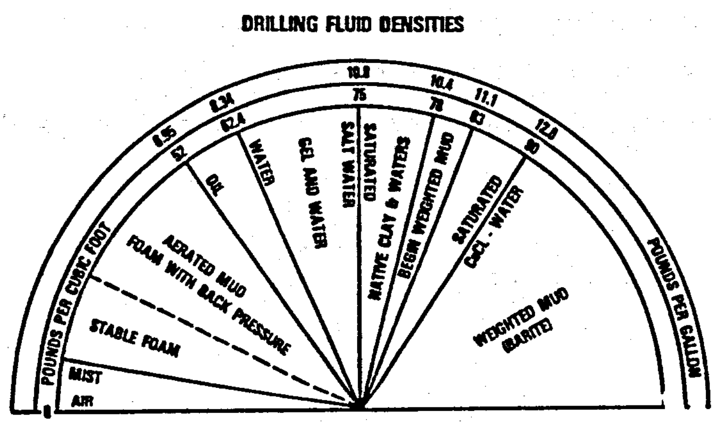


Figure 3.1. Types of Drilling Fluids and Their Relative Densities[1]

1. Hutchinson, S. O., Anderson, G. W.: "What to Consider When Selecting Drilling Fluids," World Oil, 1974.

Stable Foam

Air and mist fluids differ from stable foam and aerated mud in that air is the continuous phase in the air and mist fluids and water is the continuous phase in the stable foam and aerated mud fluids. Mitchell[2] has subdivided the second two fluids (water continuous fluids) into several regions as a function of what he terms "Quality of Foam".

Viscosity Characteristics

In Figure 3.2, Mitchell shows the foam region as consisting of a) few bubbles dispersed in the liquid phase (low viscosity), b) the bubble interference region (medium viscosity) and c) the bubble deformation region (high viscosity). In normal stable foam drilling operations bubble deformation exists and the foam has a viscosity between 5 and 20+ cp with foam quality varying between .75 and .97. Foam quality is defined by the equation:

$$\text{Foam Quality} = \frac{V_g}{V_g + V_l}$$

where

V_l = Volume of liquid
V_g = Volume of gas

It is the high viscosity properties of stiff foam coupled with the low density properties which make stiff foam so attractive as a drilling and completion fluid.

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2. Mitchell, B. J.: "Test Data Fill Theory on Using Foam as a Drilling Fluid," Oil & Gas Jour., September 6, 1971.

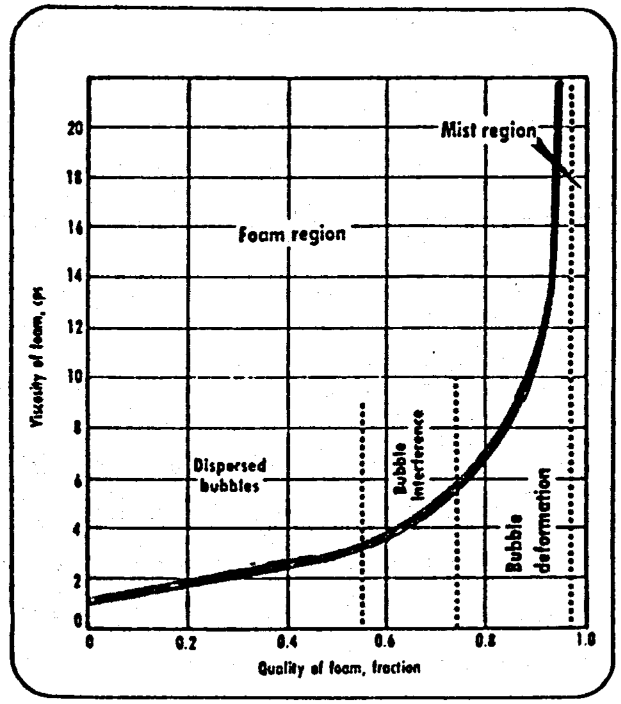

Figure 3.2. Foam Viscosity and Type as A Function of Foam Quality[2]

It is the high viscosity properties of stiff foam coupled with the low density properties which make stiff foam so attractive as a drilling and completion fluid.

Density Characteristics

The low specific gravity of the stable foams generated provides low bottom-hole pressures which prevent lost circulation from occuring in weak zones and also minimizes formation damage.[3]

3. Hutchinson, S. O.: "What Foam is and How It's Used," World Oil, November 1969.

Bottom-hole pressure of only 50 psi has been measured[3] at a depth of 2,900 feet. This represents an average fluid weight of .33 ppg.

In order to insure the proper formation of stiff foams the fluids formed must have specific chemical compositions.

Chemical Composition of Foams

Stiff foams are formed by mixing a gas, water, and certain chemicals in specific proportions using special injection equipment and pumping into the well at specific rates. The type of gas, water, and foaming agent used should be lab tested to insure compatibility.

Gases Used

The two most common gases used in stable foam drilling are air and natural gas. Other gases which have been used are nitrogen, carbon dioxide, and exhaust gases. Natural gas is preferred, but air is usually used because of lack of availability of natural gas.

Water Used

When fresh water is not available, salt water or field waters can be used. When this is done, careful testing should be carried out to insure success. Water from areas such as the Imperial Valley of California contain excess salts and metals which present unique problems.

Foaming Agents Used

In most stable foam drilling, one of several types of foaming agents are used.

1. Alcohol Ether Sulfate. These foaming agents are formed with long chain alcohol ethoxylates which are sulfonated. They are the most widespread foaming agents and can be formulated for either fresh water or salt water solutions.
2. Alkyl Benzene Sulfonate. These foaming agents have better temperature stability than (1) above, but they are not as effective. More agent is needed per gallon of water foamed.
3. Alpha Olefin Sulfonate. These agents perform very similarly to (2) above.

In each application it is necessary to determine the amount of time the foam will be in the well and the temperature of exposure before concentrations can be estimated. Usually 1/2 to 1% foaming agent (by volume) is sufficient.

When corrosion is a problem, as determined by coupon tests, a corrosion inhibitor must be added.

Corrosion Inhibitors

Three elements accelerate corrosion in the drilling string (a) oxygen, (b) carbon dioxide, and (c) hydrogen sulfide.

These three corrosive elements are usually treated[4] by raising the pH of the water to 10 with additions of sodium hydroxide or lime and by adding an inhibitor which forms a

4. Rehm, Bill, Air Drilling Handbook, August 1975.

protective chemical coating. The presence of the high pH neutralizes the hydrogen sulfide.

Rate of Injection

In normal operation the gas is injected with a single compressor at a rate of 350-400 SCFM at a pressure of 250-300 psi. The water/chemical mixture is injected into the mixing head with a liquid injection pump at a rate of about 20 gpm.

Special Equipment

The formation and maintenance of a stable foam requires several pieces of special equipment. These are covered in detail in previous sections of this report.

Requirements for Ideal Foams

An ideal stable foam cleans the hole, is stable at wellbore temperature, resists the effects of contamination, and is disposed of easily. In many cases, it is necessary to experiment with the local water, contaminants and gas to determine the ideal foam.

Hole Cleaning

In most cases an annular flow rate of 300 fpm is required to provide adequate hole cleaning. Lower rates (100 fpm) have been used, but in these cases foam quality was increased by controlling foam solution[5] composition and gas to liquid ratios. The relative lifting force of stable

5. Petroleum Engineering: "Stable Foam Cuts Cost, Increases Production," Vol. 41, No. 13, p. 61-63, December 1969.

foam increases as its liquid volume decreases, as shown[1] by Figure 3.3. Test cases have shown that considerable quantities of solids can be removed from a well using foam.

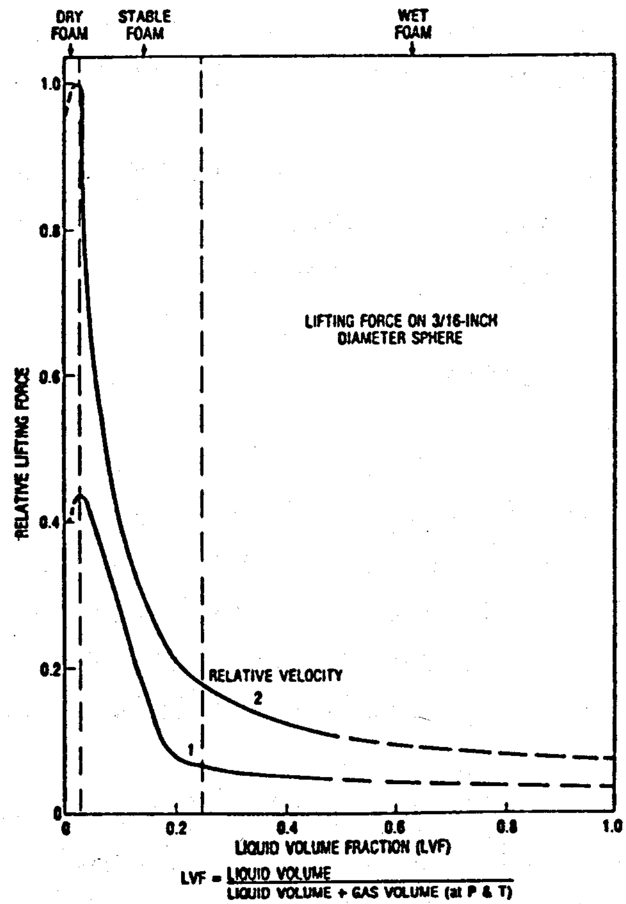

Figure 3.3. Relative lifting force of preformed stable foam (After Beyer, Millhone, & Foote)

In artic drilling[6] a 17-1/2 inch hole was successfully drilled using foam at drilling rate of 35-60 feet per hour. In another test[5] the carrying capacity of foam wa compared to that of salt water. The salt water was circulated at 150 fpm and solids were removed at a rate of 16-40 lbs/bbl of salt water. Foam was then circulated at 300 fpm and solids were removed at 43-328 lbs/bbl.

A major requirement[7] for cleaning drilled holes with foam is the formation of a stable foam which does not collapse when circulation is stopped.

Temperature Effects

A major limitation of stable foams is the temperature limits of the various foaming agents. To date very little information is available on this subject. Much research is needed to define and extend the temperature limits of foams. Experience has shown several unique uses for stable foam with regard to temperature conditions in wells.

In West Texas[8] oil zones which contained paraffin have been put back on production after being completed with foams which were made with 200°F water.

6. Anderson, Glenn, W.: "Near Guage Holes Through Permafrost," Oil & Gas Jour., pp. 126-142, September 1971.
7. Jokhoo, Khem: "Aerated Foam Drilling in Trinidad," Petroleum Engineer, Vol. 48, No. 7, pps. 24-32, June 1976.
8. Bleakley, W. B.: "West Texas Workovers with Foam Gain Favor," Oil & Gas Jour. Vol. 71, No. 11, pp. 97-98, March 1973.

Under arctic conditions[6] the freezing of foams is prevented by the use of water containing 10-15% salt water. If the fresh water is used, the foam freezes in a cellular state.

When bottom hole temperatures exceed 350°F and oils are present, air should not be used. This is to prevent fires.

A real potential exists for the use of stable foams in steam wells[3] The low heat conductivity of foam makes it an ideal circulating fluid.

Contamination of Foams

The technique of pre-forming foams at the surface has greatly solved the problem of foam failure by contaminants. It appears that once the foam is formed, contaminants do not destroy the foaming agents as readily. Foams have been designed to handle the following contaminants:[5]

1. 10-30 API Gravity Crude Oils
2. Salt Water
3. Iron Oxide and Sulfide
4. Cement
5. Solvents
6. Caustic Solutions
7. Hydrochloric and Hydrofluoric Acids
8. Hydrogen Sulfide[3]

Foam Disposal

Foams are used in the drilling operation on a once through basis and must therefore be disposed of as they exist from the well. Several methods have been devised.

The foam is mixed with crude oil[9] or salt water as it exits from the well and the foam is broken. Also, on occasion, certain chemicals can be added. If necessary these spent chemicals can be passed through an oil field heat-treater.[5]

Under Arctic conditions[6] the foam is simply allowed to freeze, then with minimal agitation the foam collapses.

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9. Anderson, G. W.: "Foam Disposal--Offshore and Urban Operations," Chevron Research Company Foam Cleanout Technical Notes, April 1977.

IV APPLICATION OF FOAMS IN GEOTHERMAL DRILLING

Drilling fluid related problems are the single most frequently sited reason for drilling problems in geothermal wells. The most apparent problems are the failures of the fluid to perform essential functions under high-temperature conditions. For example, gelation of conventional muds when circulation is stopped for operations other than drilling can lead to stuck pipe, aborted logging runs, stuck tools, etc. The related high pumping pressures can cause unexpected failure of casing seats or formation breakdown with consequent loss of circulation. Fluids formulated to remain reasonably stable at higher temperature do not have adequate filtration characteristics, resulting in formation damage.

Less obvious are the high direct costs which can be incurred with geothermal drilling fluids. Expensive treatment and replacement of materials is required to keep the fluid properly conditioned. Difficulties in corrosion control in geothermal environments lead to more frequent drill pipe replacement and drill pipe related problems than is experienced in non-geothermal applications.

Least obvious is the indirect cost from slower drilling, lost time for peripheral operations such as mixing mud, adding lost circulation materials, drill pipe inspection, etc.

As discussed in the review of foam drilling, the selection and use of drilling fluids for geothermal application requires greater care and technology than ordinary oil and gas operations. The high cost of these operations and the sensitivity of geothermal formations to irreparable drilling damage to productivity necessitates improvements in the effectiveness of drilling fluids in geothermal applications.

A three element approach was used in examining the potential of drilling foams for reducing the cost of geothermal wells. First, an extensive survey of industry personnel was made to a) develop an overview of the extent of which foams are applicable to geothermal drilling and b) to determine the problems associated with using foams. Second, to examine laboratory procedures for screening foam drilling fluids and to measure properties of typical candidate materials. Third, to recommend a program for improving drilling foams and their application in geothermal wells.

A. Survey

Over fifty industry technical personnel were contacted regarding drilling foams during the course of the study. A partial list of these is included in Appendix 4 along with summaries of questions posed to these individuals, and a sampling of responses received.

The most important conclusion drawn from this survey is that drilling foams are applicable to a significant part of geothermal drilling. Several knowledgeable people estimated as high as 70 to 80 percent of geothermal drilling could be done with foam with the majority agreeing that in excess of a third and perhaps a half of geothermal drilling will be done with foam if technical problems can be solved. Cost reduction estimates ranged from 98 percent saving on drill pipe wear down to 20 percent saving on lost time cost. Estimates were that foam would be slower than air drilling but 3 to 5 times faster than drilling with muds. Foam would definitely replace air if the technical problems are solved.

Using very conservative assumptions, according to our survey, estimates of cost benefits for improved drilling foams were made. As shown in Figure 10, improved drilling foams could directly account for a 3 percent reduction in geothermal well cost by 1986. This would result in almost a thirty-fold payback of the investment to develop this technology by '86.

HIGH TEMPERATURE DRILLING FOAMS
BENEFIT ESTIMATES

- APPLICABLE TO 35% OF HOLE
- APPLICABLE TO 44% OF WELL COSTS
- COST REDUCTION IS 20%
- BENEFITS BEGIN ACCRUING IN 1981
- PROGRAM COMPLETE BY 1986

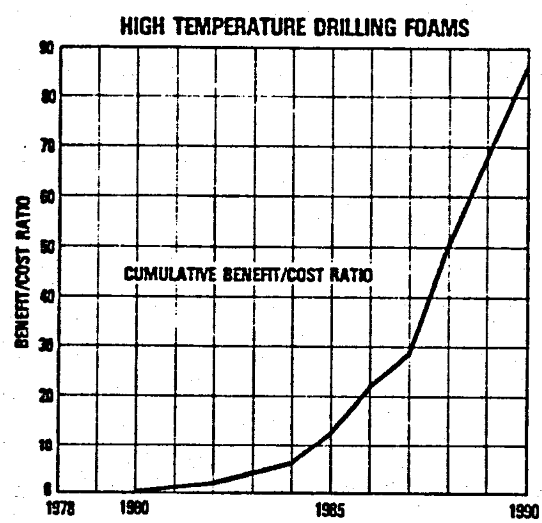


Figure 4.1. Conservative Estimate of Benefit/Cost Payout of Improved Geothermal Drilling Foam Development Program.

B. <u>Technical Problems</u>

The technical problems limiting present use of drilling foams are as follows (not in order of priority):

1. Stability of foams under changing pressure and temperature conditions
2. Stability of foams under water or brine intrusion
3. Corrosivity of foams, including pH stability
4. Foam breaking, cleaning, and disposal problems
5. Borehole stability in the presence of foams
6. Sensitivity of foams in inert or stack gas with hydrocarbon impurities
7. Foam generators and other surface hardware
8. Lifting capability of foams
9. Heat transfer/insulation and heat capacity of foams
10. Testing and screening procedures for foams

Temperature stability of foaming agents was discussed with Fred Fowkes at Le-High University. He felt that no insurmountable technical barriers existed and that a high-temperature foamer could be developed with good corrosion and physical stability properties. He recommended a binary system be considered; in this syste, one component would be effective at low temperature, the other at high temperature. Similarly other technical people felt that the development of the requisite drilling foams was a matter of a systematic laboratory and field development program. The estimated time and financial budgets for such a program are presented in Chapter VII.

Testing of Foams

Test procedures and testing of foams are included in separate sections of this report. Summarizing, however, it appears that a modified Chevron test on foams (with testing before and after high-temperature aging) is probably the best presently available screening technique. Advanced testing methods including a high-temperature, high-shear circulating flow loop is needed to test candidate foams under borehole conditions. The problem of ascertaining borehole stability in the presence of foams should also be addressed. Methods of breaking and cleaning foams will probably have to be tested on a field scale.

Non-technical Problems

It was evident in the interviews that non-technical considerations now limit the extent of which drilling foams are used in geothermal applications. The first of these is lack of technical expertise in their use and familiarity with their capabilities. Although several excellent papers have been written on the use of foam in workover operations discussions of drilling foams is less comprehensive. Also possibly impeding the use of foams is a lack of availability of reliable equipment for major drilling operations. All present economic incentives to use foams are reduced because present operating procedures entail having foam drilling as essentially an add on expense to air drilling operations.

Summation

There is a strong consensus that drilling foams will be widely applicable for geothermal drilling. Advantages of foam include:

- Good Hole Cleaning
- High Drilling Rate
- Reduced Lost Circulation Problems
- Potential High-Temperature Capability
- Reduced Capital Cost

The disadvantages of mixing, breaking, and disposal along with corrosion and borehole stability have limited present applications.

Although Union and Chevron both have significant efforts directed toward developing improved drilling foams, it does not appear that there is any comprehensive effort towards solving the technical problems. Noticeably absent in the technical development were the service companies which typically have led in the development and marketing of improved drilling services.

Several individuals stated that due to the lack of effort in this area, government R&D could play a particularly significant role in advancing technology without threatening the competitive structure of private industry.

C. Borehole Environmental Zones That Favor Foam as a Drilling Fluid

There are four classifications of borehole environments that are appropriate for using foams. These are:

1. Lost Circulation Above Permeable Rock
2. Dry Fractured Rock
3. Hot Lost Circulation
4. Variable Density Requirements

The shallowest and coolest environmental zone that favors the use of foam as a drilling fluid is in the upper section of the hole where the temperature does not exceed 250°F. Foam would be the favored drilling fluid if the rock was wet and fractured or had a lost circulation zone above a wet zone with a water drive. The water in the zones would preclude the use of air as a drilling fluid. The water in the zones would preclude the use of air as a drilling fluid. The compressible nature of the foam system would make it possible to have a light fluid at the top of the hole so as to avoid lost circulation and a denser fluid below that zone to repress the water flow. (See Appendix A--Foam Mathematics.) Figure 4.2 shows a schematic of this borehole situation.

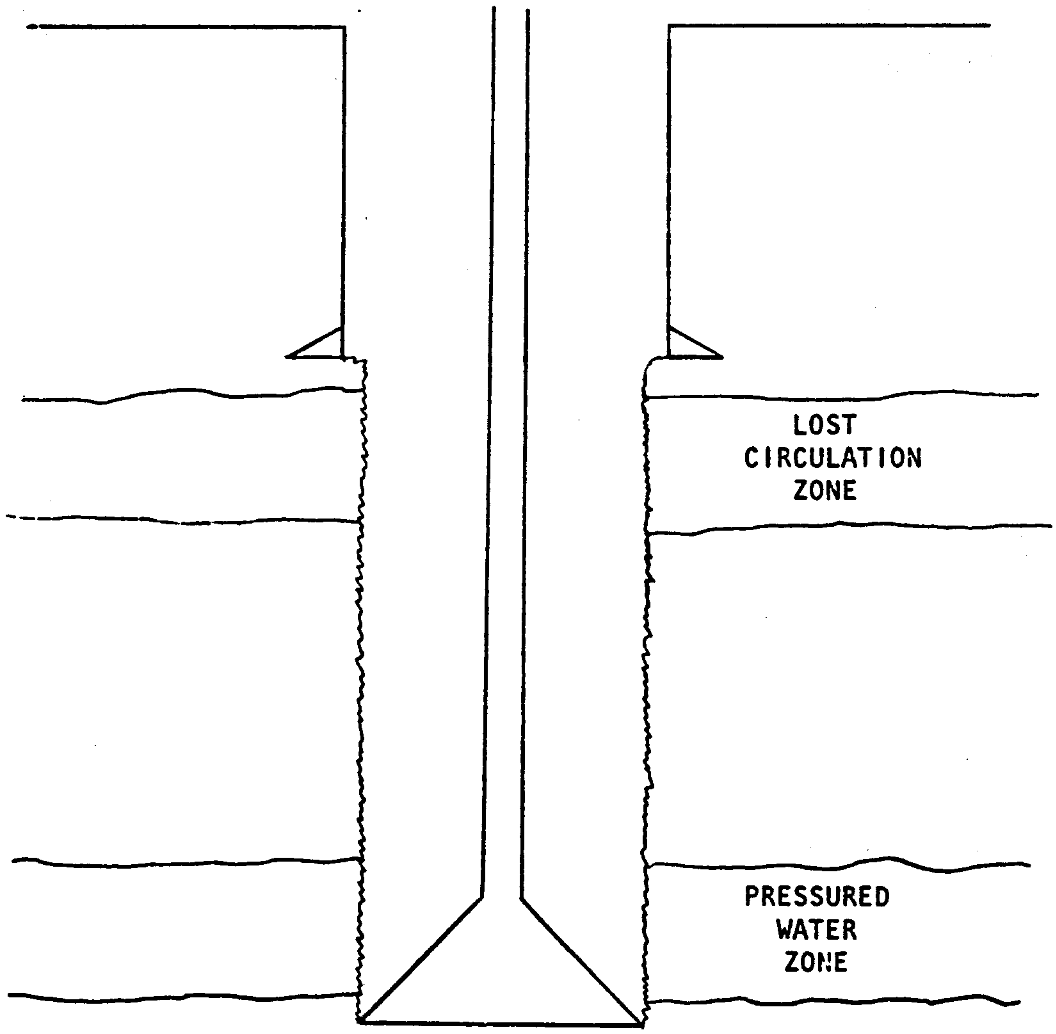


Figure 4.2. Foam Utilization Where Lost Circulation Occurs Above a Permeable Pressure Water Zone

In dry rock, foam would be a favored drilling fluid in the section of the hole below 250°F, if the rock is extensively fractured. The fracturing may be of the nature that normal drilling fluids would lose circulation, and air drilling would not support the walls of the hole which were extensively fractured and fragmented. (See comments on lifting capacity of foams in Chapter I.) Figure 4.3 indicates the borehole environment where foam can be used to support the walls of a fractured zone.

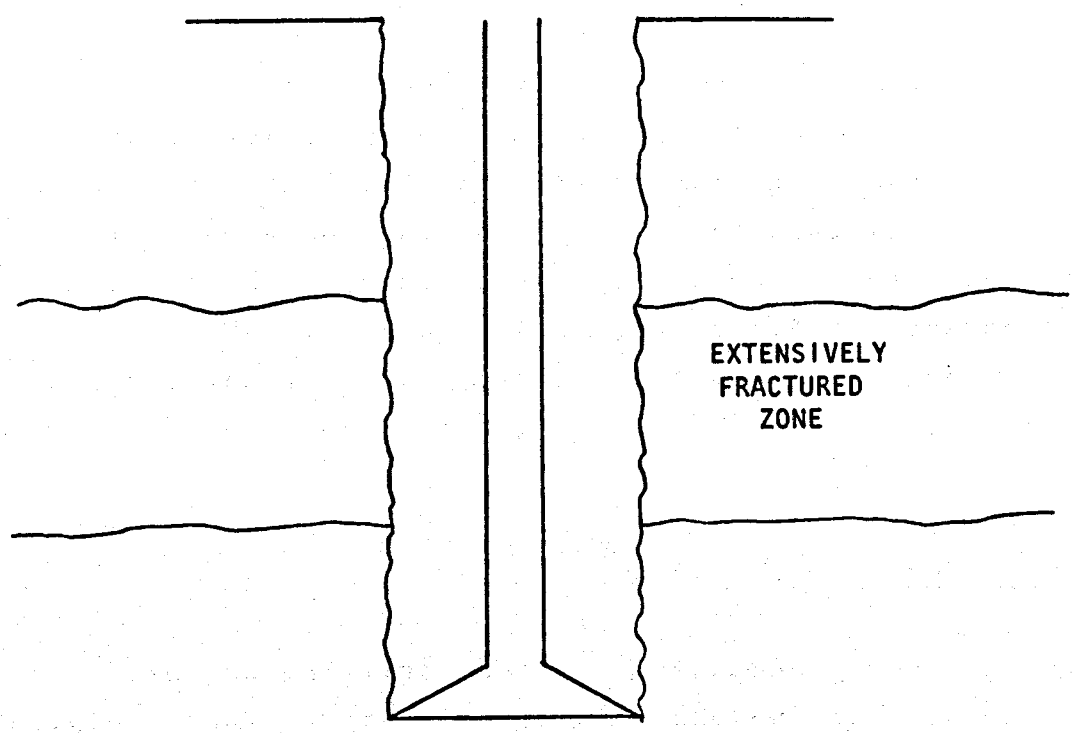


Figure 4.3. Use of Foam to Support the Walls of a Fractured Zone

In shallow holes above 250°F where there was extensive lost circulation foam would be a favored drilling fluid, wherever there were formations with a water drive that precludes the use of air drilling. The variable density of the foam system as outlined in Appendix A on Foam Mathematics allows a system to be built that can circulate and still repress most of the water drive. Foam systems can be built that will not go flat under the influence of reasonable amounts of water, so that the drilling system can achieve a practical balance. In hot systems of this nature, the insulating effect of the foam would tend to keep the hole from steam unlaoding during non drilling periods.

In deep holes, foam acts as a conventional drilling fluid at the bottom of the hole due to the compression of the air. The air expands at the top of the hole and thus effectively relieves the pressure on the upper part of the borehole by a greater percentage than on the bottom of the borehole. Figure 2.2, 2.3, and 2.4 in Chapter II show that the effective foam desnity is drastically reduced near the surface.

Equipment for Foam Drilling

The equipment necessary for foam drilling can be obtained from conventional air drilling operations equipment.

1. Air Compressors

The air compressors necessary for foam drilling fall within the range of the smaller air compressors available for air drilling. The equipment is effective and available.

2. Pumps

The mud pumps necessary for foam drilling are available on the smaller rigs or from the equipment rental companies. Small duplex or triplex pumps in the 500 hp range and capable of pressures to 1,000 psi and volumes of up to 7 bbl per minute fulfill most foam drilling requirements.

3. Foam Mixers

The foam is mixed below the air compressor and before going down the drill pipe. There are several mixing designs available, most use a venturi effect to jet the liquid into the compressed air column. These are relatively standard pieces of piping, are easy to build, and normally available from the compressor operator.

4. Air/Mud Meters

The mud meter most commonly used is the Halliburton "spinner" which is normally used to measure the volume of cement slurries. It has a certain amount of wear and inaccuracies. The reciprocating mud pump is almost as accurate at the spinner, so mud flow rate measurements are available. Air volume measurements are usually made with a differential plate in the air line and a differential air meter at the compressor. This is a poor system because it does not allow a direct readout of the air entering the hole. Better readouts that directly read air volume are available and should be used.

The only equipment that is not available at the present time is a device for breaking the foam so that the liquid can be disposed of or cleaned and remixed to foam again. Foam is used on a once through basis which adds significantly to the cost of using foam. Since the material is discharged as a persistent foam, there are areas where it cannot be used because it cannot be pumped, moved, or cleaned up until the foam breaks.

There has been very little effort made to break drilling foams. They are not pollutants in the chemical sense and so are allowed to lie in the pits until they eventually disappear. In some areas this can take years.

A major improvement in the use of foam drilling fluids would be the ability to break the foam and reuse the chemical and inhibitors. The foam is persistent and has a density of about 1 ppg with the appearance of foaming shaving cream. It is difficult to transport to any particular point because it cannot be pumped or shoveled. It can sometimes be handled by vacuum truck with difficulty. Because of these problems and because the foam has generally been used in desert or arctic areas, there has been little done to develop methods of reusing the foam or simply breaking it for disposal.

Operational Environments for Foams

1. Available Foams Fresh Water

The present foam systems are effective in fresh water environments below a temperature of 250°F. The foam is stable and persistent. Water dilution from subsurface water flows acts only to reduce the quality or percent air in the foam.

2. Available Foams Salt Water

Present foam systems are partly effective in salt water systems. In general, as the salt or mineral content of the water increases, the foaming agent becomes less effective and more foaming agent must be used. With saturated subsurface waters, the foam tends to go flat and lose its foaming ability. At present the most effective technique to deal with this problem is to make the foam with fresher water and to maintain enough foam head against the formation to repress the formation water drive. More effective foams or foaming agents need to be developed for high salt water systems.

3. Hot Fresh Systems

At temperatures above 250°F, the fresh water foams generally become ineffective as the foaming agent is broken down by the heat. Only one material was effective at 500°F and that was the only solid foaming material tested, Sulfotex LAS 90. It is then both possible and practical to build high-temperature drilling foams that will have high lifting capacities and variable column density.

4. Hot Saline Water Systems

At high temperatures, it appears that there is no foaming agent available that is effective in saturated or near saturated saline water systems. This poses two limitations to the continued development of foam systems.

a. Water influx into the bore will flatten a foam and make it impossible to regain circulation from the bottom. The bit will have to be pulled up and circulation regained above the saturated water flow and then try to foam the head of it off going back in the hole. Experience indicates that this is easier to say then to do and causes great operation difficulties.

b. The foaming agent must be made up with fresh water. In many of the potential areas where foam would be a favored drilling fluid, saline or saturated water is available, but fresh water is very expensive. One of the major limitations to previous uses of foam and to the use of mist chemicals with air drilling has been the necessity of using fresh water. To the degree that the hole stays cool, this problem has been solved at least in part. High temperature, however, flattens all of the foams and makes all known foaming agents ineffective in saturated saline and chemical systems.

V FOAM TEST PROCEDURES

INTRODUCTION

Foams were generated by the two following basic methods in this evaluation:

1. By injection of water solutions of the foamers into an air stream in a column
2. By aggitation of water solutions of the foamers with a high speed mixer

Liquid carry-over was measured in the column test. Foam volume (quality) and drainage time were measured on the foams generated with the high speed mixer. Foams were generated with eight of the commercial foamers which were submitted. Tests were performed with the foamers, as received, and also with the foamers which were exposed to 500°F-375 psi for 16 hours. A standard ten foot API column was compared with a five foot column.

Other properties of the foams which were measured included corrosion rate, pH, and surface tension. These tests were run on water solutions of the foamers, as received, and after exposure to 500°F-375 psi for 16 hours.

Column Tests

Liquid Carry-Over by 0.15% Foamer in Distilled Water

Initially, all of the commercially available foaming agents which were tested removed large amounts of liquid from the five foot column as shown in Figure 5.1. Textilana's Sulfotex LAS-90 and Baroid's Surflo S375 removed approximately 15% more liquid from the column than the other foamers which

FOAMS GENERATED BY AIR INJECTION

Liquid Carry-Over From A 5 Foot Column Containing 0.15% Foamer In Distilled Water

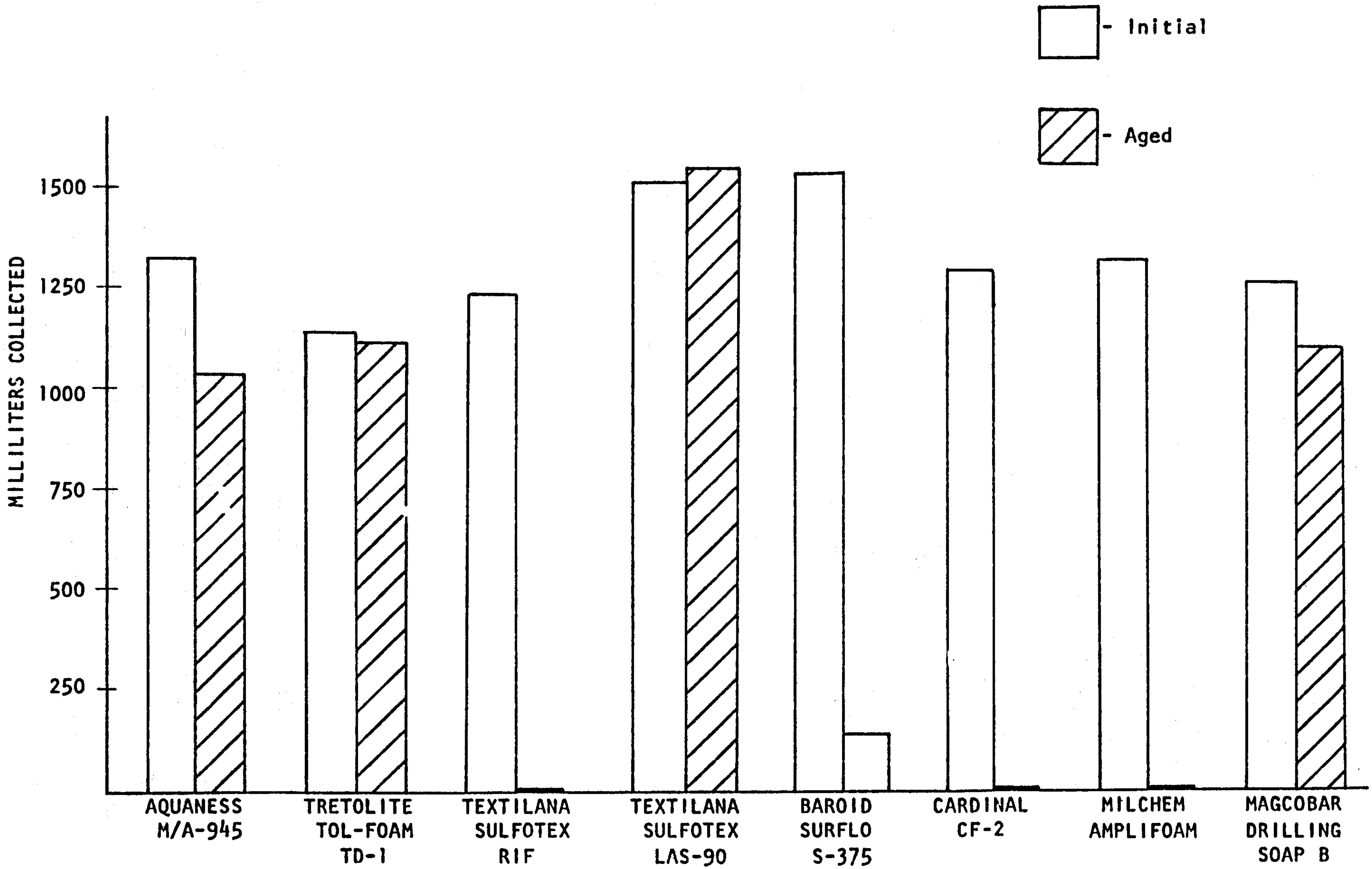


Figure 5.1. FRESH WATER FOAMS IN A 5 FOOT COLUMN

were tested. Textilana's Sulfotex RIF coated the lucite column with an oily film that was difficult to remove.

After aging at 500°F-375 psi for 16 hours, Textilana's Sulfotex LAS-90 removed about the same amount of liquid from the five foot column as before. Tretolite's Tol-Foam TD-1 also removed nearly as much liquid after exposure at 500°F as before but again the amount was approximately 15% less than that removed by the Sulfotex LAS-90. Textilana's Sulfotex RIF, Cardinal's CF-2, and Milchem's Amplifoam did not foam after aging at 500°F. The other materials which were tested foamed, but a much smaller amount of liquid was removed by these foamers after exposure to 500°F.

Similar trends were observed on tests conducted with a standard ten foot API column as shown in Figure 5.2. The foamers which removed the largest amounts of liquid on the five foot column also removed the largest amounts of liquid on the ten foot column. Initially, the amount of liquid removed by Textilana's Solfotex LAS-90 and Baroid's Surflo S375 was 20%-30% higher than that removed by the other foamers. Only liquid and no foam was collected at the discharge port when Tretolite's Tol-Foam TD-1 was tested. The size of the bubbles formed by Cardinal's CF-2 on the ten foot column were much smaller than those formed by the other materials. Generally, a smaller volume of liquid was removed from the ten foot column than from the five foot column.

After aging 16 hours at 500°F-375 psi, Textilana's Sulfotex LAS-90 removed as much liquid as when tested initially. Textilana's Sulfotex RIF, Baroid' Surflo S375, Cardinal's CF-2, and Milchem's Amplifoam failed to remove any liquid from the ten foot column after being exposed to 500°F. The remaining materials removed some liquid from the ten foot column after being exposed to 500°F, but their ability to remove liquid was severely reduced.

FOAMS GENERATED BY AIR INJECTION

Liquid Carry-Over From A 10 Foot Column Containing 0.15% Foamer in Distilled Water

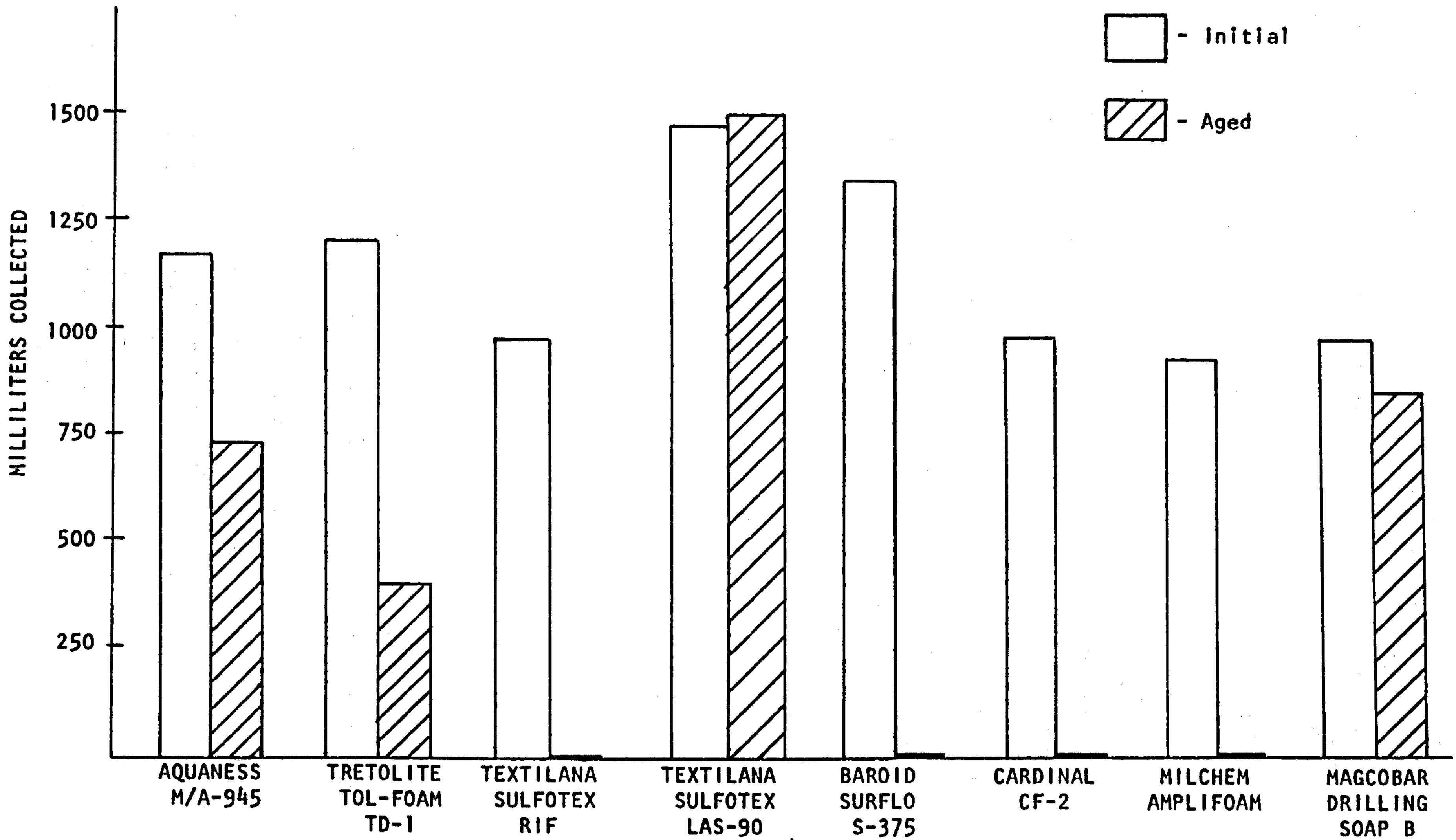


Figure 5.2. FRESH WATER FOAMS IN A 10 FOOT COLUMN

Liquid Carry-Over by 0.75% Foamer in Ten Percent Sodium Chloride Solution

When tested initially on the five foot column, seven of the foamers removed large amounts of salt water from the column. Textilana's Sulfotex LAS-90 removed about 20% less salt water than the other foamers as shown in Figure 5.3. The volume of salt water removed by the other seven materials was within 6% of each other.

After aging 16 hours at 500°F-375 psi, only Magcobar's Drilling Soap B removed any salt water from the five foot column. Even here the amount of salt water removed was very low compared to that removed initially.

Similar results were obtained on the ten foot column as shown in Figure 5.4. Here again Textilana's Sulfotex LAS-90 removed the lowest amount of salt water initially. Tretolite's Tol-Foam TD-1 removed a little more salt water than the Sulfotex LAS-90. The remaining materials removed about the same amount of salt water.

After exposure to 500°F, again, only Magcobar's Drilling Soap B removed any salt water. The amount removed on the ten foot column was even lower than that removed on the five foot column.

FOAMS GENERATED BY AIR INJECTION

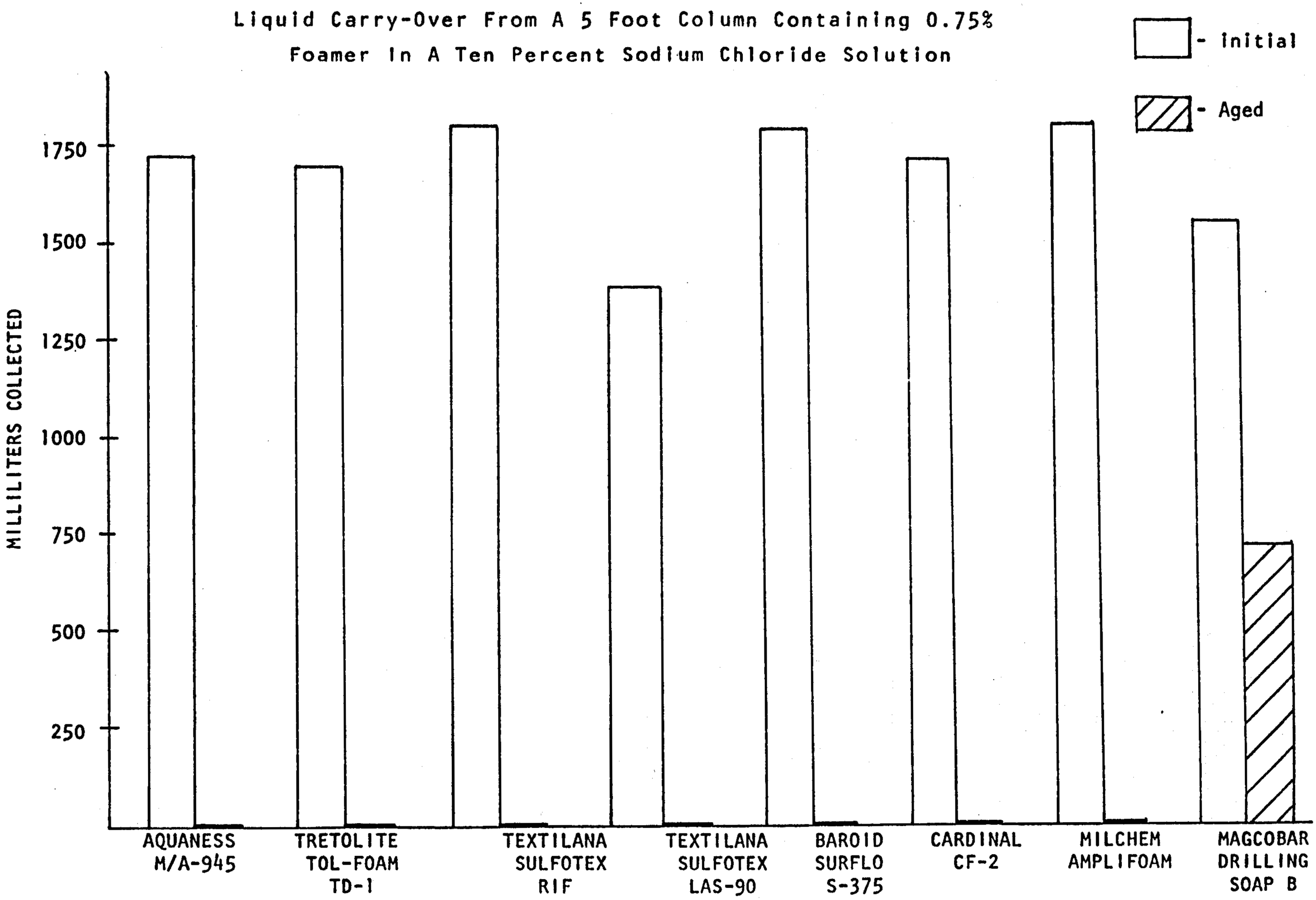


Figure 5.3. SALT WATER FOAM IN A 5 FOOT COLUMN

FOAMS GENERATED BY AIR INJECTION

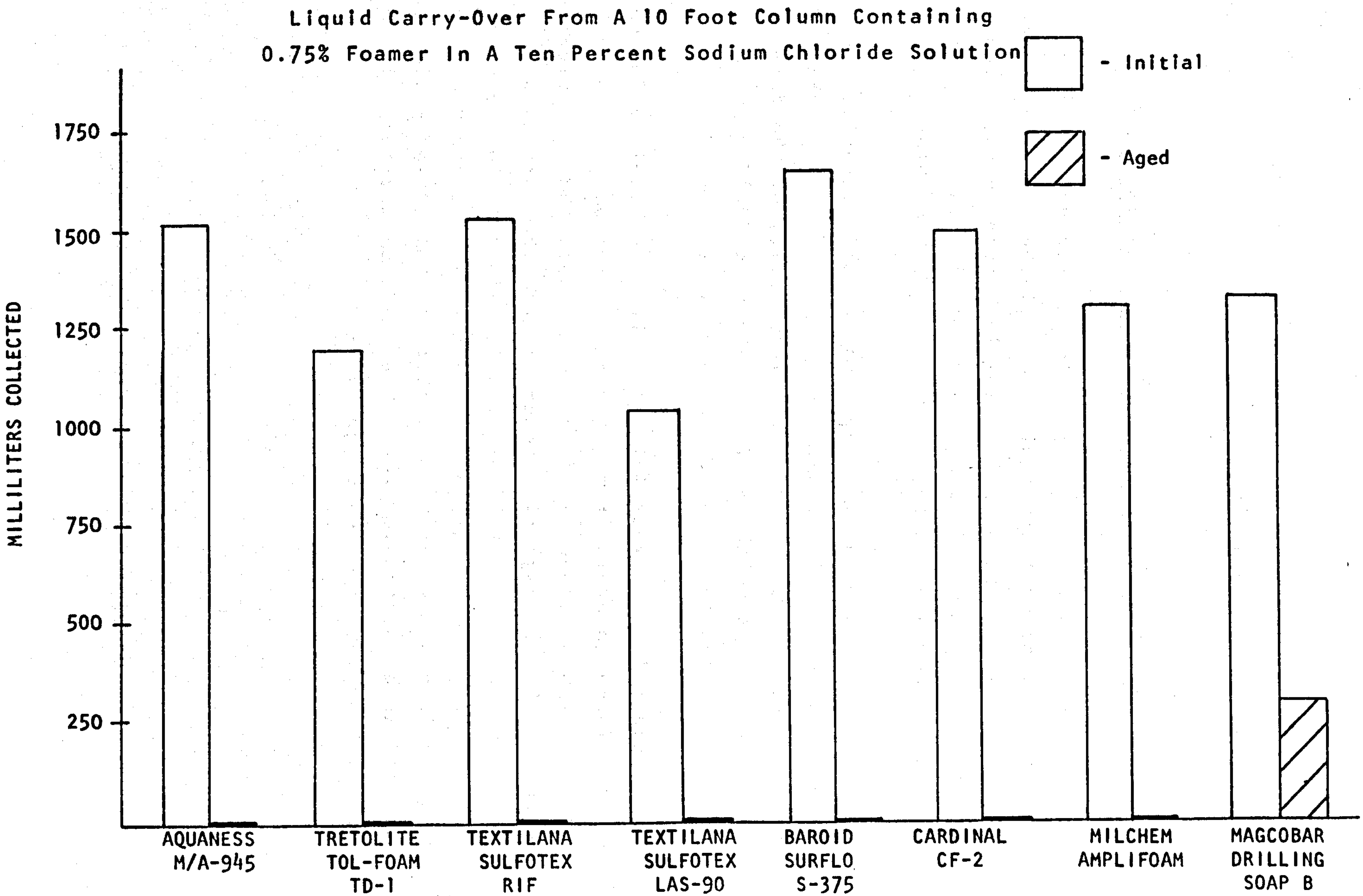


Figure 5.4. SALT WATER FOAM IN A 10 FOOT COLUMN

Foams Generated With a Mixer

Foams from 0.5% Foamer in Distilled Water

Figure 5.5 shows that initially foam volumes of 6 to 7.5 times the volume of foamer solution could be generated by a high speed mixer. Foam quality, as indicated by the volume obtained from 100 ml of foamer solution, increased when salt water was added and the solution was stirred at high speed.

Textilana's Sulfotex LAS-90 was the only material tested which foamed when stirred with the high speed mixer after aging 16 hours at 500°F-375 psi. The quality of the foam formed after heating the Sulfotex LAS-90 to 500°F was almost identical to the foam quality measured initially.

Table 5.1 shows that initially the time required for half of the liquid to drain from the foam generated with a high speed mixer was between 3-1/2 and 5 minutes. No significant change in the drainage time occurred when the samples were restirred. Addition of 25 ml of a 1% salt solution reduced the drainage time for all of the foamers except for Magcobar's Drilling Soap B. A further reduction in the drainage time occurred when the samples were restirred, except for Milchem's Amplifoam which increased slightly.

FOAMS GENERATED WITH A MIXER

Figure 5.5. Foam Volume Obtained From 100 ml of 0.5% Foamer in Distilled Water

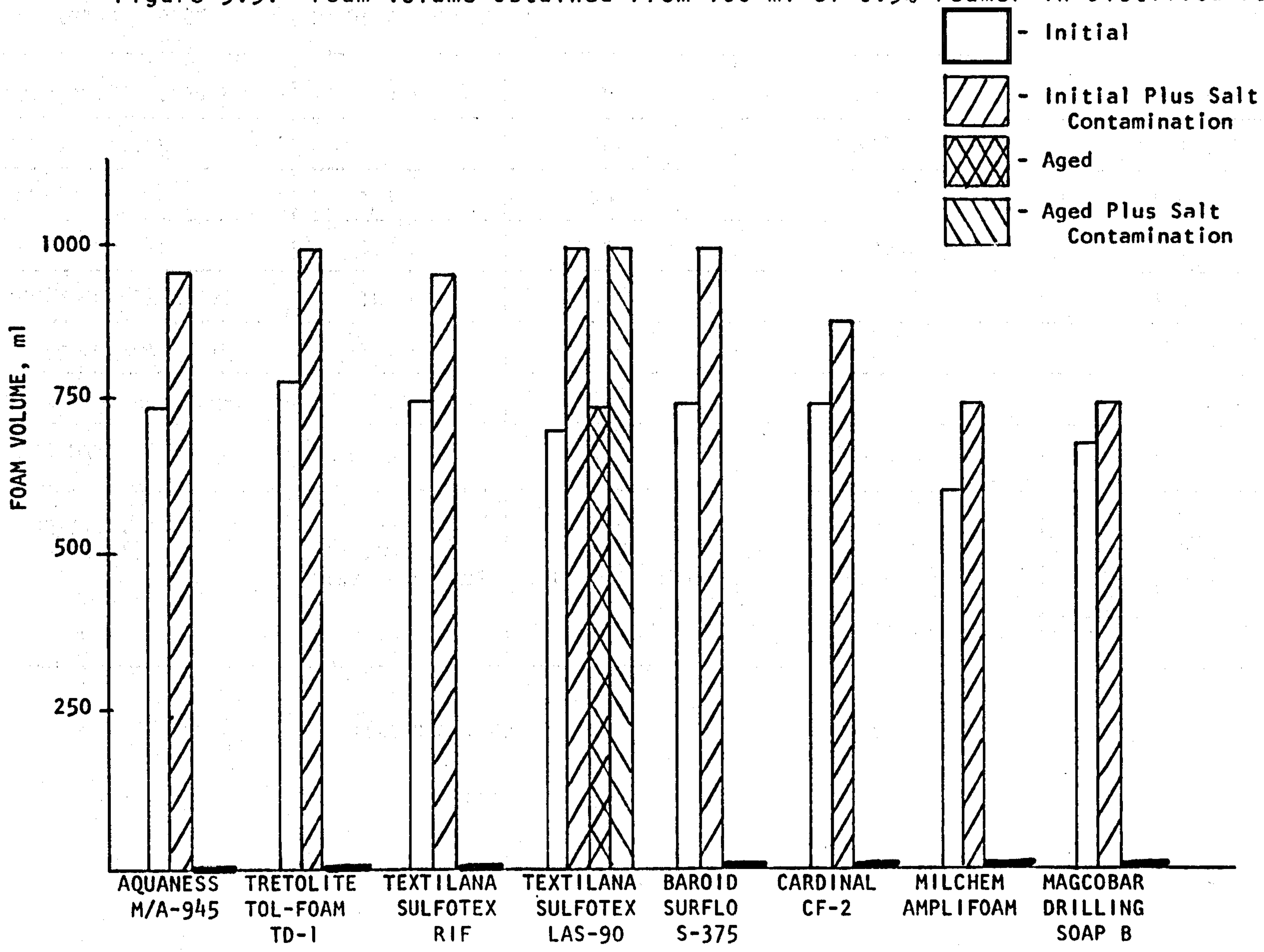


TABLE 5.1.

FOAMS GENERATED WITH A MIXER

TIME REQUIRED FOR HALF OF THE LIQUID TO DRAIN*

SAMPLE IDENTIFICATION	FIRST DRAINAGE TIME, Sec	SECOND DRAINAGE TIME, Sec	AFTER ADDITION OF 25 ml OF 1% SALT SOLUTION: FIRST DRAINAGE TIME, Sec	AFTER ADDITION OF 25 ml OF 1% SALT SOLUTION: SECOND DRAINAGE TIME, Sec
AQUANESS M/A-945	247.7	265.1	210	172
TRETOLITE TOL-FOAM TD-1	229.2	234.5	203.5	196.5
TEXTILANA SULFOTEX RIF	225.6	199.3	165	156.5
TEXTILANA SULFOTEX LAS-90	286.8	278.5	241.4	235.7
BAROID SURFLO S375	264.7	288.6	260.4	220.3
CARDINAL CF-2	291	299.5	234.4	225
MILCHEM AMPLIFOAM	290.1	304	205	243.9
MAGCOBAR DRILLING SOAP B	214.7	204.6	235	164.2

*Initial Tests - 0.5% Foamer in Distilled Water

Foams from 1.0% Foamer in Distilled Water

Foam volumes generated when 100 ml of 1.0% Foamer were stirred on the high speed mixer were only slightly higher than volumes obtained from 0.5% solutions as shown in Figure 5.6. The effect of salt water additions and high temperature aging were almost identical as those previously observed on the 0.5% solutions. Again only Textilana's Sulfotex LAS-90 foamed after exposure to 500°F and the results obtained on the unheated sample were almost identical to those on the static aged sample.

Table 5.2 shows that the initial drainage times for the 1.0% solution of foamers was similar to those of the 0.5% solutions. Addition of salt water reduced the drainage time for all of the foamers tested at 1.0% concentration. No significant change in the drainage times occurred when the samples were restirred.

A comparison of the drainage times obtained on solutions of Textilana's Sulfotex LAS-90 is shown in Table 5.3. After exposure to 500°F only a slight reduction in the drainage time occurred.

FOAM GENERATED WITH A MIXER

Figure 5.6. Foam Volume Obtained From 100 ml of 1.0% Foamer in Distilled Water

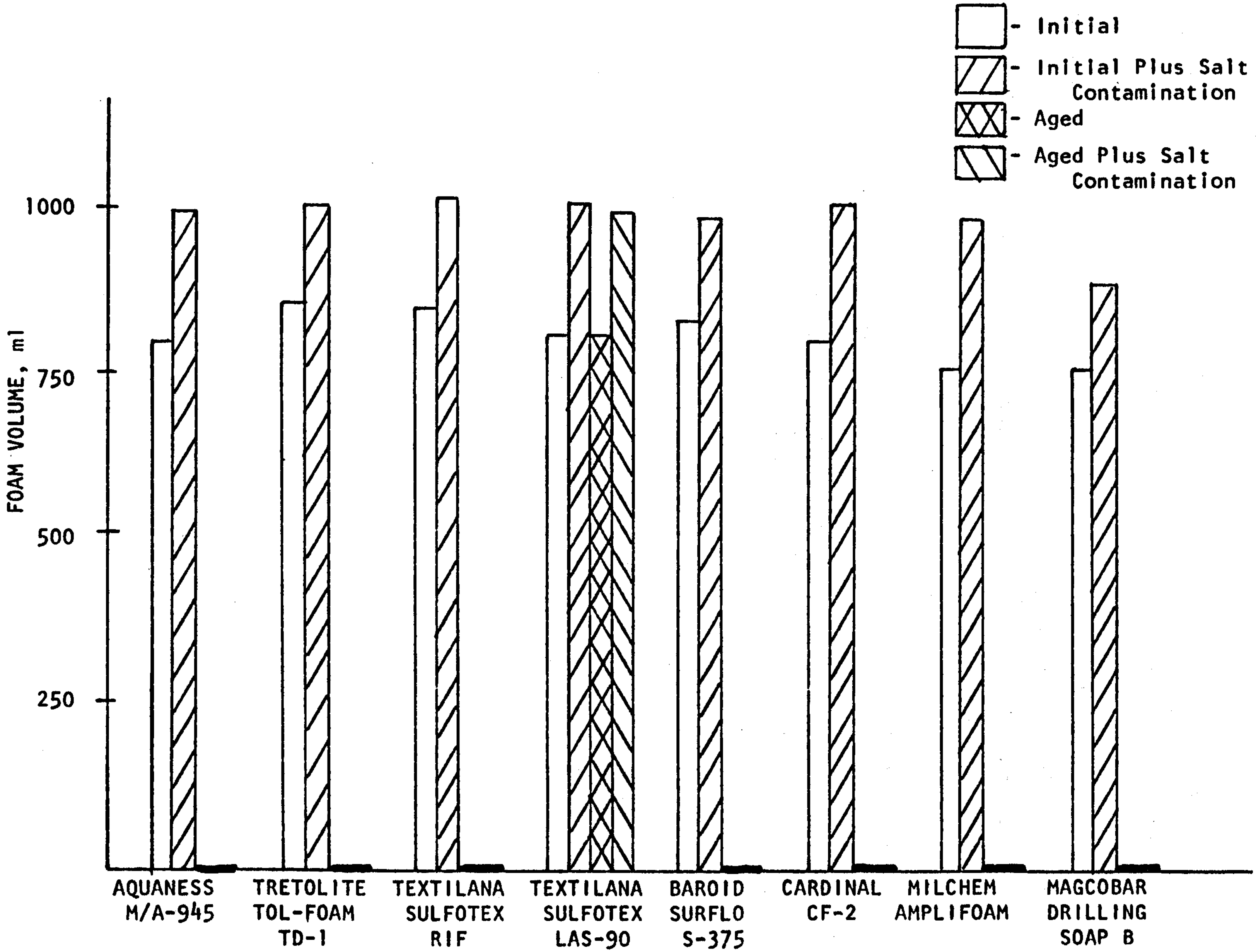


TABLE 5.2.

FOAMS GENERATED WITH A MIXER

TIME REQUIRED FOR HALF OF THE LIQUID TO DRAIN*

SAMPLE IDENTIFICATION	FIRST DRAINAGE TIME, Sec	SECOND DRAINAGE TIME, Sec	AFTER ADDITION OF 25 ml OF 1% SALT SOLUTION	
			FIRST DRAINAGE TIME, Sec	SECOND DRAINAGE TIME, Sec
AQUANESS M/A-945	241.8	241.6	183.6	180.4
TRETOLITE TOL-FOAM TD-1	223.9	214.2	176.4	181
TEXTILANA SULFOTEX RIF	244.9	235	199.3	191.5
TEXTILANA SULFOTEX LAS-90	272.5	259	219.7	190.2
BAROID SURFLO S375	264.1	265	179.4	193
CARDINAL CF-2	349	351.8	228	251.3
MILCHEM AMPLIFOAM	332.6	307	211.7	221.5
MAGCOBAR DRILLING SOAP B	266.1	249.6	170.2	159.4

*Initial Tests - 1.0% Foamer in Distilled Water

TABLE 5.3.

FOAMS GENERATED WITH A MIXER

DRAINAGE TIME FOR TEXTILANA'S SULFOTEX LAS-90 MEASURED INITIALLY AND AFTER AGING AT 500°F-375 PSI FOR 16 HOURS

SAMPLE IDENTIFICATION		FIRST DRAINAGE TIME, Sec	SECOND DRAINAGE TIME, Sec	AFTER ADDITION OF 25 ml OF 1% SALT SOLUTION	
				FIRST DRAINAGE TIME, Sec	SECOND DRAINAGE TIME, Sec
INITIAL	0.5%	286.8	278.5	241.4	235.7
	1%	272.5	259	219.7	190.2
AFTER AGING 16 HOURS AT 500°F-375 PSI	0.5%	231.5	247.3	210.9	201.3
	1%	239.5	244.7	211.5	216.8

Surface Tension

Figures 5.7 and 5.8 show that all of the foamers which were tested lowered the surface tension of distilled water and a ten percent sodium chloride solution. A further reduction in the surface tension of distilled water solutions occurred when seven of the foamers were exposed to 500°F-375 psi for 16 hours. A slight increase in the surface tension of distilled water occurred after Cardinal's CF-2 was heated to 500°F.

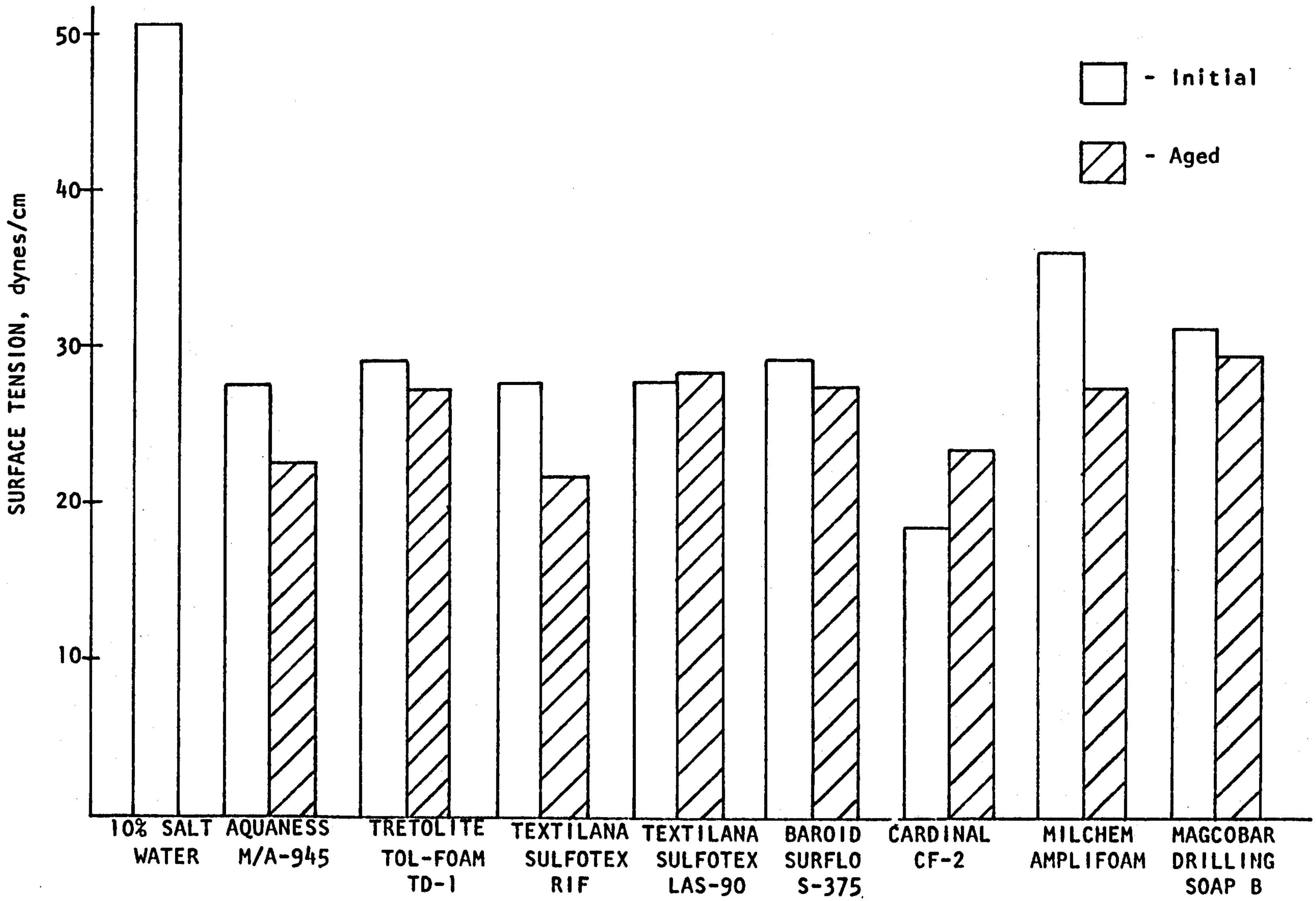
Further reductions also occurred in the surface tension of the ten percent salt water treated with most of the foamers which were heated to 500°F. No change in the surface tension occurred when the salt water was treated with Textilana's LAS-90 which was exposed to high temperature. A slight increase in the surface tension was again observed for the salt water which contained Cardinal's CF-2 after being heated to 500°F.

Corrosion Tests

The corrosion rate of mild steel coupons exposed to water solutions of the foamers for 16 hours at 500°F-375 psi is shown in Figure 5.9. The corrosion rate of distilled water and the ten percent sodium chloride solution is also shown for comparison. The only sample with a lower corrosion rate than the untreated waters was the sample treated with Textilana's Sulfotex LAS-90. Several of the saltwater solutions tested had corrosion rates greater than 50 mils per year. Corrosion rates above this level are often considered excessive. Only

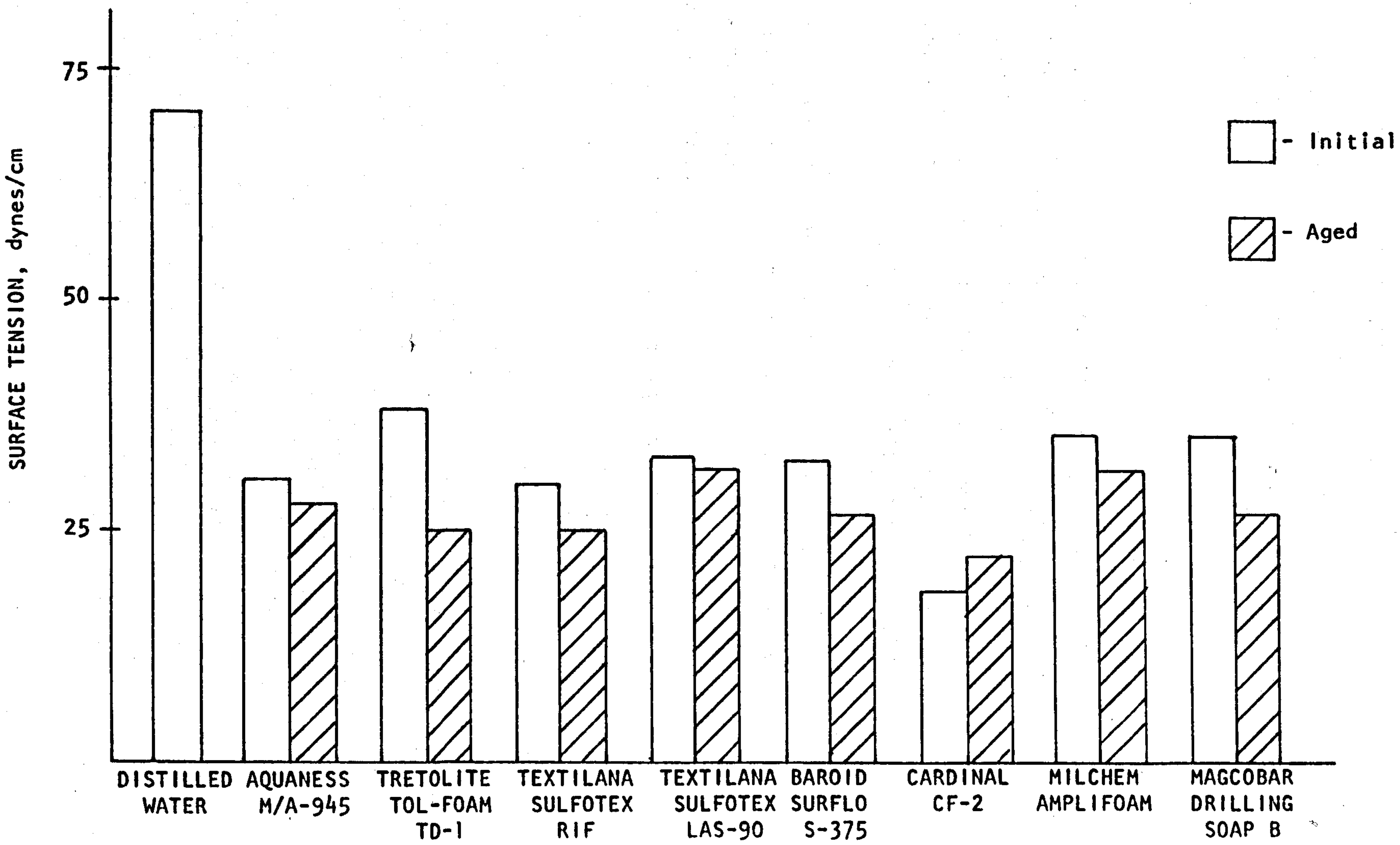
SURFACE TENSIONS OF FOAMERS

Figure 5.7. 0.15% FOAMER IN DISTILLED WATER



SURFACE TENSION OF FOAMERS

Figure 5.8. 0.75% FOAMER IN A TEN PERCENT SODIUM CHLORIDE SOLUTION



one of the materials tested, Milchem's Amplifoam, had a corrosion rate in excess of 50 mils per year in fresh water.

pH

Addition of 0..5% of the foamers to distilled water increased the pH to 7.4 - 8.6 as shown in Table 5.3. After aging 16 hours at 500°F - 375 psi, the pH was reduced to values ranging from 3 to 4 on samples containing AQUANESS N/A-945, Tretolite's Tol-Foam TD-1, Textilana's Sulfotex RIF, and Baroid's Surflo S375.

Table 5.4 shows that the pH of the ten percent sodium chloride was nearly neutral or slightly alkaline when treated with 0.75% of the foamers. After aging at 500°F samples containing the same materials as mentioned earlier became acidic with pH's ranging from 2.9 to 3.1.

Figure 5.9 CORROSION RATES OF FOAMERS

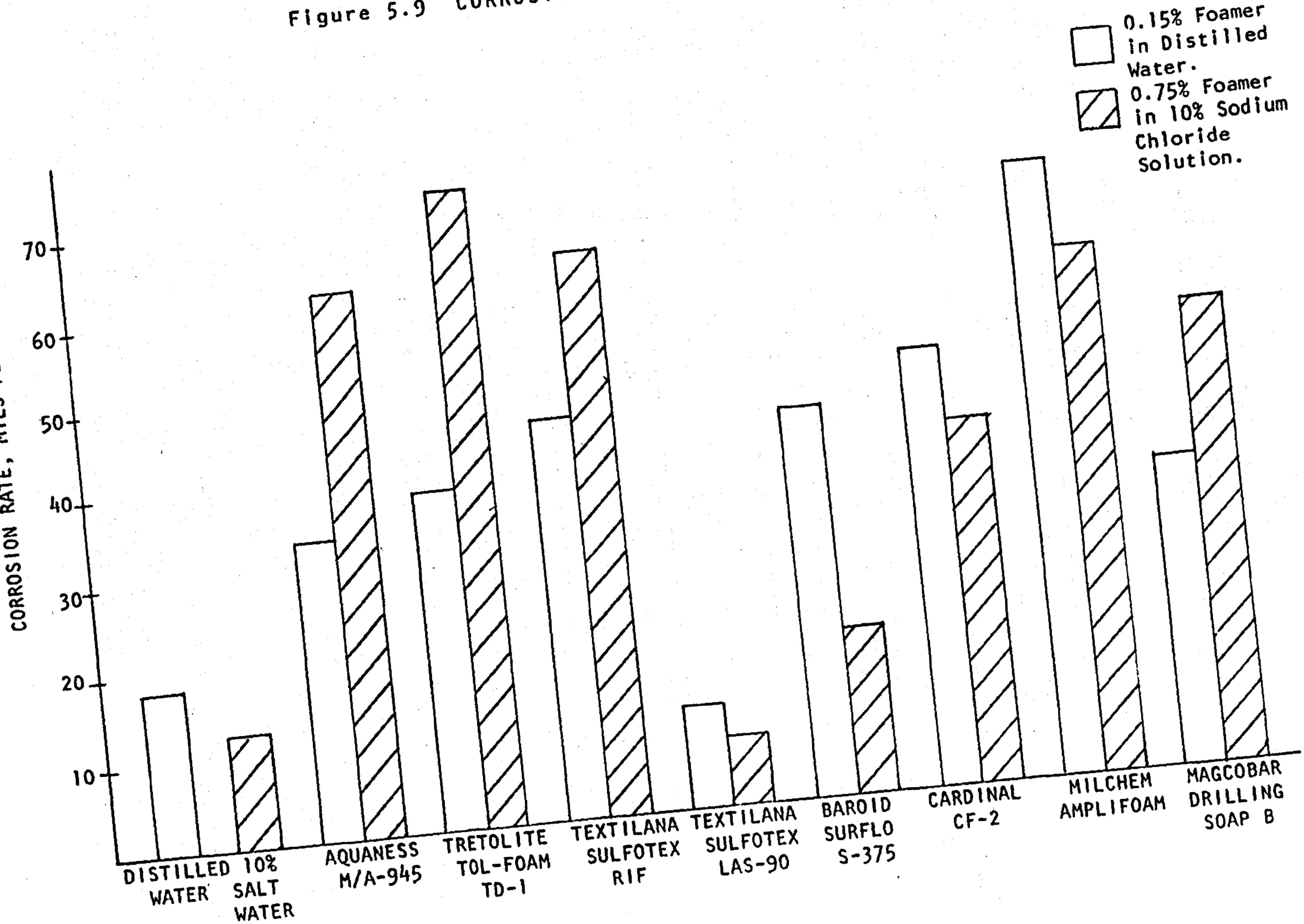


TABLE 5.4.

pH OF 0.15% FOAMER IN DISTILLED WATER

SAMPLE IDENTIFICATION	INITIAL pH	pH AFTER AGING 16 HOURS AT 500°F-375 psi
AQUANESS M/A-945	7.4	3.4
TRETOLITE TOL-FOAM TD-1	8.0	3.4
TEXTILANA SULFOTEX RIF	7.5	3.5
TEXTILANA SULFOTEX LAS-90	8.5	8.1
BAROID SURFLO S375	7.6	3.1
CARDINAL CF-2	7.7	3.8
MILCHEM AMPLIFOAM	8.6	8.3
MAGCOBAR DRILLING SOAP B	7.8	7.1

TABLE 5.5.

pH OF 0.75% FOAMER IN A TEN PERCENT SODIUM CHLORIDE SOLUTION

SAMPLE IDENTIFICATION	INITIAL pH	pH AFTER AGING 16 HOURS AT 500°F-375 psi
AQUANESS M/A-945	7.6	3.1
TRETOLITE TOL-FOAM TD-1	7.9	2.9
TEXTILANA SULFOTEX RIF	6.7	2.9
TEXTILANA SULFOTEX LAS-90	8.2	7.5
BAROID SURFLO S375	6.9	3.0
CARDINAL CF-2	7.5	4.5
MILCHEM AMPLIFOAM	8.4	8.3
MAGCOBAR DRILLING SOAP B	6.8	7.4

VI SELECTION AND TESTING OF FOAMS

Commercially available foamers used in drilling operations are normally proprietary blends. McCutcheon's Detergents and Emulsifiers lists over 2,000 materials and 49 classes of chemicals from over 150 suppliers in their 1978 North American Edition. Samples of foamers currently being used were requested from many of the larger manufacturers and suppliers. Table 6.1 contains a list of 36 samples, submitted by 15 suppliers. These materials were received during the course of this investigation.

TABLE 6.1

ALCO
- Trenamine AL-19

AQUANESS CHEMICAL COMPANY
- M/A 877
- M/A 941
- M/A 945

BRINADD
- Brinefoam

CARDINAL COMPANIES
- CF-2

DAVE NAGEL
- DN-100
- DN-200

DRESSER MAGCOBAR
- Drilling Soap A
- Drilling Soap B
- Drilling Soap C
- Unmarked Sample

DUPONT
- Zonyl FSA
- Zonyl FSB
- Zonyl FSC
- Zonyl FSJ
- Zonyl FSN
- Zonyl FSP

FAR-BEST
- Thermofoam BW-D

MILCHEM
- Ampli-Foam
- Gel-Air

NL BAROID PETROLEUM SERVICES
- Surflo S 362
- Surflo S 375
- Surflo S 378
- Surflo S 390

SELECT CHEMICAL COMPANY
- SC 403
- SC 404

SOONER CHEMICAL COMPANY
- CI 800
- MF 250

TEXTILIANA
- Sulfotex AOS
- Sulfotex LAS-90
- Sulfotex PAI
- Sulfotex RIF
- Sulfotex SAL

TRETOLITE DIVISION
- Tol-Foam TD-1
- Tol-Foam TD-12

Eight of the materials in Table 6.1 were selected for testing. Selection was based on availability of a sufficient amount of sample to complete all tests and timely reception of the samples. The number of samples which could be tested was limited by time restraints to eight samples. The following materials were selected.

- AQUANESS M/A - 945
- TRETOLITE TOL-FOAM TD - 1
- TEXTILANA SULFOTEX RIF
- TEXTILANA SULFOTEX LAS - 90
- BAROID SURFLO S-375
- CARDINAL CF-2
- MILCHEM AMPLIFOAM
- MAGCOBAR DRILLING SOAP B

The foamers were tested initially and after exposing water solutions of the materials to 500°F at an applied nitrogen pressure of 375 psi for 16 hours. Foams were generated by injecting a solution of the foamer into an air stream in a column and by stirring a solution of the foamer with a high speed mixer. Other tests included the corrosion rate of mild steel, pH, and surface tension measurements on water solutions or 10% sodium chloride solutions of the foamers. Detailed descriptions of these tests follows.

Column Testing of Foamers

This test is a modification of an API procedure for testing foaming agents for use in mist drilling.[1] The column test is set up to simulate well design and drilling practices, as well as to provide a procedure which can be

1. API RP-46

easily reproduced in most laboratories.

Basically, the test involves injection of air and a foaming agent solution into the bottom of a model well column. The air and liquid mix produces foam. The foam rises to the top of the column and exits through an outlet port and into a tared container. The material collected is weighed and the weight converted to volume. Since air and liquid flow rates are kept constant throughout each test, the various amounts of foam collected are used to rate each of the products tested.

Equipment

The individual components of the column system are listed below (see Figure 6.1).

1. Pump: A positive displacement pump is used for continuous injection of standard solutions of the foaming agents into the column. A back pressure valve is included downstream in the discharge line to aid in maintaining a constant flow rate.

2. Reservoir: A 4 liter reservoir with a magnetic stirrer is attached to the intake line of the pump.

3. Column: A 10 foot column made of clear lucite is used in the API testing procedure (see Figure 6.1). A 5 foot column is used in a modification of the API procedure. Other than height, the 5 foot column is identical in all other dimensions to the 10 foot column. Removeable plugs are located at the top and bottom of each column.

4. Air-liquid inlet tube: A 3/4 inch diameter stainless steel tube is centered inside the column and emerges through a concentric opening in the top plug. A "T" type conncetion at the top provides inlets for air and the standard foam solutions.

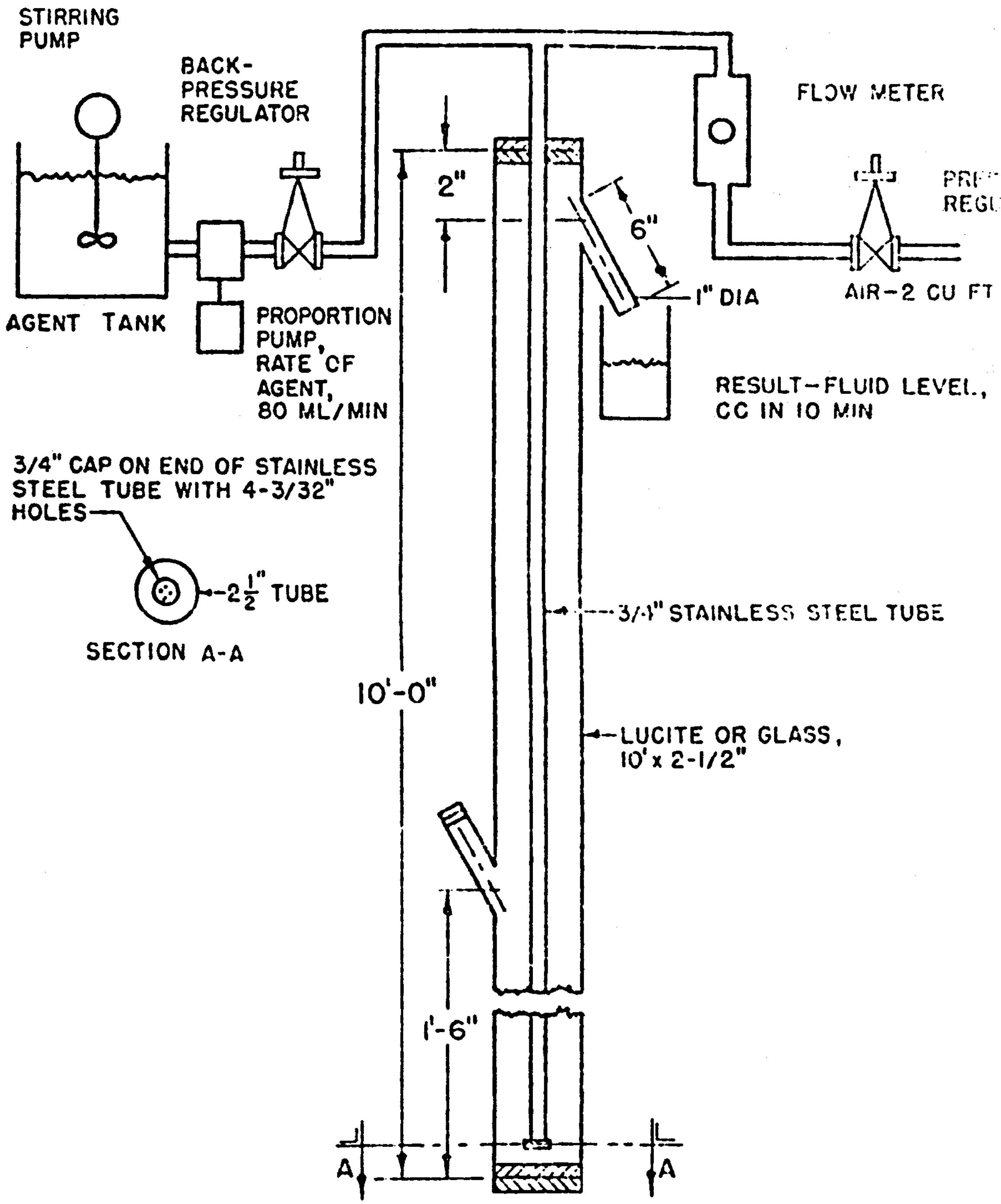


Figure 6.1. Laboratory Apparatus For Testing Foam Agents

5. Flow meter: A florator is used to monitor air flow. An air compressor and regulator provide constant air pressure.

Tests

The following standard solutions are prepared for testing in the column tests:

	Fresh Water	Salt Water
Distilled Water, ml	13,000	13,000
Sodium Chloride, gm		1,368
Foaming Agent, % by volume	0.15	0.75
Stirring time, min	5	5

The solutions are tested immediately after preparation. Each standard solution is tested four times; twice on the 5 ft column and twice on the 10 ft column. The test procedure is as follows:

1. Add 1 gm of 140-mesh silica flour to the bottom of the dry column to simulate the foam breaking effects of drilled solids.
2. Add 1 litter of the standard test solution through the inlet and into the bottom of the column. Add 4 liters of this solution to the reservoir.
3. The pump output is adjusted to 80 ml/min.
4. Air flow is adjusted to 2 standard cubic feet per minute through a check line while the inlet valve to the column is shut. The valve to the column is then opened at the same time a timer is started.

5. Test solution flow into the column is started as soon as foam from the initial solution in the bottom of the column reaches the top exit port of the column.

6. Foam overflow at the top of the column is collected for 10 minutes.

7. The foam is collected in a tared container and weighed. This allows the volume of the liquid to be calculated.

8. Steps 2-8 are repeated on both the 5 ft and 10 ft columns.

9. After each run, the column is thoroughly flushed with water. Before a new standard solution is introduced into the reservoir, the entire system is flushed with water to avoid contamination from the previous sample.

Foam Screening Test Using a High Speed Mixer to Generate The Foam

This test is a modification of a test prcedure that was developed by Chevron. The procedure used in this investigation is as follows:

1. Place 100 ml of distilled water into a 1,000 ml beaker.
2. Add foamer (1/2 ml or 1 ml).
3. Mix in beaker with a Hamilton Beach mixer for 30 seconds.
4. Measure foam volume by reading the graduated scale on beaker and record.
5. Measure the time required for 50 ml of liquid to drain from the foam after the mixer is shut off and record as the first drainage time.

6. Refoam by mixing on the Hamilton Beach mixer for 30 seconds and obtain a second reading of foam height.
7. Measure the time required for 50 ml of liquid to drain from the foam after the mixer is shut off and record as the second drainage time.
8. Add 25 ml of 1% by weight sodium chloride solution to the foam from #6.

9. Repeat Steps 3, 4, 5, and above.

Surface Tension

Standard solutions of foaming agents were prepared at the same concentrations used in the column testing. Surface tensions of the various standard solutions were measured using the Graham Tensiometer, shown in Figure 6.2. The method outlined below was used to calculate the surface tension.

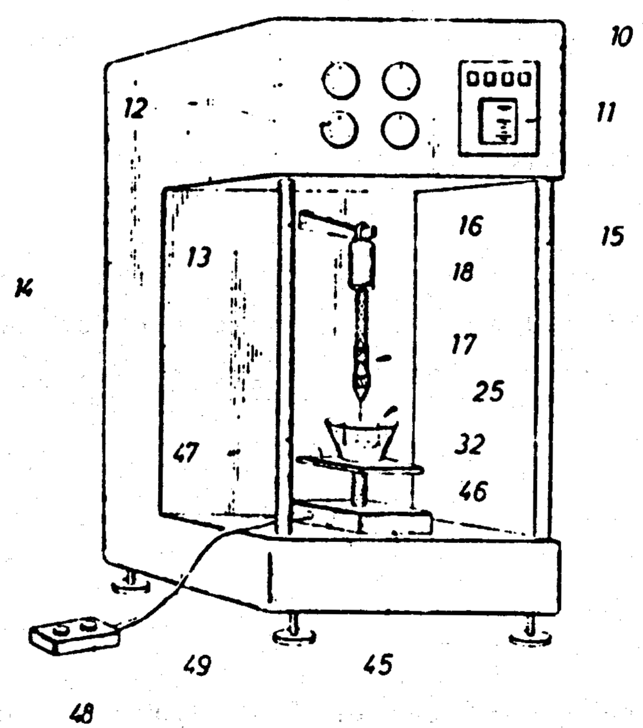


Figure 6.2. Graham Tensiometer Mounted in a Metler Balance (Drawing from U.S. Patent #3,780,569)

Procedure for Using the Graham Tensiometer

This method measures the upward force exerteo on a small wire ring as the ring is pulled through a liquid to air interface. The upward force is opposed by the downward force exerted on the ring by the elastic, membrane-like interface of the solution (see Figure 6.3).

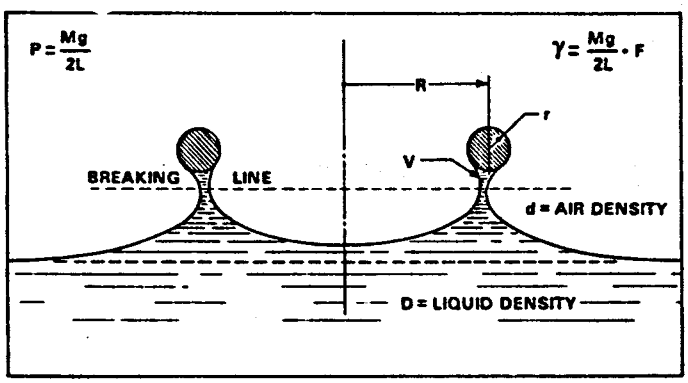


Figure 6.3. Condition of Surface Film at Breaking Point

The maximum resisting force, P, of the interface prior to rupture is defined as the apparent surface tension of the solution. The equation for calculating P is given below:

$$P = \frac{Mg}{2L} \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (1)$$

where

- P = apparent surface tension, dynes per cm
- M = mass, grams
- L = mean circumference of ring
- g = acceleration of gravity = 979.895 cm/sec^2

Several physical occurrences arise between the ring and the surface film at the point of rupture (see Figure 6.3).

1. Two surface films balance the upward pull, one interior to the ring and one exterior to the ring.

2. The distance from the center of the ring to the breaking point is less than the mean radius of the ring.

3. A small volume of liquid clings to the ring and complicates the force balance calculation.

The occurrences necessitate an addition of a correction factor in the circulation. Zuidema and Waters[1] have published a formula which gives a correction factor, F, accounting for these phenomena. Multiplication of the apparent tension by F gives the true value of surface tension, γ:

$$\gamma = (P)(F) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

1. <u>Converting the Mettler Balance to a Tensiometer</u>

Conversion of the Mettler Balance to a tensiometer using the Graham Tensiometer is accomplished as follows:

a. Remove pan from pan hook.

b. Remove pan brake from socket.

c. Insert stem of platinum - irridium ring in pin vise section of tensiometer assembly. Lock pin vise.

d. Hang tensiometer assembly from pan hook.

e. Place movable platform assembly on balance floor beneath Graham Tensiometer.

2. <u>Measurement of Surface Tension</u>

To measure surface tension:

a. Half fill a suitable glass container with the test solution.

b. With the solution in place on the platform, raise the platform until the ring is about 2 mm. beneath the test solution surface.

c. Determine the apparent weight of the assembly (with ring submerged) using standard analytical balance procedure. Record this weight, W_1.

d. With balance in "partial release" position, slowly lower the platform so that the ring slowly ascends through interface. When movement of the optical scale indicates that an "on scale" reading may be obtained, the balance is put in "full release" position. If further lowering of the platform produces an off-scale reading before rupture of the interface, the balance is returned to the partial release position and the weight increased by 0.1 gm. Continuing carefully in this manner, the apparent "weight" associated with interfacial rupture is obtained. Record this weight, W_2.

Having determined $M = W_2 - W_1$, the apparent surface tension, P, is calculated from Equation (1). To determine the correction factor, F. enter Figure 6.4 with the value P/(D-d). The true value of surface tension is, then:

$$\gamma = (F)(P)$$

e. Cleaning: Accuracy of surface tension measurements depends strongly on the cleanliness of the platinum ring surface area. Consequently, the ring must be thoroughly cleaned before and after each test. Clean the platinum ring by rinsing it in methyl ethyl ketone. Then heat in the oxidizing portion of a gas flame until a "cherry-red" color appears. Flame only that portion of the ring which will be immersed in the liquid under test.

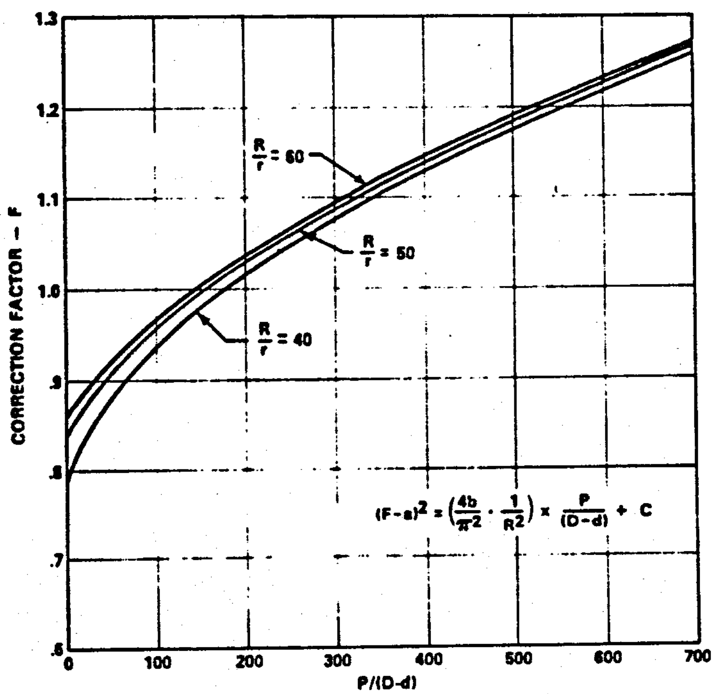


Figure 6.4. Correction Factor for Surface and Interfacial Tension by Ring Method (6 cm Ring)

VII RECOMMENDED PROGRAM

Currently, foams used to drill geothermal wells degrade when exposed to high temperatures. Many expensive fishing jobs are caused by the corrosive effects of acidic products formed when the foaming agents degrade. Rapid corrosion also occurs if acidic formation fluids enter the wellbore causing a reduction in the pH of the water phase of the foam. The high costs for using foams is also influenced by the fact that the foaming agent is injected continually at the stand pipe and discarded at the blooie line.

A program to develop improved foams should consist of the following elements:

1. Design, manufacture, and test laboratory equipment for testing foams at 700°F.
2. Design, manufacture, and test equipment to recover the foaming agent and remove solids in order to recycle the foamer.
3. Develop improved foams for use at 550°F.
4. Develop improved foams for use at 700°F.

Table 7.1 contains a proposed budget to support this program.

TABLE 7.1

PROPOSED EXPENDITURES FOR FOAMS
(Thousand Dollars)

	FY-78	FY-79	FY-80	FY-81	FY-82	FY-83	FY-84	FY-85	TOTAL
State-of-the-Art Study									
Program Formulated	100								100
Equipment									
Laboratory		175	150						325
Field				50	125	125	100		400
Developing Improved Foams									
Phase I - 550°F			100	200	125	75			500
Phase II - 700°F					75	200	200	100	575
	100	175	250	250	325	400	300	100	1900

Laboratory Equipment

In order to develop foams capable of functioning under geothermal conditions, equipment suitable for testing foamers must be developed. A laboratory instrument capable of generating foam, heating the foam to temperatures up to 700°F, measuring the rheological characteristics at the elevated temperature, cooling the foam to near ambient temperature, and discharging the foam at atmospheric pressure must be developed. A 2-year program to design and build this equipment should begin during FY-1979.

The laboratory equipment should be designed to simulate the temperature and pressure experienced by foam in the drilling operation. At least two basic approaches should be considered in order to simulate the foam cycle. One approach would be to inject foamer into an air stream at approximately 300 psi and rapidly heat the foam to elevated temperatures as the foam moves through the system. Pressure drop measurements could then be obtained at the elevated temperature. The foam would then have to be cooled rapidly and then discharged at atmospheric pressure. Temperatures and pressures could be simulated in this system, but residence time would be very short compared to actual residence time in the hole. This system would be similar to a flow loop used to test drilling muds.

Another approach which should be considered would be to aggitate the foamer in a closed vessel to simulate foam formation and movement in the drilling process. Pressure and temperature could be closely controlled and monitored in this system. Residence time and the degree of aggitation could also be regulated in order to simulate the shear history experienced by the foam.

Either of the above systems could be used to simulate pressure and temperature experienced by foams, but the second system has the advantage of being able to simulate residence time of foams

Field Equipment

Equipment for deaerating the foam, removing the solids from foams and recycling the foaming agents must also be developed. This program should begin during FY-1981. The design of this equipment should be complete by FY-1982. Equipment fabrication can be accomplished late in FY-1983. Field test should be scheduled for early in FY-1984.

Foam deaerating equipment must be capable of handling the total flow from the well. Gas flow could range from 350 to 500 cubic feet per minute. Techniques which should be considered for deaerating the foam are sonic, vacuum, electrical, chemical, and thermal. Chemical additions to foams might cause problems with reuse of the foams. Any material used to defoam the system would probably hinder the reformation of a foam. Use of thermal methods to break foams could also cause irreversible changes in the chemical compositon of the foamer. A vacuum technique might be suitable for separating the air from the liquid, but a major consideration must be the size of the equipment and the cost to operate this equipment. An electrical spark might cause the liquid to separate from the air without damaging the chemical foamer. High frequency sound has been used to defoam liquids which contained a small amount of entrained gas. Here again, equipment size, initial cost, and operating cost will be major considerations

Developing Improved Foams

The remainder of the program consists of developing foamers stable at 550°F and 700°F. These two target temperatures are represented as separate phases in the project to develop improved foams. Laboratory equipment developed earlier in the program should be used to test candidate materials.

Phase I - 550°F

In FY-1980 a study should be initiated to investigate foam systems which will be stable at 550°F. The laboratory test portion of this study should be complete by the middle of FY-1981. Field tests should be scheduled and conducted in FY-1982. This project should be complete by late in FY-1983.

Phase II - 700°F

In FY-1982, work should begin on developing foams stable at 700°F. Laboratory tests should be completed by FY-1983. Foam systems developed in this study should be field tested during FY-1984. All work on developing improved foams should be completed by FY-1985.

Table 7.2 contains the Milestones for this program.

Laboratory Equipment

In order to develop foams capable of functioning under geothermal conditions, equipment suitable for testing foamers must be developed. A single pass laboratory instrument capable of generating foam, heating the foam to temperatures up to 700°F, measuring the rheological characteristics at the elevated temperature, cooling the foam to near ambient temperature, and discharging the foam at atmospheric pressure must be developed. A 2-year program to design and build this equipment should begin during FY-1979.

Field Equipment

Equipment for deaerating the foam, removing the solids from foams and recycling the foaming agents must also be developed. This program should begin during FY-1981. The design of this equipment should be complete by FY-1982. Equipment fabrication can be accomplished late in FY-1983. Field test should be scheduled for early in FY-1984.

Developing Improved Foams

The remainder of the program consists of developing foamers stable at 550°F and 700°F. These two target temperatures are represented as separate phases in the project to develop improved foams. Laboratory equipment developed earlier in the program should be used to test candidate materials.

Phase I - 550°F

In FY-1980 a study should be initiated to investigate foam systems which will be stable at 550°F. The laboratory test portion of this study should be complete by-the middle of FY-1981. Field tests should be scheduled and conducted in FY-1982. This project should be complete by late in FY-1983.

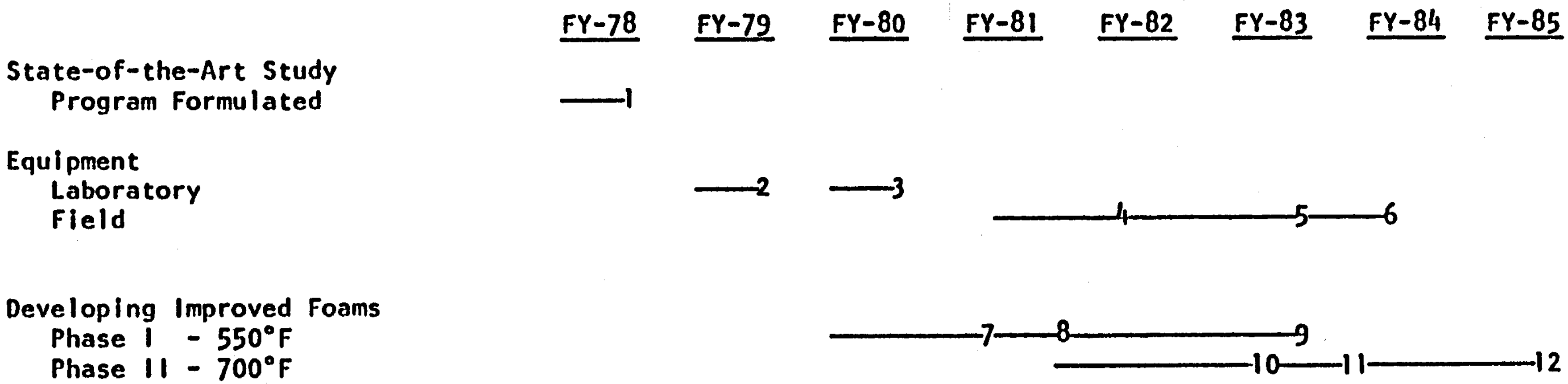
Phase II - 700°F

In FY-1982 work should begin on developing foams stable at 700°F. Laboratory tests should be completed by FY-1983. Foam systems developed in this study should be field tested during FY-1984. All work on developing improved foams should be completed by FY-1985.

Table 7.2 contains the Milestones for this program.

TABLE 7.2

MILESTONES



1. State-of-the-Art Study Completed. Program Formulated.
2. Design Complete.
3. Laboratory Equipment Completed.
4. Design of Field Equipment Complete.
5. Field Equipment Fabricated.
6. Field Tests of Foam Handling Equipment.
7. Laboratory Tests of 550°F Foam Complete.
8. Field Tests of 550°F Foam.
9. 550°F Foam Work Complete.
10. Laboratory Tests of 700°F Foam Complete.
11. Field Tests of 700°F Foam.
12. 700°F Foam Work Complete.

FOAM PRESSURE COLUMN ANALYSIS

APPENDIX A

A complete analysis was made of the iterative equation presented under "The Effect of Foam."

$$h = \frac{1}{D} \left[P + \frac{np}{100-n} \ln \left(\frac{P+p}{p}\right) \right]$$

h = depth, ft

D = hydrostatic pressure, psi, of a column of fluid one foot high with no air in it

P = pressure in atmospheres at depth h due due to mud column only

p = back pressure at wellhead, atmospheres

$\frac{n}{100}$ = fraction by volume of gas in mud at wellhead at back pressure p

Tables 1 - 7 are respentative samples of analysis from which Figures 7, 8, and 9 in the text were developed.

In the Tables, "Pressure" is gauge pressure, "Density" is average density to the surface, and "%" is the percent fluid in the foam at that depth.

Table 1

Uncut Mud Wt. 8.4 ppg
Wellhead Pressure 100 p
Ratio Air:fluid at "0" gauge 10:1

DEPTH FT	PRESSURE PSI	DENSITY BS/GAL	%
0.000	100.000	7.431	88.466
100.000	139.270	7.560	90.000
200.000	179.466	7.649	91.061
300.000	220.254	7.717	91.867
400.000	261.471	7.771	92.516
500.000	302.937	7.814	93.019
600.000	344.729	7.852	93.479
700.000	386.704	7.885	93.868
800.000	428.842	7.913	94.206
900.000	471.115	7.938	94.503
1000.000	513.499	7.960	94.767
1100.000	555.974	7.980	95.001
1200.000	598.555	7.998	95.217
1300.000	641.168	8.014	95.405
1400.000	683.864	8.029	95.580
1500.000	726.601	8.042	95.737
1600.000	769.406	8.054	95.885
1700.000	812.237	8.066	96.019
1800.000	855.124	8.076	96.145
1900.000	898.024	8.086	96.260
2000.000	940.972	8.095	96.368
2100.000	983.965	8.104	96.471
2200.000	1026.956	8.111	96.565
2300.000	1069.985	8.119	96.654
2400.000	1113.052	8.126	96.739
2500.000	1156.103	8.133	96.816
2600.000	1199.186	8.139	96.890
2700.000	1242.299	8.145	96.961
2800.000	1285.441	8.150	97.029
2900.000	1328.610	8.156	97.095
3000.000	1371.751	8.161	97.154
3100.000	1414.914	8.166	97.211
3200.000	1458.101	8.170	97.267
3300.000	1501.310	8.175	97.320
3400.000	1544.540	8.179	97.372
3500.000	1587.729	8.183	97.418
3600.000	1630.998	8.187	97.466
3700.000	1674.224	8.191	97.509
3800.000	1717.466	8.194	97.551
3900.000	1760.790	8.198	97.596
4000.000	1803.998	8.201	97.632
4100.000	1847.288	8.204	97.670
4200.000	1890.593	8.207	97.708
4300.000	1933.913	8.211	97.744
4400.000	1977.176	8.213	97.776
4500.000	2020.523	8.216	97.811
4600.000	2063.810	8.219	97.842
4700.000	2107.184	8.221	97.875
4800.000	2150.495	8.224	97.904
4900.000	2193.818	8.226	97.932
5000.000	2237.151	8.229	97.960

Table 2
Uncut Mud Wt. 8.4 ppg
Wellhead Pressure "0
Ratio Air:fluid at "0" gauge 1:1

DEPTH FT	PRESSURE PSI	DENSITY LBS/GAL	%
0.000	-0.000	4.200	50.000
100.000	27.981	5.387	64.128
200.000	62.822	6.047	71.989
300.000	100.634	6.458	76.879
400.000	139.946	6.735	80.183
500.000	180.196	6.938	82.595
600.000	221.014	7.091	84.421
700.000	262.279	7.213	85.871
800.000	303.865	7.312	87.051
900.000	345.706	7.395	88.033
1000.000	387.698	7.464	88.854
1100.000	429.844	7.523	89.557
1200.000	472.182	7.575	90.180
1300.000	514.568	7.620	90.715
1400.000	557.064	7.660	91.192
1500.000	599.639	7.696	91.618
1600.000	642.267	7.728	91.998
1700.000	685.045	7.758	92.353
1800.000	727.841	7.784	92.671
1900.000	770.632	7.808	92.955
2000.000	813.401	7.830	93.209
2100.000	856.404	7.851	93.463
2200.000	899.226	7.869	93.676
2300.000	942.273	7.887	93.892
2400.000	985.181	7.903	94.078
2500.000	1028.190	7.918	94.257
2600.000	1071.222	7.932	94.425
2700.000	1114.285	7.945	94.583
2800.000	1157.377	7.958	94.732
2900.000	1200.475	7.969	94.872
3000.000	1243.592	7.980	95.003
3100.000	1286.741	7.991	95.129
3200.000	1329.885	8.001	95.246
3300.000	1373.055	8.010	95.358
3400.000	1416.248	8.019	95.465
3500.000	1459.445	8.028	95.566
3600.000	1502.642	8.036	95.661
3700.000	1545.874	8.043	95.753
3800.000	1589.102	8.051	95.841
3900.000	1632.342	8.058	95.924
4000.000	1675.594	8.064	96.004
4100.000	1718.854	8.071	96.081
4200.000	1762.123	8.077	96.154
4300.000	1805.398	8.083	96.225
4400.000	1848.698	8.089	96.293
4500.000	1891.981	8.094	96.358
4600.000	1935.288	8.099	96.421
4700.000	1978.596	8.104	96.481
4800.000	2021.926	8.109	96.540
4900.000	2065.255	8.114	96.596
5000.000	2108.583	8.119	96.650

Table 3

Uncut Mud Wt 8.4 ppg
Wellhead Pressure "0" ps
Ratio Air:fluid at "0" gauge 10:1

DEPTH FT	PRESSURE PSI	DENSITY LBS/GAL	%
0.000	0.000	0.840	10.000
100.000	5.003	0.963	11.456
200.000	11.379	1.095	13.040
300.000	19.485	1.250	14.885
400.000	29.350	1.413	16.817
500.000	41.276	1.589	18.919
600.000	55.324	1.775	21.132
700.000	71.486	1.966	23.405
800.000	89.702	2.159	25.698
900.000	109.942	2.352	27.996
1000.000	132.015	2.541	30.256
1100.000	155.772	2.726	32.455
1200.000	181.073	2.905	34.582
1300.000	207.802	3.077	36.634
1400.000	235.742	3.242	38.591
1500.000	264.845	3.399	40.465
1600.000	294.974	3.549	42.252
1700.000	325.985	3.692	43.947
1800.000	357.785	3.827	45.555
1900.000	390.346	3.955	47.084
2000.000	423.526	4.077	48.532
2100.000	457.375	4.193	49.915
2200.000	491.692	4.303	51.221
2300.000	526.542	4.407	52.467
2400.000	561.793	4.506	53.647
2500.000	597.533	4.601	54.778
2600.000	633.556	4.691	55.846
2700.000	669.965	4.777	56.868
2800.000	706.715	4.859	57.845
2900.000	743.677	4.937	58.772
3000.000	780.979	5.012	59.662
3100.000	818.497	5.083	60.511
3200.000	856.285	5.151	61.327
3300.000	894.312	5.217	62.109
3400.000	932.450	5.280	62.853
3500.000	970.862	5.340	63.573
3600.000	1009.423	5.398	64.262
3700.000	1048.107	5.453	64.921
3800.000	1086.992	5.507	65.558
3900.000	1126.058	5.558	66.173
4000.000	1165.175	5.608	66.759
4100.000	1204.542	5.656	67.332
4200.000	1243.918	5.702	67.877
4300.000	1283.511	5.746	68.409
4400.000	1323.073	5.789	68.915
4500.000	1362.822	5.830	69.408
4600.000	1402.748	5.871	69.888
4700.000	1442.713	5.909	70.350
4800.000	1482.702	5.947	70.794
4900.000	1522.828	5.983	71.226
5000.000	1563.082	6.018	71.646

DEPTH FT	PRESSURE PSI	DENSITY LBS/GAL	%
0.000	-0.000	4.500	50.000
100.000	30.301	5.833	64.816
200.000	68.099	6.555	72.834
300.000	108.957	6.992	77.688
400.000	151.388	7.286	80.956
500.000	194.745	7.498	83.313
600.000	238.683	7.658	85.092
700.000	283.078	7.785	86.502
800.000	327.721	7.886	87.626
900.000	372.697	7.972	88.579
1000.000	417.824	8.044	89.374
1100.000	463.108	8.105	90.055
1200.000	508.485	8.158	90.639
1300.000	554.006	8.204	91.157
1400.000	599.639	8.246	91.618
1500.000	645.351	8.283	92.029
1600.000	691.116	8.316	92.395
1700.000	736.910	8.345	92.722
1800.000	782.841	8.373	93.029
1900.000	828.767	8.397	93.303
2000.000	874.806	8.421	93.562
2100.000	920.810	8.441	93.793
2200.000	966.763	8.460	93.997
2300.000	1012.827	8.478	94.195
2400.000	1058.927	8.494	94.379
2500.000	1105.055	8.510	94.550
2600.000	1151.220	8.524	94.712
2700.000	1197.400	8.538	94.862
2800.000	1243.592	8.550	95.003
2900.000	1289.822	8.562	95.137
3000.000	1336.054	8.574	95.262
3100.000	1382.318	8.584	95.382
3200.000	1428.576	8.594	95.493
3300.000	1474.859	8.604	95.599
3400.000	1521.165	8.613	95.701
3500.000	1567.474	8.622	95.797
3500.000	1613.801	8.630	95.888
3700.000	1660.145	8.638	95.976
3800.000	1706.503	8.645	96.060
3900.000	1752.853	8.653	96.139
4000.000	1799.214	8.659	96.215
4100.000	1845.605	8.666	96.288
4200.000	1891.981	8.672	96.358
4300.000	1938.386	8.678	96.425
4400.000	1984.794	8.684	96.490
4500.000	2031.206	8.690	96.552
4600.000	2077.620	8.695	96.611
4700.000	2124.056	8.700	96.669
4900.000	2170.493	8.705	96.724
4900.000	2216.927	8.710	96.777
5000.000	2263.383	8.715	96.829

Table 4

Uncut Mud Weight 9 ppg
Wellhead Pressure "0"
Ratio Air:fluid at "0"
1:1

Table 5

Uncut Mud Weight 9 ppg
Wellhead Pressure
100 psi
Ratio Air: Fluid at
"0" Gauge 2:1

DEPTH FT	PRESSURE PSI	DENSITY LBS/GAL	%
0.000	100.000	8.231	91.457
100.000	143.338	8.343	92.702
200.000	187.450	8.418	93.529
300.000	232.036	8.473	94.143
400.000	277.068	8.522	94.689
500.000	322.270	8.558	95.089
600.000	367.605	8.586	95.407
700.000	413.149	8.612	95.691
800.000	458.819	8.635	95.941
900.000	504.574	8.654	96.155
1000.000	550.412	8.671	96.345
1100.000	596.340	8.687	96.517
1200.000	642.303	8.700	96.667
1300.000	688.337	8.713	96.806
1400.000	734.408	8.724	96.930
1500.000	780.510	8.734	97.042
1600.000	826.663	8.743	97.147
1700.000	872.833	8.752	97.242
1800.000	919.047	8.760	97.332
1900.000	965.268	8.767	97.413
2000.000	1011.525	8.774	97.489
2100.000	1057.817	8.781	97.562
2200.000	1104.105	8.787	97.628
2300.000	1150.422	8.792	97.691
2400.000	1196.767	8.798	97.751
2500.000	1243.099	8.802	97.805
2600.000	1289.455	8.807	97.857
2700.000	1335.834	8.812	97.907
2800.000	1382.233	8.816	97.955
2900.000	1428.654	8.820	98.001
3000.000	1475.051	8.824	98.043
3100.000	1521.467	8.827	98.083
3200.000	1567.899	8.831	98.122
3300.000	1614.347	8.834	98.159
3400.000	1660.765	8.837	98.192
3500.000	1707.244	8.840	98.227
3600.000	1753.689	8.843	98.258
3700.000	1800.196	8.846	98.291
3800.000	1846.668	8.849	98.321
3900.000	1893.152	8.851	98.349
4000.000	1939.648	8.854	98.377
4100.000	1986.155	8.856	98.404
4200.000	2032.622	8.858	98.427
4300.000	2079.150	8.861	98.453
4400.000	2125.689	8.863	98.478
4500.000	2172.185	8.865	98.500
4600.000	2218.689	8.867	98.521
4700.000	2265.257	8.869	98.544
4800.000	2311.778	8.871	98.564
4900.000	2358.308	8.873	98.584
5000.000	2404.845	8.874	98.603

Table 6

Uncut Mud Weight 9 ppg
Wellhead Pressure "0"
Ratio Air: Fluid at
"0" Gauge 2:1

DEPTH FT	PRESSURE PSI	DENSITY LBS/GAL	%
0.000	-0.000	3.001	33.340
100.000	20.633	4.011	44.563
200.000	50.003	4.813	53.479
300.000	84.216	5.404	60.047
400.000	121.556	5.850	65.003
500.000	160.849	6.193	68.812
600.000	201.480	6.465	71.829
700.000	243.127	6.686	74.294
800.000	285.403	6.868	76.311
900.000	328.182	7.020	77.999
1000.000	371.447	7.151	79.454
1100.000	415.058	7.264	80.711
1200.000	458.937	7.363	81.807
1300.000	503.074	7.450	82.776
1400.000	547.404	7.527	83.637
1500.000	591.922	7.597	84.410
1600.000	636.594	7.650	85.106
1700.000	681.370	7.716	85.734
1800.000	726.302	7.768	86.310
1900.000	771.309	7.815	86.835
2000.000	816.410	7.858	87.317
2100.000	861.604	7.899	87.762
2200.000	906.870	7.936	88.174
2300.000	952.215	7.970	88.558
2400.000	997.621	8.002	88.915
2500.000	1043.074	8.032	89.247
2600.000	1088.587	8.060	89.559
2700.000	1134.149	8.087	89.851
2800.000	1179.749	8.111	90.126
2900.000	1225.408	8.135	90.386
3000.000	1271.084	8.157	90.630
3100.000	1316.836	8.178	90.863
3200.000	1362.589	8.197	91.082
3300.000	1408.370	8.216	91.290
3400.000	1454.171	8.234	91.486
3500.000	1500.022	8.251	91.674
3600.000	1545.919	8.267	91.855
3700.000	1591.821	8.282	92.026
3800.000	1637.722	8.297	92.188
3900.000	1683.654	8.311	92.344
4000.000	1729.654	8.325	92.495
4100.000	1775.640	8.337	92.638
4200.000	1821.607	8.350	92.773
4300.000	1867.633	8.361	92.905
4400.000	1913.673	8.373	93.032
4500.000	1959.726	8.384	93.154
4600.000	2005.831	8.395	93.273
4700.000	2051.902	8.405	93.385
4800.000	2098.019	8.415	93.495
4900.000	2144.139	8.424	93.600
5000.000	2190.260	8.433	93.701

Table 7
Uncut Mud Wt. 9 ppg
Wellhead Pressure "0"
Ratio Air:fluid at "0" gauge
20:1

DEPTH FT	PRESSURE PSI	DENSITY LBS/GAL	%
0.000	0.000	0.450	5.000
100.000	2.552	0.491	5.460
200.000	5.450	0.525	5.828
300.000	8.947	0.574	6.379
400.000	12.734	0.613	6.810
500.000	17.217	0.663	7.366
600.000	22.358	0.717	7.971
700.000	28.192	0.775	8.615
800.000	34.845	0.839	9.317
900.000	42.315	0.905	10.057
1000.000	50.698	0.976	10.845
1100.000	60.060	1.051	11.679
1200.000	70.463	1.130	12.560
1300.000	81.916	1.213	13.479
1400.000	94.527	1.300	14.443
1500.000	108.233	1.389	15.434
1600.000	123.070	1.481	16.453
1700.000	139.076	1.575	17.499
1800.000	156.288	1.672	18.573
1900.000	174.583	1.769	19.655
2000.000	194.058	1.868	20.755
2100.000	214.563	1.967	21.855
2200.000	236.190	2.067	22.965
2300.000	258.765	2.166	24.066
2400.000	282.374	2.265	25.167
2500.000	307.019	2.364	26.269
2600.000	332.490	2.462	27.354
2700.000	358.769	2.558	28.423
2800.000	385.946	2.654	29.484
2900.000	413.897	2.748	30.529
3000.000	442.481	2.839	31.549
3100.000	471.917	2.931	32.563
3200.000	501.941	3.020	33.552
3300.000	532.524	3.107	34.518
3400.000	563.771	3.192	35.468
3500.000	595.664	3.276	36.404
3600.000	627.903	3.358	37.309
3700.000	660.738	3.438	38.198
3800.000	694.047	3.516	39.068
3900.000	727.794	3.593	39.917
4000.000	761.983	3.667	40.748
4100.000	796.560	3.740	41.558
4200.000	831.517	3.811	42.349
4300.000	866.848	3.881	43.121
4400.000	902.514	3.949	43.875
4500.000	938.526	4.015	44.612
4600.000	974.830	4.080	45.330
4700.000	1011.439	4.143	46.032
4800.000	1048.315	4.204	46.716
4900.000	1085.476	4.265	47.385
5000.000	1122.884	4.323	48.038

REVIEW OF FOAM DRILLING

APPENDIX B

BASIC MUD REQUIREMENTS

There are three basic requirements for drilling. They are the tool, the system for handling the tool, and a method of cleaning the tool cuttings from the hole. Applications of these requirements vary from the small hand drill used by the handyman around his home to the complex drilling rig capable of drilling to 30,000 feet. The drilling rig that is used to explore for natural resources uses a drilling fluid to clean the hole. The drilling fluid used depends upon the situation, but varies from natural gas to weighted drilling mud with a density of 21 ppg.

Normally there are seven functions of a drilling fluid that are basic to its design or use. They are:

1. Clean the bit
2. Clean the hole
3. Lubricate and cool the bit and drill string
4. Control subsurface pressures
5. Support the walls of the hole
6. Suspend cuttings or cavings in the hole when circulation is stopped
7. Support part of the weight of the drill string and casing

The drilling fluid used on any particular project will depend upon the priorities of the above functions and other related problems such as the ability to improve drilling rate and the problems of lost circulation.

Geothermal drilling fluids are a natural evolution from oil well drilling fluids since oil well drilling on a large commercial scale preceded geothermal work. The development of rotary drilling fluids was affected more and more by temperatures as drilling for oil and gas went deeper and into areas of higher temperature gradients. The Southwest Texas area, with high-temperature gradients and deep holes, provided many of the first indications of temperature limitations in drilling mud.

The first problems arose with the phosphate thinner used in oil well muds in the 1930s. At the depths drilled in that period — 7,000 - 10,000 feet, the bottom-hole temperatures rose above the 150°F mark which causes the breakdown of the phosphates.

When lime muds replaced the phosphate treated mud in the 1940s, high-temperature gelation (cementing) occurred at 300°F in the deeper hotter holes of that period. It was discovered that the solids content of the mud was, and is, a powerful factor in the destabilization of the mud due to temperature.

Later work resulted in muds with lower pH (low lime muds and gypsum mud) to reduce the high-temperature gelation. It was also learned that lignite and sodium chromate would work effectively to keep muds fluid up to 300°F.

In efforts to drill deeper and hotter with heavy muds, Mobil Oil developed the DMS-DME Sodium Surfactant mud in the 1950s. It had some undesirable properties, but the Ginther well was drilled with bottom-hole temperatures of 450°F and mud weights of 18#/gal using the sodium surfactant system.

The introduction of low solid muds in the 1960s led to the use of asbestos as a bentonite replacement. It was not very successful for that purpose, but it turned out to be a good water thickener for the high temperatures that were just then being drilled at The Geysers in California. The development of sepiolite was a research concept that postulated 'what was needed was a bentonite that was stable at about 500°F.' Mineralogically, this was sepiolite.

Geothermal muds have evolved from this background with Cypan and sepiolite being the only present products developed purely for high-temperature mud. This progression is quite logical considering that most geothermal areas are cool enough near the surface to be drilled with conventional muds that are then slowly converted to geothermal systems.

There is, however, a further problem — lost circulation. Lost circulation is probably the single most expensive problem of rotary drilling. In geothermal drilling, the lost circulation problem is accentuated by the fractures in the typical geothermal reservoir rock and the normal extremes of relief in the area. These are problems that are common to oil and gas drilling and mineral exploration, but the altered and fractured nature of geothermal rocks makes the problem of lost circulation in geothermal drilling the dominant control over drilling costs.

The history of oil and gas drilling, and mineral exploration, provides the technical background for lost circulation control. In its most basic form, lost circulation is caused by one or two conditions.

Condition One - Lost Circulation

The pressure of the drilling fluid column is greater than the fluid pressure in fractured or vugular formations, and the drilling fluid is lost to existing passages. This occurs in areas where the water table is low, such as in areas around the Grand Canyon or on high mesas. The drilling fluid column, if it is water or heavier than water, exerts a greater pressure than the normal formation fluid pressure. Normal formation fluid pressure is generally considered to be equal to the pressure exerted by a column of water to the surface or back.

Condition Two - Lost Circulation

The pressure of the drilling fluid column fractures the rock and the drilling fluid is lost to the induced fracture.

A term developed for calculating fracture gradients in sedimentary formations is:

$$\frac{P_w}{D} = \left(\frac{S}{D} - \frac{p}{D}\right)\left(\frac{v}{1-v}\right) + \frac{p}{D}$$

where

P_w = Wellbore Pressure, psi

v = Poisson's Ratio (horizontal to vertical stress ratio)

S = Overburden Stress, psi (varies with depth)

D = Depth, ft

p = Formation Pressure, psi

The conditions that cause lost circulation then are basic to the geology of the area. Lost circulation materials are used to help plug the fractures or vugs. The materials are generally wood fibers, nut hulls, cottonseed hulls, etc. The use of lost circulation materials is dependent upon the area, sometimes they are effective, almost always they are expensive, and often they are totally ineffective. Lost circulation is best solved by avoiding it.

To avoid lost circulation, the density of the drilling fluid needs to be reduced to below formation pressure or fracture pressure. Some care needs to be taken in reducing the pressure of the drilling fluid column to below that of the formation fluid, because formation fluid may flow into the wellbore.

Air (or natural gas) was used as a drilling fluid at least as early as the 1930s. Where the formations are strong enough or competent enough so that they would not slough into the hole, and where very little water is produced into the hole, air drilling is very successful. The Geysers in California provide an excellent example of air drilling in the geothermal environment. The upper part of the hole at The Geysers produces too much water to air drill. The bottom of the hole produces only steam and so air drilling is successful.

Air is the best drilling fluid when it can be used because of increased drilling rates in hard rock. It has, however, limitations:

1. Air has poor lifting capacity and large air volumes must be used so it is expensive.

2. Water in the hole compresses the air. This reduces the lifting capacity and also often causes the hole to slough.

3. Formations can produce fluid and gas into the hole to make air drilling impossible.

4. Air drilling is expensive because of the high cost of air compression and the wear and corrosion on the drill pipe.

Mist drilling was developed as a method of coping with water influx into the air drilled hole. A foaming detergent and lime water is added to the air stream in the ratio of water to air of 1:1000 to help form a mist in the air stream. This approach is only partly effective. As the influx volume of water increases, the system tends to go into two phase flow with the water crawling up the side of the hole and the air blowing out the center of the hole. So mist drilling is effective in damp holes or to clean mud rings out of damp holes, but does not solve the problems of fluid influx or sloughing formations.

The obvious approach to the limitations of air drilling was to combine air and drilling mud into aerated mud. This was done as early as the late 1940s but usually the results were disappointing. The aerated mud or water was generally too expensive, and the system too unstable. Nevertheless, since that time there has been considerable work done with aerated muds. Given close supervision under the proper hole conditions they have performed well in some areas.

Foam was developed as an improvement to aerated mud. The aerated mud was too unstable, so a stable aerated mud was developed. It was so stable, however, it could not be broken down and reused. The mixture looked like aerosol shaving foam, but was stable and persistent. It had a good lifting capacity, was lighter than water and helped support the walls of the hole.

ABSTRACTS

APPENDIX C

Anderson, Glenn W.: "Near Gauge Holes Through Permafrost," Oil & Gas Journal, p. 126-142, September 1971.

Anderson, Glenn W.: "Stable Foam Circulation Cuts Surface Hole Costs," World Oil, Vol. 173, No. 4, p. 39-42, September 1971.

FOAM DRILLING THROUGH PERMAFROST

Penetration rate of large diameter surface holes drilled through permafrost in Northern Canada has been increased significantly by a stable foam circulating system. It is estimated that use of foam can reduce cost of drilling 800 feet of surface hole as much as $12,000 - $18,000 oer well.

WHY USE FOAM?

Due to its excellent insulating properties, low heat capacity and poor heat conductance, stable foam allows drilling of a near-gage hole through frozen sections. Stable foam was used in drilling parts of wells where ambient temperature ranged from -5° to -68°F.

PROBLEMS AND REMEDIES

The problems encountered while drilling through permafrost with stable foam are:

1. Freezing of the foam
2. Getting formation samples
3. Circulating stable foam from about 1,800 feet due to compressor limitations and low surface temperatures (-70°F) ect.

A compressor combination with more flexibility should be used. For winter operation some type of heat jacketed line from the foam generator to the rig is essential. An independent water tank, heated and thermostatically controlled for winter use, should be installed for the stable foam process.

Bleakley, W. B.: "West Texas Workovers with Foam Gain Favor," Oil & Gas Journal, Vol. 71, No. 11, p. 97-98, March 1973.

USE OF FOAM IN WEST TEXAS

Stabilized foam permits circulation in wells where water or heavier liquids would be lost to the formation. Standard Oil Company of California has successfully used stabilized foam, to work over more than 100 wells in West Texas with low bottom hole pressures for clean-out and deepening.

PERFORMANCE OF FOAM

Stabilized foam with a density of about 2 lb/cu.ft. can be circulated without losing returns and still the foam can remove collected debris or drill cuttings. Even bit cones have been circulated out successfully. The technique used in drilling a large number of new infill wells in the Persian Basin to prevent reservoir damage and loss of drilling fluids is to drill these wells to the top of the pay, set casing, then drill through with foam for an open hole completion.

When paraffin is a problem, foam made from water at 200°F has been helpful. In wells with high standing water levels, getting circulation started without using large air volumes and excess pressure requires special techniques.

ADVANTAGES OF FOAM

1. Lower move-in cost.
2. Larger cuttings returned.
3. Safer--less combustible.
4. Less corrosive.
5. Moves more formation fluid.

Jokhoo, Khem,: "Aerated Foam Drilling in Trinidad," Petroleum Engineer, Vol. 48, No. 7, pp. 24-32, June 1976.

GENERAL

Foam has been very successful as a drilling fluid in low pressure, partially depleted areas in Trinidad. Old wells drilled with conventional muds presented problems of lost circulation and resulted in low initial potential and ultimate recovery. New wells drilled with foam showed excellent initial potential.

PERFORMANCE OF FOAM

Foam as experienced in Trinidad is that the foam must be stable throughout the system until it leaves the blooie line.

The most successful procedure used in Trinidad to minimize reservoir damage and the loss of drilling fluids to the low pressure formation was to drill the wells to the top of the pay, run and cement casing, and then drill to total depth with foam for an open hole completion with preperforated casing landed opposite the pay zone.

The density of liquid foam-mix commingled with air utilized in Trinidad was as low as 0.27 lb/gal continuous circulation is almost imperative in foam drilling and it avoids the problem of drill pipe sticking.

COST CONSIDERATIONS

The cost of a foam rig is higher than a conventional mud rig on a daily basis but on a job basis it might be cheaper to drill a given well with foam than with mud. Drilling costs from top of pay to completion of well were 15% to 20% lower for wells drilled with the foam system as compared to the conventional mud system.

Hutchinson, S. O. and Anderson, G. W.: "What to Consider When Selecting Drilling Fluids," World Oil, October 1974.

Selecting proper drilling fluids is very important for the economic drilling of wells. Major points to consider when choosing a circulating medium include formation geology, formation pressure, geothermal temperature, makeup water availability and quality, penetration rates, formation evaluation, completion procedures, and ecological considerations.

The following information pertains to stable foams:

1) Classification and Characteristics

Density Range	pH Range	Temperature Limit °F	Cost Per Bbl	Uses & Limitations
0.56 - 0.8 ppg	7.0 - 8.0	250	$2.50 - $3.50	Good penetration rates, excellent large hole cleaning can handle large vol. water, will not tolerate salt water or oil.

AEC Stiff Foam Gel Mud and Foaming Surfactant

Density Range	pH Range	Temperature Limit °F	Cost Per Bbl	Uses & Limitations
0.4 - 0.8 ppg	4.0 - 10.0	400	$0.25 - $3.00	Excellent penetration rates and large hole cleaning, can handle large volume of wate excellent insulation to hea or cold, can tolerate contaminants--oil, salt, calcium solids, acids, etc.

Prefored Stable Foam

2) Hole Cleaning Capabilities

Viscosity Funnel	Hole Size Inches	Annular Vel.fpm	Volume (gpm)	Problem
Thick Stable	9-7/8	75	300 cfm 20 gpm	Excellent cleaning regardless of hole size.
	17-1/2	40	300 cfm 20 gpm	Adequate hole cleaning. Increasing annular velocity annular velocity improves lifting ability and reduces return time.

Stable Foam.

Anderson, G. W.: "Foam Disposal - Offshore and Urban Operations," Chevron Research Company Foam Cleanout Technical Notes, April 1977.

FOAM DISPOSAL

Following are the four basic principles for satisfactory foam disposal:

1. Containment

To absorb the violent surge of energy generated by the foam returning at surface at reduced pressure, a vessel or separator must be provided.

2. Foam Suppression

   a. Foam collapse by expansion in a low pressure chamber.

   b. Blending with a large volume of crude oil or produced water from other wells.

   c. Chemical foam breakers such as aluminium stearate in diesel oil or water dispersable defoamers in water can be sprayed on the foam surface to break the foam so that the liquids can be pumped or drained off.

3. After the foam has been separated into gas and liquids, it must be subjected to violent agitation or the foam will tend to reform.

4. If natural gas is being used as the gaseous phase, means must be provided to recover or flare the gas.

Essary, R. L., and Rogers, E. E.: "Techniques and Results of Foam Redrilling Operations - San Joaquin Valley, California," AIME Formation Damage Control Symposium, SPE Paper 5715, pp. 237-244, 1976.

GENERAL

During the past three years, Standard Oil Company of California has had a very active foam redrill program in several oil fields in the Southern San Joaquin Valley. Approximately 150 shallow zone wells have been reconditioned by replacing liners using foam redrilling techniques so that the wells could be utilized for steam stimulation and steam flood operations.

ADVANTAGES OF FOAM REDRILLING

1. The use of low density stable foam provides a practical, economic method for redrilling old low-pressure, high-permeability wells without creating significant formation damage.

2. Redrilling old wells with stable foam provides a substantial savings compared to the drilling of new wells.

LIMITATIONS

1. Open hole logs cannot be run.
2. Drilled in liners cannot be gravel packed.
3. Intermediate water zones cannot be excluded effectively.
4. Existing small diameter casing would preclude installing satisfactory size liner.

Bobo, Roy A.: "New Air/Mud System Can Boost Bit Performance," Oil & Gas Journal, May 1968.

Magcobar, Dresser: "Air Drilling Handbook," August 1975.

____________________,: "Modified Stable Foam Can Give Lower Drilling Cost," Petroleum International, Vol. 15, No. 2, February 1975.

GENERAL

It is a confirmed fact that the lower the borehole drilling pressure, the greater is the drilling rate. This effect is more pronounced at higher bit loads. Also, the lower the difference between bottom hole mud pressures and formation fluid pressures, the greater would be the drilling rate (at higher bit loads).

REDUCTION IN BOTTOM HOLE PRESSURES CAN BE ACHIEVED BY:

1. Aerated Mud: (Air mixed with mud)
   a. No lost circulation material cost.
   b. Maintain (in some cases increase) drilling rate.
   c. Less fluid cost.
   d. Less danger of differential sticking of pipe.
2. Dust Drilling: (Air-Drilling)

   When properly used can bring faster penetration rates, longer bit life resulting in fewer round trips, better control of lost circulation, cleaner cores, cleaner formations, etc. can be used only when the formation is completely dry or the water influx is slight enough to be absorbed by the air stream. As the well deepens, more air is necessary to maintain the velocity needed to bring cuttings to the surface.
3. Mist Drilling: (Air plus Foaming Agent)

   Mist drilling is used when fluids are encountered. It removes larger cuttings and most of the advantages achieved by straight air drilling are approached. About 30% to 40% more air is required for mist drilling (Foam) than for Air-Drilling. Hole sloughing and caving cause most unsuccessful mist drilling jobs because as the hole enlarges, annular velocity drops and the air foam ceases to lift cuttings efficiently.

   There is only one drilling situation that precludes the usage of foam drilling and that is where hydrostatic pressure is deemed necessary. (Foam densities varies from 0.4 to 0.8 lb/gal.)

Hutchinson, S. O.: "What Foam Is and How It's Used," World Oil, November 1969.

GENERAL

Stable preformed foam is easy to circulate and relatively inexpensive to produce. It replaces mud, oil, water, air, etc. as a circulating medium in well completion and remedial operations.

ADVANTAGES OF STABLE FOAM

1. Low Hydrostatic Head: 15 psi @ 1,000 ft --- Actual
   50 psi @ 2,900 ft --- Measurements
   Problems like formation damage, lost curculation are eliminated.
2. No hole washout in unconsolidated formations while drilling in liners.
3. Excellent carrying capacity for cuttings.
4. Low compression requirements.
5. Low circulating pressures.
6. Stable at high temperatures and bottom hole pressures.

COMPOSITION OF FOAM

Stable foam consists of a detergent, fresh water, and compressed gas. It must be preformed, i.e., it must be generated out of contact with the solid and liquid contaminants naturally encountered in a well. Foam should have a gas to liquid volume ratio from 3 - 50 cu. ft/gal depending on downhole requirements. Various gaseous sources used to produce foam include nitrogen, carbon dioxide, natural gas, inert gas air, etc.

PERFORMANCE OF FOAM

Use of a 2 lb/cu-ft preformed foam circulating medium has speeded well cleanout, reduced sanding problems. Foam has been used successfully on wells deeper than 9,500 ft with tubing pressured to 1,850 psi.

Magcobar, Dresser: "Stiff Foam," Technical Memorandum, February 1970.

WHAT IS FOAM?

Stiff foam is a very stable air-in-mud emulsion formulated with stabilizing mud additives and foaming agents. The system has special application where neither straight air or mist drilling techniques nor aerated muds will suffice because of economic mechanical or other reasons.

WHY USE FOAM?

1. To drill large diameter holes (straight air drilling needs large air volumes).
2. To drill unconsolidated formations. (Stiff foam stabilizes this type of formation.)
3. To drill in low pressure or unconsolidated producing zones. (Exerts minimum hydrostatic pressure).
4. To drill water sensitive shales which teno to slough badly when mist drilled.
5. To drill severe lost circulation zones.

COMPOSITION OF FOAM

Stiff foam consists of a thin medium slurry (4-14 gpm) injected with enough air to give a 100 to 200 fpm annular velocity near the surface. Air mud ratios range from 100:1 to 300:1. In order to obtain stable foam, the mud slurry should consist of 12 #/bbl maglogel, 1 #/bbl soda ash, 1/2 #/bbl Hi Vis CMS, 1/2 to 1% by volume magco foamer 66, 1/2 #/bbl Drispac, and 1 #/bbl cypan.

PERFORMANCE OF FOAM

The system is safe, and geological interpretation is facilitated by visual observation at the surface of large cuttings. Penetration rates approaching those obtained with air can be obtained.

LIMITATIONS

1. High volumes of water or oil limit the true stiff foam approach. Even small amounts of gas can cause troubles.
2. Foam cannot be recirculated.
3. Economical for a depth over 5,000 - 6,000 ft.

Petroleum Engineering: "Stable Foam Cuts Costs, Increases Production," Vol. 41, No. 13, pp. 61-63, December 1969.

GENERAL

When used as a circulating medium, stable foam with low density and high solids carrying capacity can reduce workover costs and al increases production.

COST OF FOAM DRILLING

Heavier units needed for mixing and circulating the foam will cost in the range of $35,000 to $50,000. Total cost of equipment rentals, chemical usage and royalty payments will range from $200 to $500 per day.

PERFORMANCE OF FOAM

Greatest use of the stable foam has been in cleaning out wells with unconsolidated sand formations where severe sandup problems have occurred. Also, foam has proven advantageous over other cleanout methods by stabilizing the sand. In a survey by Standard Oil Company, twelve wells saved an average of 48% in sand removal cost, 71% in future sand entry and 23% in controllable costs while cumulative production increased 31%.

Stable foam has been effective in reducing the cost of certain fishing operations. Other remedial applications have included circulating in of inner liners, plug-back cementing, recompletions and plugging of old wells. In all cementing operations stable foam has the advantage of minimizing or eliminating lost circulatio because of the low overall hydrostatic head.

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APPENDIX D.

FLUID

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AUTHORS	BALLARD D
SOURCE	HYDROCARBON PROCESS V 56, NO 4, PP 111-118, APRIL 1977
ENTRY YEAR	1977
INDEX TERMS	ABSORBER; ABSORPTION; ABSORPTION PROCESS; ACIDITY/BASICITY; ACTIVITY; CHART; CLEANING; COLUMN; CONSTRUCTION; CONTAMINATION; CONTROL; CORROSION; *CORROSION CONTROL; CORROSIVITY; COST; *DRYING; ECONOMIC FACTOR; ENGLISH; FILTRATION; FLOW CHART; FOAMING; FREEZING; *GAS DEHYDRATION; *GAS PROCESSING; GAS PRODUCING; *GLYCOL DEHYDRATION; *HYDROGEN SULFIDE REMOVAL; INSPECTING; OPERATING COST; PH; PHASE BEHAVIOR; PHASE CHANGE; PHYSICAL PROPERTY; PHYSICAL SEPARATION; PIPELINE CORROSION; PREVENTION; PROCESS CONTROL; PRODUCING; PURIFYING; REGENERATION; SEPARATION EQUIPMENT; SOLIDIFICATION; SORPTION; SORPTION PROCESS; STARTUP; TESTING

ACCESSION NUMBER	234917
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AUTHORS	COOPER L W; HOOK R A; PAYNE B R
SOURCE	WORLD OIL V 184, NO 5, PP 95-96, 100, 102, 106, APRIL 1977
ENTRY YEAR	1977
INDEX TERMS	*AIR DRILLING; AMOCO PRODUCTION CO; BIT PERFORMANCE; BIT (ROCK); CHART; CIRCULATING RATE; COMPRESSOR; CUTTINGS REMOVAL; DATA; DRILLING DATA; *DRILLING EQUIPMENT; DRILLING FLUID; DRILLING PROBLEM; DRILLING RATE; *DRILLING (WELL); ENGLISH; FLOW RATE; *FOAM DRILLING; GRAPH; LOST CIRCULATION; *MIST DRILLING; RATE; REMOVAL; *ROTARY DRILLING; TECHNOLOGY

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INDEX TERMS	*ABSORBENT; ABSORBER; ABSORPTION; ABSORPTION PROCESS; ADDITIVE; ALCOHOL; BUTYL ALCOHOL; CARBON DIOXIDE; CARBON DIOXIDE REMOVAL; CHART; CHEVRON RESEARCH CO; CIRCULATING SYSTEM; COMPOSITION; COMPOUND; CONTAMINATION; DATA; DESIGN; DESIGN CRITERIA; DIAGRAM; *ELUTION; ENGINEERING; ENGLISH; ETHER; FLOW CHART; FOAM; *FOAMING; GAS ABSORPTION; *GAS PROCESSING; *HYDROCARBON SOLVENT; HYDROGEN SULFIDE; HYDROGEN SULFIDE REMOVAL; INORGANIC; KETONE; MIXTURE; NATURAL GAS; ORGANIC; PATENT (A); PETROLEUM; *PHYSICAL SEPARATION; PREVENTION; PROCESS DESIGN; PRODUCING OIL + GAS; PURIFYING; SEPARATION EQUIPMENT; SOLVENT; *SORBENT; SORPTION; SORPTION PROCESS; SOUR GAS; SPECIFICATION; SULFIDE; SURFACE ACTIVE AGENT; SYSTEM (ASSEMBLAGE); TABLE (DATA); (P) USA

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AUTHORS	ANDERSON G W; HUTCHISON S O
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SOURCE	U S 3.995.695. C 12/7/76. F 8/25/75; ATLANTIC RICHFIELD CO
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AUTHORS	CORNWELL C E; PLUNGUIAN M
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AUTHORS	FISCHER P W; PYE D S
SOURCE	U S 3.995.705. C 12/7/76. F 10/24/75; UNION OIL CO CALIFORNIA
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AUTHORS	ESTEBANEZ J; LINFIELD P M
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ACCESSION NUMBER 228784
TITLE LIGHTWEIGHT CELLULAR CEMENT COMPOSITIONS AND METHODS OF CASTING THE SAME
AUTHORS SUTTON D L
SOURCE U S 3,979,217, C 9/7/76, F 5/5/75, PR US 6/1/73; HALLIBURTON CO
ENTRY YEAR 1977
INDEX TERMS *ADDITIVE; CASING SETTING; *CEMENT; *CEMENT COMPOSITION; CEMENT HANDLING; CEMENT WATER RATIO; *CEMENTING; *COMPOSITION; CONCRETE; CONSTRUCTION; CONSTRUCTION MATERIAL; CONTROL; DEFORMATION; *DENSITY; ENGLISH; FOAM; FOAMING; FORMING; HALLIBURTON CO; *LIGHTWEIGHT CEMENT; MIXTURE; MOLDING; PATENT (A); *PHYSICAL PROPERTY; PROCEDURE; STABILIZER (ADDITIVE); *SURFACE ACTIVE AGENT; WEIGHT; WEIGHT CONTROL; WELL COMPL SERV + WORKOVER; WELL COMPLETION; (P) USA

ACCESSION NUMBER 228593
TITLE GEOTHERMAL WELL DRILLING FLUID TECHNOLOGY--A LITERATURE SURVEY
AUTHORS GOODE A H; LILES K J; SADLER L Y III
SOURCE U S BUR MINES INFORM CIRC NO 8724, 28 PP, 1976
ENTRY YEAR 1977
INDEX TERMS ACRYLIC ACID HOMOPOLYMER; *ADDITIVE; ASIA; ATLANTIC OCEAN; CALIFORNIA; CHROMATE; COMPOSITION; CONTROL; DATA; *DRILLING FLUID; DRILLING FLUID CONTROL; DRILLING PROBLEM; *DRILLING (WELL); DRILLING (WELL) (C); ENGLISH; EUROPE; *EXPLORATION; *EXPLORATORY DRILLING; FIELD DATA; FLUID PROPERTY; *GEOPHYSICAL EXPLORATION; *GEOTHERMAL EXPLORATION; HAWAII; HIGH TEMPERATURE; ICELAND; ITALY; JAPAN; LIGNOSULFONATE; *MUD ADDITIVE; MUD PROPERTY; MUD WEIGHT; NEVADA; NEW ZEALAND; NORTH AMERICA; OCEANIA; PHYSICAL PROPERTY; POLYMER; SEAS AND OCEANS; TABLE (DATA); TEMPERATURE; TURKEY; UNITED STATES; *WATER BASE MUD; WELL TEMPERATURE; WESTERN US; WORLD WIDE

ACCESSION NUMBER 228022
TITLE CHEMICAL TREATMENT PROGRAMMES FOR INJECTION WATER:-- AN INSTRUMENTATION PACKAGE FOR NORTH SEA FIELDS
AUTHORS BAKER C; WITHERS A
SOURCE PETROL TIMES V 80, NO 2036, PP 23, 25, 27, 10/1/76
ENTRY YEAR 1976
*TRANSITION TEMPERATURE; WATER; *WATER BASE MUD; WATER CONTENT; WELL COMPL SERV + WORKOVER; *WELL COMPLETION; *ZONE (GEOLOGY); (P) USA

ACCESSION NUMBER 227120
TITLE THE POTENTIAL OF STABLE FOAM
AUTHORS MITCHELL T
SOURCE OILWEEK V 27, NO 35, P 11, 10/11/76
ENTRY YEAR 1976
INDEX TERMS AIR DRILLING; ALBERTA; CANADA; CASE HISTORY; COMPARISON; CONTAMINATION; CONTROL; DATA; *DRILLING FLUID; DRILLING PROBLEM; *DRILLING (WELL); DRILLING (WELL) (C); ENGLISH; *FOAM; *FOAM DRILLING; FOOTHILLS STRUCTURE;

FREEZING; GENERATOR; INSULATING MATERIAL; LIMIT; *LOST CIRCULATION; MINIMUM; *MIXTURE; MOUNTAIN; NEWS; NORTH AMERICA; PHASE BEHAVIOR; PHASE CHANGE; *PHYSICAL PROPERTY; SAFETY; SHELL CANADA LTD; SOAP; SOLIDIFICATION; *STABILITY; THERMAL INSULATION

ACCESSION NUMBER	226995
TITLE	TAR SANDS TREATMENT
AUTHORS	SMITH R H
SOURCE	CAN 993,392. C 7/20/76. F 10/3/73. PR US 7/9/73; ATLANTIC RICHFIELD CO
ENTRY YEAR	1976
INDEX TERMS	ALT FUELS + ENERGY SOURCES; ATLANTIC RICHFIELD CO; *BITUMINOUS SANDSTONE; CENTRIFUGE; CENTRIFUGING; *CRUDE OIL; DESIGN; DESIGN CRITERIA; DILUTING; DISPOSAL; DRYING; ENGINEERING; ENGLISH; FOAM; FOAMING; GRAVITATIONAL SEPARATION; *HOT WATER; *MANUFACTURED CRUDE OIL; MECHANICAL DEHYDRATION; MIXTURE; *OIL AND GAS RECOVERY; *OIL RECOVERY; PARTICLE; PATENT (A); *PETROLEUM; PHYSICAL SEPARATION; PROCESS DESIGN; *RECOVERY PROCESS; RESIDUE; *ROCK; *SANDSTONE; *SEDIMENTARY ROCK; SEPARATION EQUIPMENT; SOLID; SPECIFICATION; STEAM; STRIPPING; *TAR SAND; *TAR SAND OIL; *TAR SAND OIL RECOVERY; *WATER; WATER DISPOSAL; WATER VAPOR; (P) CANADA

ACCESSION NUMBER	223382
TITLE	AERATED FOAM DRILLING IN TRINIDAD
AUTHORS	JOKHOO K
SOURCE	PETROL ENG V 48, NO 7, PP 24, 26, 28, 32, JUNE 1976
ENTRY YEAR	1976
INDEX TERMS	CASING SETTING; CENOZOIC; CENTRAL AMERICA; COST; CUTTINGS REMOVAL; DATA; DRILLING COST; DRILLING DATA; DRILLING EQUIPMENT; *DRILLING FLUID; DRILLING PROBLEM; *DRILLING PROGRAM; DRILLING RATE; *DRILLING (WELL); DRILLING (WELL) (C); EARTH AGE; ECONOMIC FACTOR; ENGLISH; FLUID PROPERTY; FOAM; *FOAM DRILLING; FORMATION (GEOLOGY); GEOLOGIC STRUCTURE; GUAYAGUAYARE OIL FIELD; INCOMPETENT BED; LESSER ANTILLES; LOST CIRCULATION; LOW PRESSURE; MIOCENE; MIXTURE; MUD PROPERTY; MUD WEIGHT; OIL AND GAS FIELDS; OIL FIELD; OIL RESERVOIR; PHYSICAL PROPERTY; PIPE STICKING; PRESSURE; REMOVAL; RESERVOIR; SANDSTONE RESERVOIR; TERTIARY PERIOD; *TRINIDAD; TRINIDAD AND TOBAGO; UNCONSOLIDATED FORMATION; *UNUSUAL DRILLING CONDITION; WELL LOGGING; WEST INDIES

ACCESSION NUMBER	222543
TITLE	THE EFFECT OF POTASSIUM-SALT MUDS ON GAMMA RAY, AND SPONTANEOUS POTENTIAL MEASUREMENTS
AUTHORS	COX J W; RAYMER L L
SOURCE	17TH ANNU SPWLA LOGGING SYMP TRANS 20 PP, 1976 (PAPER NO II)
ENTRY YEAR	1976
INDEX TERMS	BICARBONATE; BUSINESS OPERATION; CHEMISTRY; CHLORIDE; *DRILLING FLUID; *ELECTRIC LOGGING; ELECTROCHEMISTRY; ELEMENT (CHEMICAL); ENGLISH; EVALUATION; FILTRATE; FLUID

PROPERTY; FORMATION DAMAGE; FORMATION EVALUATION; *GAMMA RAY LOGGING; *INTERPRETATION; INVADED ZONE; ION; ISOTOPE; *MINERAL; MUD PROPERTY; MUD RESISTIVITY; *NUCLEAR LOGGING; PHYSICAL PROPERTY; POTASSIUM; POTASSIUM BICARBONATE; POTASSIUM CHLORIDE; *POTASSIUM MINERAL; RADIOACTIVE ISOTOPE; RADIOACTIVE MINERAL; RADIOACTIVITY; *SALT WATER MUD; *SELF POTENTIAL LOGGING; THERMAL PROPERTY; *WATER BASE MUD; *WELL LOG INTERPRETATION; *WELL LOGGING; WELL LOGGING + SURVEYING

STABILIZATION; HYDRAULICS; MUD ADDITIVE; *MUD COMPOSITION; *MUD PROGRAM; NORTH AMERICA; OKLAHOMA; STABILIZATION; TEMPERATURE; TEXAS; UNITED STATES; *UNUSUAL DRILLING CONDITION; USA; WATER BASE MUD

ACCESSION NUMBER	219176
TITLE	FORMATION FRACTURING WITH STABLE FOAM
AUTHORS	BLAUER R E; DURBOROW J
SOURCE	U S 3,937,283, C 2/10/76, F 10/17/74; DOW CHEMICAL CO, MINERALS MANAGEMENT INC
ENTRY YEAR	1976
INDEX TERMS	ACID; ADDITIVE; AIR; BLOCK DIAGRAM; CARBON DIOXIDE; CHART; COMPOSITION; COMPOUND; COMPRESSED GAS; DIAGRAM; DOW CHEMICAL CO; ELEMENT (CHEMICAL); EMULSION; ENGLISH; FISSURE (GEOLOGY); FLUID; *FOAM; FOAMING; FRACTURE EXTENSION; FRACTURE (ROCK); *FRACTURING; *FRACTURING FLUID; FRACTURING PRESSURE; GAS; GAS INJECTION; GEOLOGIC STRUCTURE; GRAPHICAL REPRESENTATION; *HYDRAULIC FRACTURING; INDUCED FRACTURE; INJECTION; LIQUID; MATHEMATICAL ANALYSIS; MATHEMATICS; MINERALS MANAGEMENT INC; MIXING; *MIXTURE; NITROGEN; OIL; ORGANIC; PATENT (A); *PHYSICAL PROPERTY; PRESSURE; PROCEDURE; QUALITY; *STABILITY; SURFACE ACTIVE AGENT; TEMPERATURE; WATER; WELL COMPL SERV + WORKOVER; WELL COMPLETION; *WELL STIMULATION; (P) USA

ACCESSION NUMBER	218874
TITLE	METHOD OF RECOVERING OIL USING STEAM
AUTHORS	NEEDHAM R B
SOURCE	U S APPL B 529,836, F 12/5/74; PHILLIPS PETROLEUM CO
ENTRY YEAR	1976
INDEX TERMS	ADDITIVE; CHEMICAL INJECTION; CRUDE OIL; ENGINEERING; ENGLISH; *FOAM; FOAMING; FOAMING AGENT; *FORMATION PLUGGING; GEOLOGIC STRUCTURE; INJECTION; INJECTION WELL; INJECTIVITY; *INJECTIVITY PROFILING; *MIXTURE; OIL AND GAS RECOVERY; OIL PRODUCING; OIL RECOVERY; OIL RESERVOIR; PATENT (A); PETROLEUM; PETROLEUM ENGINEERING; PHILLIPS PETROLEUM CO; PHYSICAL PROPERTY; *PLUGGING; *PLUGGING AGENT; PRODUCING; PRODUCING WELL; *PROFILING; RECOVERY CATEGORY; *RECOVERY PROCESS; RESERVOIR; RESERVOIR ENG + REC METHOD; RESERVOIR ENGINEERING; SECONDARY RECOVERY; STEAM;

ACCESSION NUMBER 218057
TITLE COMPOSITION AND PROCESS FOR DEFOAMING DRILLING FLUIDS
AUTHORS ELTING K A C
SOURCE U S 3.920.559. C 11/18/75. F 2/19/74: MILCHE INC
ENTRY YEAR 1976
INDEX TERMS ACID: *ADDITIVE: ALCOHOL: ALUMINUM STEARATE: *ANTIFOAMING AGENT: CALCIUM STEARATE: COMPOUND: *CONTROL: DATA: *DEFOAMING: *DEGASSING: *DRILLING FLUID: *DRILLING FLUID CONTROL: DRILLING (WELL) (C): ENGLISH: ESTER: FOAM: INHIBITION: IRON STEARATE: MILCHEM INC: MIXTURE: OLEYL ALCOHOL: ORGANIC: ORGANIC ACID: ORGANOMETALLIC COMPOUND: PATENT (A): *PHYSICAL SEPARATION: PROPYLENE OXIDE: SALT: SOAP: STEARATE: STEARIC ACID: SURFACE ACTIVE AGENT: *SYNERGISTIC EFFECT: TABLE (DATA): *WATER BASE MUD: ZINC STEARATE: (P) USA

ACCESSION NUMBER 217859
TITLE TECHNIQUES AND RESULTS OF FOAM REDRILLING OPERATIONS--SAN JOAQUIN VALLEY, CALIFORNIA
AUTHORS ESSARY R L: ROGERS E E
SOURCE 2ND SPE OF AIME FORMATION DAMAGE CONTR SYMP PREPRINT NO SPE-5715, PP 237-244, 1976
ENTRY YEAR 1976
INDEX TERMS CALIFORNIA: CASE HISTORY: *CIRCULATING SYSTEM: COST: CUTTINGS REMOVAL: DATA: DRILLING COST: *DRILLING FLUID: *DRILLING (WELL): ECONOMIC FACTOR: ENGLISH: FOAM: *FOAM DRILLING: FORMATION DAMAGE: INJECTION WELL: *LINER COMPLETION: LOW PRESSURE: MIXTURE: NORTH AMERICA: PRESSURE: RECOVERY PROCESS: REMOVAL: SAN JOAQUIN BASIN: *SHALLOW WELL: STANDARD OIL CO CALIFORNIA: STEAM INJECTION: *SYSTEM (ASSEMBLAGE): THERMAL RECOVERY: UNITED STATES: *WELL: WELL COMPL SERV + WORKOVER: *WELL COMPLETION

ACCESSION NUMBER 217844
TITLE PREFORMED STABLE FOAM PERFORMANCE IN DRILLING EVALUATING SHALLOW GAS WELLS IN NORTHEASTERN ALBERTA
AUTHORS BENTSEN N W: VENY J N
SOURCE 2ND SPE OF AIME FORMATION DAMAGE CONTR SYMP PREPRINT NO SPE-5712, PP 213-218, 1976
ENTRY YEAR 1976
INDEX TERMS *ADDITIVE: *ALBERTA: CANADA: CAPACITY (ROCK): CIRCULATING SYSTEM: CORING: CUTTINGS REMOVAL:

ACCESSION NUMBER 212005
TITLE FOAM RECOVERY PROCESS
AUTHORS ROOT P J
SOURCE U S 3.893.511. C 7/8/75. F 6/9/71: SUN OIL CO
ENTRY YEAR 1975
INDEX TERMS ADDITIVE: CARBON DIOXIDE: *CARBON DIOXIDE INJECTION: CHEMICAL: CHEMICAL INJECTION: COMPOUND: *CONTROL: CRUDE OIL: CYCLIC INJECTION: EFFICIENCY: ENGINEERING: ENGLISH: FLOODING (FORMATION): *FLOW CONTROL: *FLUID ENTRY PROFILING: FLUID FLOW: *FOAM: FOAM FLOODING: FOAMING: FOAMING AGENT: FORMATION DAMAGE: *GAS ENTRY PROFILING: *GAS INJECTION: GEOLOGIC STRUCTURE: HETEROGENEITY: IN SITU:

*INJECTION; INJECTION WELL; INJECTIVITY; INJECTIVITY PROFILING; *MIXTURE; OIL RECOVERY; OIL RESERVOIR; ORGANIC; PATENT (A); PERMEABILITY; PERMEABILITY (ROCK); PETROLEUM; PETROLEUM ENGINEERING; PHYSICAL PROPERTY; *PROFILING; *RECOVERY; RESERVOIR; RESERVOIR ENG + REC METHOD; RESERVOIR ENGINEERING; *SECONDARY RECOVERY; SUN OIL CO; SURFACE ACTIVE AGENT; SWEEP EFFICIENCY; WELL; (P) USA

ACCESSION NUMBER	211954
TITLE	FOAM PRESSURE LOSS IN VERTICAL TUBING
AUTHORS	KRUG J A
SOURCE	OIL GAS J V 73, NO 40, PP 74-76, 78, 10/6/75
ENTRY YEAR	1975
INDEX TERMS	*ARTIFICIAL LIFT; CALCULATING; *CHANGE; CHART; COEFFICIENT OF FRICTION; CONTROL; DATA; *DECREASE; DENSITY; DIAMETER; DRILLING (WELL); *EMPIRICAL ANALYSIS; ENGLISH; EQUATION; EXAMPLE; FANNING FRICTION FACTOR; FLOW PROPERTY; FLUID FLOW; FOAM; FOAM DRILLING; *FOAM LIFTING; FOAMING; FRICTION; *FRICTION LOSS (FLUID); GRAPH; *GRAPHICAL SOLUTION; LAMINAR FLOW; *LOSS; *MATHEMATICAL ANALYSIS; MATHEMATICAL MODEL; *MATHEMATICS; MECHANICAL PROPERTY; MIXTURE; MODEL; MULTIPHASE FLOW; PHYSICAL PROPERTY; PIPE DIAMETER; PRESSURE; *PRESSURE DECLINE; QUALITY; QUALITY CONTROL; REYNOLDS NUMBER; *TRANSMISSION LOSS; TUBE; TUBING (WELL); TUBULAR GOODS; TURBULENT FLOW; VERTICAL; VISCOSITY; WELL COMPL SERV + WORKOVER; YIELD POINT

ACCESSION NUMBER	205152
TITLE	APPARATUS FOR GENERATING AND PUMPING FOAM
AUTHORS	ERON R E
SOURCE	GR BRIT 1,387,975, C 3/19/75, F 2/26/73
ENTRY YEAR	1975
INDEX TERMS	*ADDITIVE; AGITATING; AGITATOR; AIR DRILLING; *ARTIFICIAL LIFT; CLEANING; *DRILLING (WELL); DRILLING (WELL) (C); ENGLISH; *FIRE FIGHTING; *FLOODING (FORMATION); FOAM; *FOAM DRILLING; *FOAM FLOODING; *FOAM LIFTING; *FOAMING AGENT; GAS DRILLING; GENERATOR; MEASURING; METERING; MIXTURE; NOZZLE; PATENT (A); PHYSICAL PROPERTY; PUMPING; *RECOVERY; SOAP; STABILITY; STABILIZER (ADDITIVE); SURFACE ACTIVE AGENT; TESTING; WELL CLEANOUT; (P) GREAT BRITAIN

ACCESSION NUMBER	204966
TITLE	FOAMED CONCRETE STRUCTURES
AUTHORS	ERGENE M T
SOURCE	U S 3,867,159, C 2/18/75, F 9/10/73, PR US 10/22/70; STANLEY WORKS
ENTRY YEAR	1975
INDEX TERMS	*ADDITIVE; ADHESIVE; CASING SETTING; CAVITY; *CEMENT; *CEMENT ACCELERATOR; CEMENT ADDITIVE; *CEMENT COMPOSITION; CEMENTING; CHEMICAL; CHLORIDE; *COMPOSITION; COMPOUND; CONCENTRATION; DENSITY; ENGLISH; FIBER; *FOAM; FOAMING; *FOAMING AGENT; FORMING; INORGANIC; *LIGHTWEIGHT CEMENT; *MIXTURE; MOLDING; PATENT (A); PHYSICAL PROPERTY; POLYMER; PORE; PORE SIZE; POROSITY; PRESSURE; PROCEDURE; REINFORCING AGENT; STANLEY WORKS; SYNTHETIC RESIN; WELL COMPL SERV + WORKOVER; WELL COMPLETION; (P) USA

ACCESSION NUMBER 204908
TITLE MODIFIED STABLE FOAM CAN GIVE LOWER DRILLING COSTS
AUTHORS HIGGINS B
SOURCE PETROLEUM INT V 15, NO 2, PP 12-14, 16, FEB 1975
ENTRY YEAR 1975
INDEX TERMS ARTIFICIAL LIFT; CARRYING CAPACITY; *COST; CUTTINGS REMOVAL; *DRILLING COST; *DRILLING FLUID; *DRILLING FLUID COST; DRILLING FLUID HYDRAULICS; *DRILLING (WELL); DRILLING (WELL) (C); *ECONOMIC FACTOR; ENGLISH; FLOW PROPERTY; *FOAM; *FOAM DRILLING; FOAM LIFTING; HYDRAULICS; *MIXTURE; PHYSICAL

ACCESSION NUMBER 200402
TITLE CLOSED CIRCUIT METHOD OF CIRCULATING A SUBSTANTIALLY SOLID FREE DRILLING FLUID
AUTHORS JACKSON J M
SOURCE U S 3,844,361, C 10/29/74, F 4/19/73, PR US 12/23/70
ENTRY YEAR 1975
INDEX TERMS ADDITIVE; CALCIUM CHLORIDE; CATION; CHANGE; CHEMICAL; CHLORIDE; *CIRCULATING; *CIRCULATING SYSTEM; CLAY SWELLING; *CLOSED SYSTEM; *COMPOSITION; COMPOUND; CONTAMINATION; CONTROL; CUTTINGS REMOVAL; CUTTINGS (ROCK); *DRILLING FLUID; DRILLING FLUID CONTROL; DRILLING FLUID HYDRAULICS; *DRILLING FLUID SYSTEM; DRILLING (WELL); ELECTROLYTE; ENGLISH; EXPANSION; FLOW PROPERTY; HYDRAULICS; HYDROXYETHYL CELLULOSE; INHIBITOR; INORGANIC; ION; *LOW SOLIDS MUD; *MUD COMPOSITION; MUD SEPARATOR; MUD VISCOSITY; ORGANIC; PATENT (A); PHYSICAL PROPERTY; PREVENTION; REMOVAL; ROCK SAMPLE; ROTARY DRILLING; SALT; SAMPLE; SCREEN; SEPARATION EQUIPMENT; SHALE SHAKER; SODIUM CHLORIDE; SURFACE ACTIVE AGENT; *SYSTEM (ASSEMBLAGE); VISCOSITY; WATER; WATER BASE MUD; (P) USA

ACCESSION NUMBER 200217
TITLE SILICATE FOAM STRUCTURES AND METHOD OF PREPARATION
AUTHORS HORAI J C; SHEELER C W JR
SOURCE U S 3,844,804, C 10/29/74, F 1/3/72; GAF CORP
ENTRY YEAR 1975
INDEX TERMS ACID; ALKALI METAL; *CEMENT; CHEMICAL; CHEMICAL REACTION; COMPOSITION; COMPOUND; CONCENTRATION; *CONSTRUCTION MATERIAL; *DENSITY; ENGLISH; *FOAM; FOAMING; FORMING; GAF CORP; HEATING; IN SITU; INORGANIC; *LIGHTWEIGHT CEMENT; *MECHANICAL PROPERTY; *MECHANICAL STRENGTH; *MIXTURE; MOLDING; PATENT (A); PHOSPHORIC ACID; *PHYSICAL PROPERTY; POTASSIUM SILICATE; SILICATE; SODIUM SILICATE; SOLUBILITY; TEMPERATURE; WATER SOLUBILITY; (P) USA

SURFACE TENSION; TABLE (DATA); TESTING; THIN FILM; *VELOCITY; VISCOSITY; WATER; *WAVE VELOCITY

ACCESSION NUMBER	197598
TITLE	EXTINGUISHING LIQUID HYDROCARBON FIRES
SOURCE	AUSTRAL 453,734, C 10/10/74, F 4/29/69, PR US 4/30/68; UNION CARBIDE CORP
ENTRY YEAR	1974
INDEX TERMS	ADDITIVE; CHANGE; *CHEMICAL; COMBUSTION; *COMPOUND; DECREASE; ENGLISH; *FILM; FIRE; *FIRE FIGHTING; FLAMMABILITY; FLUID; *FOAM; *FOAMING; FOAMING AGENT; *HYDROCARBON COMPOUND; LIQUID; *MIXTURE; PATENT (A); PHYSICAL PROPERTY; SAFETY; SILICONE; SOLUBILITY; SUPPLEMENTAL TECHNOLOGY; SURFACE ACTIVE AGENT; SURFACE PROPERTY; SURFACE TENSION; *THIN FILM; UNION CARBIDE CORP; WETTABILITY; (P) AUSTRALIA

ACCESSION NUMBER	197490
TITLE	METHOD OF PRODUCING AND USING A GELLED OIL BASE PACKER FLUID
AUTHORS	MONDSHINE T C
SOURCE	U S 3,831,678, C 8/27/74, F 5/2/73; N L INDUSTRIES INC
ENTRY YEAR	1974
INDEX TERMS	*ADDITIVE; ASBESTOS; CLAY; COMPOSITION; CONCENTRATION; *CONTROL; DATA; DEPOSIT (GEOLOGY); *DISPERSANT; DISPERSING; DRILLING FLUID; ENGLISH; FERROMAGNESIAN MINERAL; GEL; GELATION; *GELLING AGENT; HEAT; HEATING; IN SITU; MINERAL; MIXTURE; N L INDUSTRIES INC; OIL BASE MUD; *PACKER FLUID; PATENT (A); PHASE BEHAVIOR; PHASE CHANGE; PROCEDURE; SILICATE MINERAL; TABLE (DATA); TEMPERATURE; *TEMPERATURE CONTROL; VISCOUS OIL; WELL COMPL SERV + WORKOVER; WELL COMPLETION; *WELL SERVICING; WELL WORKOVER; (P) USA

ACCESSION NUMBER	197130
TITLE	DRILLING PROGRESS. PT. 1. EACH DRILLING FLUID HAS A SPECIFIC APPLICATION
AUTHORS	ANDERSON G W; HUTCHISON S O
SOURCE	WORLD OIL V 179, NO 5, PP 84-86, OCT 1974
ENTRY YEAR	1974
INDEX TERMS	ACIDITY/BASICITY; ADDITIVE; AIR; APPLICATION; CHART; *CLASSIFICATION; COMPOSITION; *CONTROL; COST; DATA; DENSITY; DIAGRAM;

ACCESSION NUMBER	195118
TITLE	AIR DRILLING MAY PLAY ROLE IN GROWING DEEP APPALACHIAN PLAY
SOURCE	OIL GAS J V 72, NO 38, PP 136-138, 9/23/74
ENTRY YEAR	1974
INDEX TERMS	ADDITIVE; *AIR DRILLING; APPALACHIAN BASIN; ARTIFICIAL LIFT; CARRYING CAPACITY; CASING SETTING; CASING STRING DESIGN; CEMENTING; CHART; COLUMNAR SECTION; COST; CUTTINGS REMOVAL; *DEEP DRILLING; DESIGN; DRILLING COST; DRILLING PROBLEM; DRILLING PROGRAM; DRILLING RIG; *DRILLING (WELL); DRILLING (WELL) (C); *ECONOMIC FACTOR; ENGINEERING; ENGLISH; *EXPLORATORY DRILLING; FLOW PROPERTY; FOAM; FOAM DRILLING; FOAM LIFTING; FOAMING AGENT; FORMATION DAMAGE; *GAS DRILLING; *GAS RESERVE; HOLE CAVING; HOLE DEVIATION; HOLE STABILIZATION; LAND AND LEASING; MIXTURE; MUD PROGRAM; NEWS; NORTH AMERICA; PHYSICAL PROPERTY; PIPE STICKING; PROGRAM; REMOVAL; *RESERVE; SALT BED; SHORTAGE; SLOUGHING SHALE; STABILIZATION; WATER ENTRY; WEST VIRGINIA

ACCESSION NUMBER	194948
TITLE	MATERIALS FOR LEAK-PROOFING NAVY OIL TANKERS (SUPPLEMENT)
AUTHORS	MATHEWS C W; VIND H P
SOURCE	U S NAVAL CIVIL ENG LAB REP NO NCEL-TN-1252-S, 11 PP, JULY 1973; AD-765,568/1
ENTRY YEAR	1974
INDEX TERMS	ADDITIVE; *CRUDE OIL; ENGLISH; *FLUID LOSS; FOAM; *FOAMED PLASTIC; FOAMING; FOAMING AGENT; *LEAK; MAINTENANCE; MARINE TRANSPORTATION; MIXTURE; *PETROLEUM; PIPELINING, SHIP + STORAGE; *PLASTIC; *POLYMER; PUMPING; REMOVAL; REPAIR; SEAL; *SEALING; *SHIP; STORAGE FACILITY; TANK; TANK BOTTOM; *TANKER; TRANSPORTATION; US NAVAL CIVIL ENG LAB; *VEHICLE

ACCESSION NUMBER	194476
TITLE	WATERFLOODING PROCESS
AUTHORS	JONES L W
SOURCE	U S 3,817,331, C 6/18/74, F 12/22/72; AMOCO PRODUCTION CO
ENTRY YEAR	1974
INDEX TERMS	*ADDITIVE; ALCOHOL; ALIPHATIC; AMOCO PRODUCTION CO; CHEMICAL; COMPOSITION; COMPOUND; CRUDE OIL; DATA; *EFFICIENCY; CEMENT COATED PIPE; CHART; COAL TAR; *COATING MATERIAL; *COATING PROCESS; *CONSTRUCTION; CONTROL; CORROSION CONTROL; CRUDE OIL; DEPTH; DIAGRAM; ENGLISH; *EXTERNAL COATING; FOAM; FOAMED PLASTIC; FOAMING; INDONESIA; INDONESIAN SEAS; *INSULATING MATERIAL; JAVA; JAVA SEA; LINE PIPE; MANUFACTURING; MECHANICAL JACK; MIXTURE; OFFSHORE; OFFSHORE EQUIPMENT; OIL AND GAS FIELDS; OIL FIELD; PETROLEUM; PIPE; PIPELAYING BARGE; *PIPELINE; *PIPELINE CONSTRUCTION; PIPELINING, SHIP + STORAGE; PIPING SYSTEM; PLASTIC; POLYMER; POLYURETHANE; PREFABRICATION; PROCEDURE; SEAS AND OCEANS; SHIP; SOLID HYDROCARBON; SOUTHEAST ASIA; SYSTEM (ASSEMBLAGE); TAR; *THERMAL INSULATION; TUBULAR GOODS; *UNDERWATER PIPELINE; VEHICLE; WATER DEPTH; WELDED PIPE; WELDING

ACCESSION NUMBER	187338
TITLE	CHEMICAL FOAMING AND SENSITIZING OF WATER-BEARING EXPLOSIVES WITH HYDROGEN PEROXIDE
AUTHORS	TOMIC E A
SOURCE	U S 3,790,415, C 2/5/74, F 8/18/70; DU PONT DE NEMOURS & CO
ENTRY YEAR	1974
INDEX TERMS	ACRYLAMIDE; ACRYLAMIDE COPOLYMER; ACRYLAMIDE HOMOPOLYMER; *ADDITIVE; AMMONIUM NITRATE; BLASTING; CHEMICAL; *COLLOIDAL DISPERSION; COMPOSITION; COMPOUND; CONCENTRATION; DATA; DU PONT DE NEMOURS & CO; ENGLISH; *EXPLOSIVE; *FOAM; FOAMING; *FOAMING AGENT; FUEL; FUEL OIL; GEL; GELLING AGENT; HEATING FUEL; HYDROGEN PEROXIDE; INORGANIC; *LIQUID EXPLOSIVE; *MIXTURE; NITRATE; ORGANIC; OXIDIZING AGENT; PATENT (A); PEROXIDE; POLYMER; PROCEDURE; SENSITIVITY; *SENSITIZER; TABLE (DATA); TEMPERATURE; THICKENER; WATER; WELL COMPL SERV + WORKOVER; (P) USA

ACCESSION NUMBER	187317
TITLE	LOST CIRCULATION CONTROL
AUTHORS	MESSENGER J U
SOURCE	U S 3,788,406, C 1/29/74, F 12/27/71; MOBIL OIL CORP
ENTRY YEAR	1974
INDEX TERMS	*ADDITIVE; *ASPHALT; BRIDGE PLUGGING; *BRIDGING MATERIAL; CHEMICAL; *COAL; COMPOSITION; COMPOUND; CONCENTRATION; DATA; DISPERSANT; DISPERSING; DRILLING FLUID;

ACCESSION NUMBER	185052
TITLE	CEMENT SPACER FLUID
AUTHORS	CARNEY L L
SOURCE	SPE OF AIME FORMATION DAMAGE MTG PREPRINT NO SPE-4784, PP 151-164, 1974
ENTRY YEAR	1974
INDEX TERMS	CEMENT; CEMENT SLURRY; *CEMENTING; CIRCULATING; COMPATIBILITY; *DISPLACEMENT; DRILLING FLUID; EMULSION; EMULSION MUD; ENGLISH; FIELD TESTING; *FLUSHING; FORMATION DAMAGE; HALLIBURTON SERVICES; MIXTURE; OIL BASE MUD; TESTING; WELL COMPL SERV + WORKOVER; WELL COMPLETION; *WELL COMPLETION FLUID

ACCESSION NUMBER	185006
TITLE	DRILLING FLUID FILTRATION UNDER SIMULATED DOWNHOLE CONDITIONS
AUTHORS	SIMPSON J P
SOURCE	SPE OF AIME FORMATION DAMAGE MTG PREPRINT NO SPE-4779, PP 103-116, 1974
ENTRY YEAR	1974
INDEX TERMS	CHANGE; CLAY SWELLING; COMPOSITION; DATA; *DRILLING FLUID; *DRILLING FLUID TESTING; DRILLING (WELL); DRILLING (WELL) (C); ENGLISH; EXPANSION; EXPERIMENTAL DATA; FILTRATE; *FILTRATION; FLUID LOSS; FLUID PROPERTY; *FORMATION DAMAGE; HIGH PRESSURE; HIGH TEMPERATURE; *INVADED ZONE; *LABORATORY EQUIPMENT; LABORATORY TESTING; MUD COMPOSITION; *MUD FILTER PRESS; MUD FILTRATE; MUD PROPERTY; OIL BASE MUD; PHYSICAL PROPERTY; *PHYSICAL SEPARATION; PRESSURE; PRODUCTIVITY; ROTARY DRILLING; TEMPERATURE; *TESTING; WATER BASE MUD

ACCESSION NUMBER	184559
TITLE	METHOD OF REMOVING LIQUIDS AND SMALL SOLIDS FROM WELL BORES
AUTHORS	GROVES W L JR
SOURCE	U S 3,773,110, C 11/20/73, F 8/14/72; CONTINENTAL OIL CO
ENTRY YEAR	1974
INDEX TERMS	ADDITIVE; *AIR DRILLING; ALKALI METAL; ANION; *ARTIFICIAL LIFT; CHEMICAL; CHEMICAL INJECTION; CLEANING; CONTINENTAL OIL CO; CONTROL; CUTTINGS REMOVAL; DRILLING FLUID; *DRILLING (WELL); DRILLING (WELL) (C); DRYING; ELEMENT (CHEMICAL); ENGLISH; *FOAM DRILLING; *FOAM LIFTING; FOAMING; FOAMING

*DETERIORATION; *DRILLING FLUID; DRILLING FLUID SYSTEM; DRILLING (WELL); ENGLISH; FLOW PROPERTY; GELATION; *HIGH TEMPERATURE; MILCHEM INC; MIXTURE; MUD ADDITIVE; MUD COMPOSITION; MUD SYSTEM; ORGANIC ACID; PATENT; PHASE BEHAVIOR; PHASE CHANGE; PHYSICAL PROPERTY; POLYMER; REMOVAL; ROTARY DRILLING; SALT; STABILITY; SYSTEM (ASSEMBLAGE); TEMPERATURE; THERMAL STABILITY; *THIXOTROPY; VISCOSITY; WATER BASE MUD; (P) USA

ACCESSION NUMBER 182258
TITLE FOAM FOR SECONDARY AND TERTIARY RECOVERY
AUTHORS GOGARTY W B
SOURCE U S 3,759,325, C 9/18/73, F 6/24/71; MARATHON OIL CO
ENTRY YEAR 1973
INDEX TERMS ADDITIVE; CHEMICAL INJECTION; CONTROL; EFFICIENCY; *EMULSION FLOODING; ENGLISH; FLOODING (FORMATION); FOAM; *FOAM FLOODING; FOAMING; FOAMING AGENT; IN SITU; INJECTION; MARATHON OIL CO; MICELLE; MISCIBLE DISPLACEMENT; MIXTURE; MOBILITY; MOBILITY RATIO; OIL RECOVERY; PARTICLE; PATENT; RECOVERY; RECOVERY MECHANISM; RESERVOIR ENG + REC METHOD; *SECONDARY RECOVERY; SOLUBLE OIL; SURFACE ACTIVE AGENT; SWEEP EFFICIENCY; *TERTIARY RECOVERY; *WATER DRIVE (MISCIBLE); WATERFLOOD CONTROL; (P) USA

ACCESSION NUMBER 182197
TITLE HERE'S HOW OIL MUDS PERFORM AT HIGH TEMPERATURES
AUTHORS BAUMANN R; METHVEN N E
SOURCE PETROL PETROCHEM INT V 13, NO 9, PP 54-56, 61, SEPT 1973
ENTRY YEAR 1973
INDEX TERMS CIRCULATING SYSTEM; CIRCULATING TEMPERATURE; CONTROL; CORROSION; CORROSION CONTROL; *DEEP DRILLING; DENSITY; DRILL PIPE CORROSION; DRILLING FLUID; *DRILLING FLUID HYDRAULICS; DRILLING FLUID SYSTEM; DRILLING (WELL); ENGLISH; FLOW PROPERTY; FLUID PROPERTY; FORCE; HIGH TEMPERATURE; HYDRAULICS; MECHANICAL PROPERTY; *MUD PROPERTY; MUD SYSTEM; MUD VISCOSITY; MUD WEIGHT; *OIL BASE MUD; PHYSICAL PROPERTY; RHEOLOGY; SHEAR; STABILITY; STRESS; SYSTEM (ASSEMBLAGE); TEMPERATURE; THERMAL STABILITY; VISCOSITY; YIELD POINT

ACCESSION NUMBER 172154
TITLE WEST TEXAS WORKOVERS WITH FOAM GAIN FAVOR
AUTHORS BLEAKLEY W B
SOURCE OIL GAS J V 71, NO 11, PP 97-98, 3/12/73
ENTRY YEAR 1973
INDEX TERMS ADDITIVE; ARTIFICIAL LIFT; CLEANING; DEEP PRODUCING; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; *FOAM DRILLING; *FOAM LIFTING; FOAMING; FOAMING AGENT; *FORMATION DAMAGE; GAS WELL; HOT WATER; LOSS; LOST CIRCULATION; *LOW PRESSURE; NEWS; PARAFFIN REMOVAL; PRESSURE; PRODUCING; REMOVAL; SAND REMOVAL; STABILIZATION; SUCCESS RATIO; WELL; WELL CLEANOUT; WELL COMPL SERV + WORKOVER; *WELL WORKOVER

ACCESSION NUMBER	171712
TITLE	CHEMICAL FOAMING OF WATER-BEARING EXPLOSIVES
AUTHORS	TOMIC E A
SOURCE	U S 3.711.345. C 1/16/73. F 8/18/70: DU PONT DE NEMOURS & CO
ENTRY YEAR	1973
INDEX TERMS	ADDITIVE: AMMONIUM NITRATE: BLASTING: BLENDING: BORCHYDRIDE: COLLOIDAL DISPERSION: COMPOSITION: DU PONT DE NEMOURS & CO: EMULSION: ENGLISH: *EXPLOSIVE: *FOAMING: *FOAMING AGENT: FUEL: FUEL OIL: GAS GENERATOR: GEL: GEOLOGY: GUAR GUM: HEATING FUEL: MIXING: MIXTURE: NATURAL RESIN: NITRATE: PATENT: *SENSITIZER: SLURRY: SODIUM BOROHYDRIDE: SUSPENSION: *THICKENER: WATER THICKENING: WATER TREATING: WELL COMPL SERV + WORKOVER: (P) USA

ACCESSION NUMBER	171668
TITLE	OIL PHASE DRILLING FLUID ADDITIVE. COMPOSITION AND PROCESS
AUTHORS	BROWNING W C: CHESSER B G: WOOD J L
SOURCE	U S 3.709.819. C 1/9/73. F 5/14/71: MILCHEM INC
ENTRY YEAR	1973
INDEX TERMS	ABSORBENT: ACRYLIC ACID COPOLYMER: ADDITIVE: ASPHALT: CIRCULATING SYSTEM: COMPOSITION: CONTROL: DEEP DRILLING: DEPOSIT FORMATION: *DRILLING FLUID: DRILLING FLUID SYSTEM: DRILLING (WELL): EMULSION: EMULSION MUD: ENGLISH: FILTER CAKE: FILTRATION: *FLUID LOSS ADDITIVE: GEOLOGY: HIGH PRESSURE: HIGH TEMPERATURE: *INVERTED EMULSION MUD: MILCHEM INC: MIXTURE: *MUD ADDITIVE: *MUD

ACCESSION NUMBER	167870
TITLE	AQUEOUS FOAMED WELL CIRCULATION FLUIDS CONTAINING A BASE COMPONENT AND THEIR USE IN THE TREATMENT OF WELLS
AUTHORS	ANDERSON G W: HUTCHISON S O: MCKINNELL J C
SOURCE	CAN 913.891. C 11/7/72. F 5/26/70. PR US 7/7/69: CHEVRON RESEARCH CO
ENTRY YEAR	1972
INDEX TERMS	ACID: *ACIDIZING: ADDITIVE: BASE (CHEMICAL): CHEMICAL: CHEVRON RESEARCH CO: *CIRCULATING SYSTEM: CLEANING: COMPOUND: ENGLISH: FOAM: FOAMING: FOAMING AGENT: MIXTURE: *NEUTRALIZER: PATENT: SYSTEM (ASSEMBLAGE): *WELL CLEANOUT· WELL COMPL SERV + WORKOVER: WELL COMPLETION: WELL COMPLETION FLUID: *WELL STIMULATION: (P) CANADA

ACCESSION NUMBER	167848
TITLE	COMPOSITIONS FOR CONTROLLING FOAM IN AQUEOUS SYSTEMS AND ITS METHOD OF USE
AUTHORS	LIEBERMAN H
SOURCE	U S 3.697.442. C 10/10/72. F 8/13/70: BETZ LABORATORIES INC
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE: ALKALINE EARTH METAL: ALUMINUM OXIDE: *ANTIFOAMING AGENT: BETZ LABORATORIES INC: CARRIER: CHEMICAL: DRILLING FLUID: DRILLING (WELL): EMULSION: ENGLISH: FATTY ACID: HYDROXIDE: LIPOPHILIC: MIXTURE: *MULTICOMPONENT MIXTURE: ORGANIC: PARTICLE: PATENT: PHYSICAL PROPERTY: ROTARY DRILLING: SILICA: *SURFACE ACTIVE AGENT: SURFACE PROPERTY: *WATER BASE MUD: WETTABILITY: (P) USA

ACCESSION NUMBER	167847
TITLE	DEFOAMER COMPOSITIONS CONTAINING ORGANIC PARTICLES
AUTHORS	LICHTMAN I A; WOODWARD F E
SOURCE	U S 3,697,440, C 10/10/72, F 6/27/69; DIAMOND SHAMROCK CORP
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; AMIDE; *ANTIFOAMING AGENT; CHEMICAL; COMPOUND; *DEFOAMING; DEGASSING; DIAMOND SHAMROCK CORP; DRILLING FLUID; DRILLING (WELL); ENGLISH; FOAM; HYDROCARBON COMPOUND; MIXTURE; MULTICOMPONENT MIXTURE; OIL SOLUBILITY; ORGANIC; *PARTICLE; PATENT; PHYSICAL PROPERTY; PHYSICAL SEPARATION; *POLYMER; ROTARY DRILLING; SILICONE; *SOLID; USA

ACCESSION NUMBER	166340
TITLE	REMOVING OIL FROM WATER
SOURCE	GR BRIT 1,291,649, C 10/4/72, F 2/20/70, PR US 3/6/69; TEXACO DEVELOPMENT CORP
ENTRY YEAR	1972
INDEX TERMS	ADSORBENT; ADSORPTION; CLEANING; *COALESCING; COMBUSTION; CONTAMINATION; CRUDE OIL; ENGLISH; FLOATING; FOAM; *FOAMED PLASTIC; FOAMING; MIXTURE; *OIL WASTE; PATENT; PETROLEUM; PHYSICAL SEPARATION; PLASTIC; POLYMER; *REMOVAL; SORBENT; SORPTION; *SPILL; STYRENE; SUPPLEMENTAL TECHNOLOGY; TEXACO DEVELOPMENT CORP; WATER POLLUTION; (P) GREAT BRITAIN

ACCESSION NUMBER	166023
TITLE	MICROSCOPIC BEHAVIOR OF FOAM IN POROUS MEDIA
AUTHORS	MAST R F
SOURCE	47TH ANNU SPE OF AIME FALL MTG PREPRINT NO SPE-3997, 12 PP, 1972
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; ANALYTICAL METHOD; BUBBLE; CHANGE; COMPOSITION; CONCENTRATION; DATA; DETERGENT; DRAINAGE; ENGLISH; EXPERIMENT; FLOODING (FORMATION); FLUID FLOW; FOAM; *FOAM FLOODING; FOAMING; FOAMING AGENT; *FORMATION PLUGGING; *GAS FLOW; INCREASE; INSTRUMENT; INTERFACE; *JAMIN EFFECT; LABORATORY DATA; MICROSCOPE; MICROSCOPY; MIXTURE; MODEL; MULTIPHASE FLOW; OPTICAL INSTRUMENT; PHASE BEHAVIOR; PHYSICAL PROPERTY; PLUGGING; POROUS MEDIA; RECOVERY; RESERVOIR ENG + REC METHOD; *RESERVOIR FLUID FLOW; STABILITY; SURFACE ACTIVE AGENT; TESTING; WELL PLUGGING

ACCESSION NUMBER	165985
TITLE	FACTORS AFFECTING FOAM CIRCULATION IN OIL WELLS
AUTHORS	BEYER A H; HASKIN C A; MILLHONE R S
SOURCE	47TH ANNU SPE OF AIME FALL MTG PREPRINT NO SPE-4001, 12 PP, 1972
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; CARRYING CAPACITY; CIRCULATING; CIRCULATING SYSTEM; CLEANING; COMPUTER; COMPUTER PROGRAMING; *CUTTINGS REMOVAL; DESIGN CRITERIA; DIGITAL COMPUTER; DRILLING (WELL); ENGLISH; FLOW PROPERTY;

FLUID FLOW; FOAM; *FOAM DRILLING; *FOAM LIFTING; FOAMING; FOAMING AGENT; INJECTION PRESSURE; MATHEMATICAL ANALYSIS; *MATHEMATICAL MODEL; MATHEMATICS; MIXTURE; MODEL; PARAMETER; PHYSICAL PROPERTY; PRESSURE; PROGRAMING; REMOVAL; SPECIFICATION; SURFACE ACTIVE AGENT; SYSTEM (ASSEMBLAGE); *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL COMPLETION; WELL PRESSURE; WELL WORKOVER

ACCESSION NUMBER	165984
TITLE	FLOW BEHAVIOR OF FOAM AS A WELL CIRCULATING FLUID
AUTHORS	BEYER A H; FOOTE R W; MILLHONE R S
SOURCE	47TH ANNU SPE OF AIME FALL MTG PREPRINT NO SPE-3986, 12 PP, 1972
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; CIRCULATING; *CIRCULATING SYSTEM; CLEANING; DRILLING (WELL); ENGLISH; EQUATION; *FIELD TESTING; FLOODING (FORMATION); FLUID FLOW; *FLUID FLOW EQUATION; FOAM; FOAM DRILLING; FOAM FLOODING; *FOAM LIFTING; FOAMING; FOAMING AGENT; LABORATORY SCALE; MATHEMATICAL MODEL; MATHEMATICS; MIXTURE; MODEL; MULTIPHASE FLOW; RECOVERY; REMOVAL; RHEOLOGY; SAND REMOVAL; *STEADY STATE FLOW; SURFACE ACTIVE AGENT; SYSTEM (ASSEMBLAGE); TESTING; VERTICAL FLOW; WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL WORKOVER

ACCESSION NUMBER	165983
TITLE	APPARATUS FOR FORMING FOAM FOR USE IN WELLS
AUTHORS	CAMPBELL A E
SOURCE	U S 3,685,807, C 8/22/72, F 12/3/69; CHEVRON RESEARCH CO
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; CHEMICAL INJECTION; CHEVRON RESEARCH CO; CIRCULATING; *CIRCULATING SYSTEM; COMPOSITION; DRILLING (WELL); ENGLISH; FLOODING (FORMATION); FLUID FLOW; *FOAM; FOAM DRILLING; FOAM FLOODING; FOAM LIFTING; *FOAMING; *FOAMING AGENT; GENERATOR; INJECTION; MIXER; MIXING; MIXTURE; PATENT; PHYSICAL PROPERTY; RECOVERY; SOLUTION; STABILITY; SYSTEM (ASSEMBLAGE); *TURBULENT FLOW; WELL COMPL SERV + WORKOVER; WELL STIMULATION; (P) USA

ACCESSION NUMBER	161366
TITLE	EXPLOSIVE-PROOF METHOD AND INCINERATOR FOR BURNING DRILL CUTTINGS
AUTHORS	GRIFFIN P III; PHILLIPS W C
SOURCE	U S 3,658,015, C 4/25/72, F 4/15/70; DRESSER INDUSTRIES INC
ENTRY YEAR	1972
INDEX TERMS	CHEMICAL; COMBUSTION; COMPOUND; CONTAMINATION; CRUDE OIL; *CUTTINGS (ROCK); DISPOSAL; DRESSER INDUSTRIES INC; DRILLING FLUID; DRILLING (WELL); EMULSION MUD; ENGLISH; EXPLOSION; *FIRE HAZARD; HAZARD; HYDROCARBON COMPOUND; OFFSHORE DRILLING; *OIL BASE MUD; PATENT; PETROLEUM; PREVENTION; REMOVAL; ROCK SAMPLE; ROTARY DRILLING; SAFETY EQUIPMENT; SAMPLE; SUBSURFACE; UNDERWATER; *WASTE DISPOSAL; *WATER POLLUTION; (P) USA

ACCESSION NUMBER 161201
TITLE DENSITY OF ADSORBED WATER AT PLASTIC LIMIT
AUTHORS DOHENY E J; FUNGAROLI A A
SOURCE J SOIL MECH FOUND DIV AMER SOC CIVIL ENG PROC V 98, NO SM5, PP 523-529, MAY 1972
ENTRY YEAR 1972
INDEX TERMS ACCURACY; *ADSORPTION; BLOCK DIAGRAM; CAPILLARITY; CAPILLARY PHENOMENON; CHART; CLAY MINERAL; COMPARISON; COMPOSITION; DATA; *DENSITY; DETERMINING; DIAGRAM; DRILLING FLUID; DRILLING (WELL); ENGLISH; EQUATION; EXPERIMENTAL DATA; *FLUID PROPERTY; GRAPH; LABORATORY TESTING; MATHEMATICS; MECHANICAL PROPERTY; MINERAL; MOISTURE; *MONTMORILLONITE; MUD PROPERTY; PHYSICAL PROPERTY; PLASTICITY; PRESSURE; SILICATE MINERAL; SOIL (EARTH); SORPTION; SURFACE PROPERTY; TEMPERATURE; TESTING; WATER; WATER BASE MUD; *WATER CONTENT

ACCESSION NUMBER 160833
TITLE STABLE FOAM USED AS A CIRCULATING MEDIA IN WELLWORK PROCESSES
AUTHORS POOL F M
SOURCE 19TH ANNU SW PETROL SHORT COURSE ASS MTG PROC PP 25-30, 1972
ENTRY YEAR 1972
INDEX TERMS ADDITIVE; ARTIFICIAL LIFT; *CIRCULATING; CLEANING; CONTROL; CORING; COST; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FISHING (WELL); FOAM; FOAM DRILLING; *FOAM LIFTING; FOAMING; FOAMING AGENT; FORMATION DAMAGE; GEOLOGIC STRUCTURE; HIGH PRESSURE; MIXTURE; OFFSHORE WELL; PERFORMANCE; PHYSICAL PROPERTY; POROSITY; POROSITY (ROCK); PRESSURE; PRODUCTIVITY INDEX; REMOVAL; RESERVOIR; SAFETY; SAND CONTROL; *SAND REMOVAL; STABILITY; STABILIZER (ADDITIVE); THIEF FORMATION; WELL; *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL COMPLETION; WELL PERFORMANCE; WELL SERVICING; WELL WORKOVER; *WORKOVER FLUID

ACCESSION NUMBER 160799
TITLE PRE-FORMED STABLE FOAM: THE NEW APPROACH TO BIG HOLE DRILLING AND SLIM-HOLE HIGH-PRESSURE CLEANOUTS
AUTHORS ANDERSON G W; HUTCHISON S O
SOURCE 19TH ANNU SW PETROL SHORT COURSE ASS MTG PROC PP 9-18, 1972
ENTRY YEAR 1972
INDEX TERMS ADDITIVE; ARTIFICIAL LIFT; BLOWOUT (WELL); CHART; CLEANING; CLIMATE; CONTAMINATION; COST; DATA; *DRILLING COST; *DRILLING FLUID; DRILLING RATE; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; *FOAM; *FOAM DRILLING; FOAM LIFTING; FORMATION DAMAGE; FORMATION (GEOLOGY); GRAPH; LARGE HOLE DRILLING; LOW PRESSURE; LUBRICATOR (WELL); METEOROLOGICAL PHENOMENON; MIXTURE; PERFORMANCE; PERMAFROST; PHYSICAL PROPERTY; PRESSURE; PRODUCTIVITY INDEX; RATE; SAFETY; SEAL; STABILITY; STABILIZER (ADDITIVE); STANDARD OIL CO CALIFORNIA; TABLE (DATA); WATER POLLUTION; WELL CLEANOUT; WELL COMPLETION; *WELL COMPLETION FLUID; WELL PERFORMANCE; WELL SERVICING; WELL WORKOVER; WORKOVER FLUID

ACCESSION NUMBER	160625
TITLE	PROCESS FOR MAINTAINING THERMAL CONDUCTIVITY OF INSULATION IN PERMAFROST COMPLETION
AUTHORS	BLOUNT E M
SOURCE	U S 3,642,065, C 2/15/72, F 7/23/70; MOBIL OIL CORP
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; *ANNULUS; ARCTIC AREA; CASING SETTING; CLIMATE; ENGLISH; FOAM; FOAMING; FOAMING AGENT; *GAS INJECTION; INJECTION; INSULATING MATERIAL; METEOROLOGICAL PHENOMENON; MIXTURE; MOBIL OIL CORP; PATENT; *PERMAFROST; PHYSICAL PROPERTY; SEAL; SEALING; *THERMAL CONDUCTIVITY; *THERMAL INSULATION; THERMAL PROPERTY; THERMODYNAMIC SITU; *INCOMPETENT BED; INJECTION; LOSS; *LOST CIRCULATION; MIXING; MIXTURE; PATENT; PLASTIC; PLUGGING; POLYMER; POLYMERIZATION; RESERVOIR; SAND CONSOLIDATION; SAND CONTROL; SETTING TIME; SLOUGHING SHALE; *THIEF FORMATION; TIME; WELL PLUGGING; (P) USA

ACCESSION NUMBER	158896
TITLE	STABILIZATION OF HARD SHALY FORMATIONS WITH ALKALI METAL SILICATE
AUTHORS	DARLEY H C H
SOURCE	U S 3,640,343, C 2/8/72, F 5/20/70; SHELL OIL CO
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; ADHESIVE; ALKALI METAL; BOND STRENGTH; CONTROL; DRILLING FLUID; DRILLING PROBLEM; DRILLING (WELL); ENGLISH; HOLE CAVING; *HOLE STABILIZATION; INCOMPETENT BED; MECHANICAL PROPERTY; MECHANICAL STRENGTH; PATENT; PHYSICAL PROPERTY; ROTARY DRILLING; *SHALE CONTROL; SHELL OIL CO; SILICATE; *SLOUGHING SHALE; STABILITY; STABILIZATION; *STABILIZER (ADDITIVE); *WATER BASE MUD; (P) USA

ACCESSION NUMBER	158573
TITLE	LIFTING FOAMING CRUDE BY A VARIABLE RPM SUBMERSIBLE PUMP
AUTHORS	DRAKE E L; VINCENT R P
SOURCE	CAN 893,526, C 2/22/72, F 2/27/70, PR US 4/17/69; AMOCO CANADA PETROLEUM CO SEE REL PAT ABSTR#144,652
ENTRY YEAR	1972
INDEX TERMS	AMOCO CANADA PETROLEUM CO; BORG WARNER CORP; ENGLISH; PATENT; (P) CANADA

ACCESSION NUMBER	158510
TITLE	THE EFFECT OF MINERAL OIL ON THE SURFACE PROPERTIES OF BINARY SURFACTANT SYSTEMS
AUTHORS	GODDARD E D; PRINCEN H M
SOURCE	J COLLOID INTERFACE SCI V 38, NO 2, PP 523-534, FEB 1972
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; ALCOHOL; CHEMICAL; COMPOUND; CRUDE OIL; DODECYL ALCOHOL; ELUTION; ENGLISH; EXTRACT; FILM; FOAM; FOAMING; *FOAMING AGENT; MIXTURE; PETROLEUM; PHYSICAL PROPERTY; PHYSICAL SEPARATION; RESERVOIR ENG + REC METHOD; SODIUM DODECYL SULFATE; STABILITY;

ACCESSION NUMBER 156949
TITLE WELL-CEMENTING METHOD USING A SPACER COMPOSITION
AUTHORS PARKER P N
SOURCE U S 3,625,286, C 12/7/71, F 6/1/70; ATLANTIC RICHFIELD CO
ENTRY YEAR 1972
INDEX TERMS ACID; ATLANTIC RICHFIELD CO; BORATE; CASING SETTING; CEMENT; *CEMENT SLURRY; *CEMENTING; CEMENTING EQUIPMENT; CHEMICAL; COMPOUND; DRILLING FLUID; EMULSION; ENGLISH; HALIDE; HYDROXIDE; MIXTURE; *OIL BASE MUD; ORGANIC ACID; PATENT; *SEPARATOR (PLUG); SULFATE; *WATER IN OIL EMULSION; WELL COMPL SERV + WORKOVER; WELL COMPLETION FLUID; (P) USA

ACCESSION NUMBER 156929
TITLE CHARTS HELP FIND VOLUME, PRESSURE NEEDED FOR FOAM DRILLING
AUTHORS KRUG J A; MITCHELL B J
SOURCE OIL GAS J V 70, NO 6, PP 61-64, 2/7/72
ENTRY YEAR 1972
INDEX TERMS ADDITIVE; ARTIFICIAL LIFT; CHART; *CUTTINGS REMOVAL; DIFFERENTIAL EQUATION; DRILLING FLUID; DRILLING PROBLEM; DRILLING RATE; DRILLING (WELL); ENGLISH; EQUATION; FLUID; FLUID FLOW; FOAM; *FOAM DRILLING; *FOAM LIFTING; FOAMING; FOAMING AGENT; GRAPH; HOLE CAVING; *INCOMPETENT BED; MATHEMATICAL ANALYSIS; MATHEMATICAL MODEL; MATHEMATICS; MIXTURE; MODEL; NEWTONIAN FLUID; NONNEWTONIAN FLUID; NUMERICAL ANALYSIS; PHYSICAL PROPERTY; PRESSURE; RATE; REMOVAL; *SLOUGHING SHALE; STABILITY; SUBSURFACE PRESSURE; WELL PRESSURE; WELL SERVICING; WELL WORKOVER; WORKOVER FLUID

ACCESSION NUMBER 156791
TITLE WATER CLARIFIER AND SEPARATOR
AUTHORS WATERMAN L C
SOURCE U S 3,623,608, C 11/30/71, F 2/20/70, PR US 10/31/68
ENTRY YEAR 1972
INDEX TERMS *CRUDE DESALTING; DRYING; ENGLISH; FLOATING; FOAMING; GAS INJECTION; INJECTION; LEASE EQUIPMENT; *MECHANICAL DEHYDRATION; OIL PRODUCING; OIL TREATING (FIELD); *OIL WATER SEPARATION; *OIL WATER SEPARATOR; PATENT; PHYSICAL SEPARATION; PRODUCING; PRODUCING OIL + GAS; SEPARATION EQUIPMENT; WASTE MATERIAL;

METHOD; ROCK; SANDSTONE; SEDIMENTARY ROCK; *SEPARATION EQUIPMENT; *TAR SAND; *TAR SAND OIL; *TAR SAND OIL RECOVERY; VISCOUS OIL RECOVERY; WATER; (P) CANADA

ACCESSION NUMBER 156477
TITLE METHOD OF GAS DRILLING
AUTHORS MUCKLEROY J A
SOURCE CAN 890,822, C 1/18/72, F 8/1/58, PR US 5/8/58; AMOCO CANADA PETROLEUM CO
ENTRY YEAR 1972
INDEX TERMS ADDITIVE; AMOCO CANADA PETROLEUM CO; ARTIFICIAL LIFT; CHEMICAL INJECTION; CIRCULATING; *CUTTINGS REMOVAL; DRILLING RATE; DRILLING (WELL); ENGLISH; *FOAM

DRILLING; *FOAM LIFTING; FOAMING; *FOAMING AGENT; GAS DRILLING; IMPROVEMENT; INJECTION; MIXING; PATENT; RATE; REMOVAL; *WATER ENTRY; (P) CANADA

ACCESSION NUMBER	156365
TITLE	RECOVERY OF BITUMEN FROM TAR SAND
AUTHORS	CLARK L
SOURCE	CAN 889,284, C 12/28/71, F 1/22/68; CITIES SERV ATHABASCA INC, ATLANTIC RICHFIELD CO, IMPERIAL OIL
ENTRY YEAR	1972
INDEX TERMS	AERATION; ATLANTIC RICHFIELD CO; *BITUMINOUS DEPOSIT; BITUMINOUS SANDSTONE; CITIES SERV ATHABASCA INC; CRUDE OIL; DEASPHALTING; DEPOSIT (GEOLOGY); ENGLISH; FOAM; FOAMING; IMPERIAL OIL LTD; MIXING; MIXTURE; OIL RECOVERY; PATENT; PETROLEUM; PHYSICAL SEPARATION; RECOVERY; REMOVAL; RESERVOIR ENG + REC METHOD; ROCK; ROYALITE OIL CO LTD; SANDSTONE; SEDIMENTARY ROCK; SOLID; *TAR SAND; *TAR SAND OIL; *TAR SAND OIL RECOVERY; (P) CANADA

ACCESSION NUMBER	155731
TITLE	METHOD FOR DRILLING IN PERMAFROST
AUTHORS	BONE L; ELLARD J D
SOURCE	U S 3,618,680, C 11/9/71, F 5/15/70; ATLANTIC RICHFIELD CO
ENTRY YEAR	1972
INDEX TERMS	ADDITIVE; *ARCTIC DRILLING; ASBESTOS; ATLANTIC RICHFIELD CO; CLIMATE; CONTROL; *DRILLING FLUID; DRILLING (WELL); *EMULSION MUD; ENGLISH; FERROMAGNESIAN MINERAL; ENGLISH; EXPANSION; FILTRATE; FLUID FLOW; FLUID LOSS; FLUID PROPERTY; FORMATION DAMAGE; GAS FLOW; GAS RESERVOIR; GAS WELL; *GAS WELL CAPACITY; GEOLOGIC STRUCTURE; *INVADED ZONE; INVERTED EMULSION MUD; MUD FILTRATE; MUD PROGRAM; MUD PROPERTY; PERFORMANCE; PERMEABILITY; PERMEABILITY (ROCK); PHASE BEHAVIOR; PHASE DIAGRAM; PHYSICAL PROPERTY; PRODUCING CAPACITY; PRODUCTIVITY; PROGRAM; RELATIVE PERMEABILITY; RESERVOIR; RESERVOIR FLUID FLOW; ROCK PROPERTY; WATER BASE MUD; *WATER BLOCK; WELL; *WELL PERFORMANCE

ACCESSION NUMBER	152479
TITLE	APPLICATIONS OF STABLE FOAM IN CANADA
AUTHORS	CHRISTENSEN R J; CONNON R K; MILLHONE R S
SOURCE	OILWEEK V 22, NO 31, PP 30, 32-35, 67, 9/20/71
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; CANADA; CHEVRON STANDARD LTD; CLIMATE; DENSITY; DISPOSAL; *DRILLING FLUID; DRILLING PROBLEM; DRILLING (WELL); ENGLISH; FLUID FLOW; FLUID PROPERTY; FLUID VELOCITY; FOAM; *FOAM DRILLING; *FOAM LIFTING; FOAMING; FOAMING AGENT; *FORMATION DAMAGE; HOLE CAVING; HUSKY ~~OIL CANADA LTD;~~ *LOW PRESSURE; METEOROLOGICAL PHENOMENON; MIXTURE; NEWS; PERFORMANCE; PERMAFROST; PHYSICAL PROPERTY; PRESSURE; RESERVOIR PRESSURE; STABILITY; SURFACE ACTIVE AGENT; VELOCITY; WASTE DISPOSAL; WELL WORKOVER

ACCESSION NUMBER	152473
TITLE	DEEP MISSISSIPPI DRILLING PRACTICES
AUTHORS	KIRK W L
SOURCE	46TH ANNU SPE OF AIME FALL MTG PREPRINT NO SPE-3510, 12 PP, 1971
ENTRY YEAR	1971
INDEX TERMS	ANTICLINE; BASIN; BIT PERFORMANCE; BIT TYPE; BIT (ROCK); BLOWOUT PREVENTER; CASING SETTING; *CASING STRING DESIGN; CEMENT; *CEMENTING; CONTROL EQUIPMENT; CORROSION; *DEEP DRILLING; DEEP WELL; DESIGN; DIAMOND BIT; DOME; DRILL STEM; DRILLING EQUIPMENT; DRILLING FLUID; DRILLING PROGRAM; DRILLING (WELL); EARTH AGE; ENGINEERING; ENGLISH; FOLD (GEOLOGY); GAS WELL; GEOLOGIC STRUCTURE; GEOLOGY; HIGH PRESSURE; HYDROGEN SULFIDE CORROSION; JURASSIC; MESOZOIC; MISSISSIPPI; MISSISSIPPI SALT BASIN; *MUD PROGRAM; NATURAL GAS; OIL BASE MUD; PERFORMANCE; PETROLEUM; PRESSURE; PRESSURE CONTROLLER; PROGRAM;

ACCESSION NUMBER	151385
TITLE	STABLE FOAM CIRCULATION CUTS SURFACE HOLE COSTS
AUTHORS	ANDERSON G W
SOURCE	WORLD OIL V 173, NO 4, PP 39-42, SEPT 1971
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; *ARCTIC DRILLING; ARTIFICIAL LIFT; CANADA; CASE HISTORY; CASING (WELL); CAVITATION; CHART; CLIMATE; COST; DATA; *DRILLING COST; DRILLING FLUID; *DRILLING RATE; DRILLING (WELL); EAGLE PLAIN AREA; ECONOMIC FACTOR; ENGLISH; EXPLORATORY DRILLING; FLUID FLOW; FOAM; *FOAM DRILLING; *FOAM LIFTING; FOAMING AGENT; GRAPH; METEOROLOGICAL PHENOMENON; MIXTURE; NEWS; PERMAFROST; RATE; SHALLOW WELL; STANDARD OIL CO CALIFORNIA; SURFACE CASING; TABLE (DATA); TUBULAR GOODS; WELL; YUKON

ACCESSION NUMBER	151376
TITLE	NEAR-GAUGE HOLES THROUGH PERMAFROST
AUTHORS	ANDERSON G W
SOURCE	OIL GAS J V 69, NO 38, PP 128, 130, 132, 134, 136, 139, 141-142, 9/20/71
ENTRY YEAR	1971
INDEX TERMS	*ARCTIC DRILLING; BIT DIAMETER; BIT TYPE; *BIT WEAR; BIT (ROCK); CANADA; CASING SETTING; CASING (WELL); COMPARISON; COST; DIAMETER; *DRILLING COST; DRILLING EQUIPMENT; DRILLING FLUID; *DRILLING RATE; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FOAM; *FOAM DRILLING; HOLE DIAMETER (WELL); MIXTURE; NEWS; PHYSICAL PROPERTY; RATE; STABILITY; STABILIZATION; STANDARD OIL CO CALIFORNIA; SURFACE CASING; TUBULAR GOODS; WATER BASE MUD; WEAR; YUKON

ACCESSION NUMBER	151210
TITLE	APPARATUS FOR MAKING PREFORMED FOAM FOR USE IN WELLS
AUTHORS	HUTCHISON S O
SOURCE	U S 3,593,800, C 7/20/71, F 8/25/69; CHEVRON RESEARCH CO
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; CHEVRON RESEARCH CO; CIRCULATING; CLEANING; ENGLISH; FOAM;

FOAM LIFTING; FOAMING; *FOAMING AGENT; GENERATOR; MIXTURE; PATENT; *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL COMPLETION; WELL COMPLETION FLUID; WELL WORKOVER; *WORKOVER FLUID; (P) USA

ACCESSION NUMBER	151168
TITLE	WELL DRILLING METHOD USING DECANOL IN PLACE OF OIL IN AQUEOUS DRILLING FLUIDS
AUTHORS	ESTES J C; PARK A
SOURCE	U S 3,594,317, C 7/20/71, F 11/12/69; PAN AMERICAN PETR CORP
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; ALCOHOL; CHEMICAL; CLAY MUD; COMPOSITION; COMPOUND; DECYL ALCOHOL; DRILLING FLUID; DRILLING (WELL); ENGLISH; FLOW PROPERTY; FLUID PROPERTY; FRICTION; *MUD ADDITIVE; *MUD COMPOSITION; MUD PROPERTY; MUD VISCOSITY; OIL BASE MUD; PAN AMERICAN PETR CORP; PATENT; PHYSICAL PROPERTY; PIPE STICKING; ROTARY DRILLING; SKIN FRICTION; VISCOSITY; *WATER BASE MUD; (P) USA

ACCESSION NUMBER	150950
TITLE	FOAMING AGENT CONCENTRATE
SOURCE	GR BRIT 1,248,358, C 9/29/71, F 4/7/70, PR US 4/7/69; CHEVRON RESEARCH CO SEE REL PAT ABSTR # 144,600
ENTRY YEAR	1971
INDEX TERMS	CHEVRON RESEARCH CO; ENGLISH; PATENT; (P) GREAT BRITAIN

ACCESSION NUMBER	150648
TITLE	TEST DATA FILL THEORY GAP ON USING FOAM AS A DRILLING FLUID
AUTHORS	MITCHELL B J
SOURCE	OIL GAS J V 69, NO 36, PP 96-100, 9/6/71
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; BUBBLE; BUBBLE FLOW; CHART; CUTTINGS REMOVAL; DATA; *DRILLING FLUID; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; EXPERIMENTAL DATA; FILM; FLOW PROPERTY; FLUID FLOW; *FOAM; *FOAM DRILLING; FOAM LIFTING; FOAMING AGENT; GRAPH; *HYDRODYNAMIC THEORY; INTERFACE; LAMINAR FLOW; MATHEMATICAL ANALYSIS; MATHEMATICS; MIXTURE; PERFORMANCE; PHYSICAL PROPERTY; QUALITY; REMOVAL; RHEOLOGY; STATISTICAL ANALYSIS; *SUCCESS RATIO; SURFACE ACTIVE AGENT; TABLE (DATA); THEORY; THIN FILM; VISCOSITY

BEHAVIOR; PHYSICAL PROPERTY; *POROUS MEDIA; PRESSURE GRADIENT; RECOVERY; *RELATIVE PERMEABILITY; RESERVOIR ENG + REC METHOD; *RESERVOIR FLUID FLOW; STABILIZATION; STABILIZER (ADDITIVE); STEADY STATE FLOW; SURFACE; *SURFACE ACTIVE AGENT; SURFACE PROPERTY; SURFACE TENSION; THESIS; UNSTEADY STATE FLOW

ACCESSION NUMBER	150002
TITLE	FOAM AIDS DRILLING IN IRAN'S ZAGROS MOUNTAIN AREA
AUTHORS	GARAVINI O; RADENTI G; SALA A
SOURCE	OIL GAS J V 69, NO 33, PP 82-84, 89-90, 8/16/71
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; COMPARISON; COMPOSITION; CORROSION; COST; DRILL PIPE CORROSION; DRILLING FLUID; DRILLING PROBLEM; *DRILLING RATE; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FOAM; *FOAM DRILLING; FOAMING; FOAMING AGENT; HAZARD; *HOLE CAVING; *HOLE STABILIZATION; HYDROGEN SULFIDE; IRAN; LOSS; *LOST CIRCULATION; MIXTURE; NEWS; PERSONNEL; RATE; STABILIZATION; SULFIDE; ZAGROS MT

ACCESSION NUMBER	149795
TITLE	GAS-LIQUID SCRUBBING TOWER
AUTHORS	HARDISON L C
SOURCE	U S 3,585,786, C 6/22/71, F 8/12/68; UNIVERSAL OIL PRODUCTS CO
ENTRY YEAR	1971
INDEX TERMS	ABSORBER; ABSORPTION; ABSORPTION PROCESS; CLEANING; COLUMN; ENGLISH; FLUID; FOAMING; *GAS DEHYDRATION; *GAS PROCESSING; INHIBITION; LIQUID; *MASS TRANSFER; PATENT; PHYSICAL SEPARATION; *PRODUCING EQUIPMENT; PRODUCING OIL + GAS; *PURIFYING; REMOVAL; SEPARATION EQUIPMENT; SOLID; SORPTION; SORPTION PROCESS; UNIVERSAL OIL PRODUCTS CO; (P) USA

FORMATION DAMAGE; *FORMATION EVALUATION; FRACTURED RESERVOIR; GEOLOGIC STRUCTURE; INTERPRETATION; *INVADED ZONE; MUD ADDITIVE; MUD FILTRATE; NEUTRON CAPTURE; *NEUTRON LOGGING; NUCLEAR LOGGING; NUCLEAR REACTION; PERMEABILITY; *PERMEABILITY (ROCK); PHYSICAL PROPERTY; POROSITY; POROSITY (ROCK); PRODUCING CAPACITY; RESERVOIR; RESERVOIR CHARACTERISTIC; RESERVOIR FLUID; ROCK PROPERTY; SALT CONTENT; SALT WATER MUD; SATURATION; SONIC LOGGING; VUGGY POROSITY; WATER BASE MUD; WATER SATURATION; *WELL LOG INTERPRETATION; WELL LOGGING; WELL LOGGING + SURVEYING

ACCESSION NUMBER	145919
TITLE	THE RHEOLOGY OF FOAM
AUTHORS	MARSDEN S S JR
SOURCE	14TH ANNU ACS PETROL RES FUND REP RES P 92, 1970
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; BUBBLE; COMPRESSIBILITY; ENGLISH; FLOODING (FORMATION); FLOW PROPERTY; FLUID; FLUID FLOW; *FLUID PROPERTY; *FOAM; FOAM FLOODING; FOAMING; FOAMING AGENT; GEL STRENGTH; MATHEMATICAL ANALYSIS; MATHEMATICS; MECHANICAL PROPERTY; MIXTURE; MULTIPHASE FLOW; NONNEWTONIAN FLUID; PARTICLE SIZE; PHYSICAL PROPERTY; POROUS MEDIA; RECOVERY; RESERVOIR ENG + REC METHOD; RESERVOIR FLUID FLOW; *RHEOLOGY; SLIP VELOCITY; TUBE; TUBULAR GOODS; VELOCITY; VISCOSITY

ACCESSION NUMBER 145918
TITLE THE RHEOLOGY OF FOAM
AUTHORS MARSDEN S S JR
SOURCE 13TH ANNU ACS PETROL RES FUND REP RES P 92. 1969
ENTRY YEAR 1971
INDEX TERMS BUBBLE; BUSINESS OPERATION; COMPRESSIBILITY; DISTRIBUTION; EMULSION; EMULSION FLOODING; ENGLISH; EXPERIMENT; FLOODING (FORMATION); FLOW PROPERTY; FLUID; FLUID FLOW; *FLUID PROPERTY; *FOAM; FOAM FLOODING; FOAMING; GEL STRENGTH; MATHEMATICAL ANALYSIS; MATHEMATICS; MECHANICAL PROPERTY; MIXTURE; NONNEWTONIAN FLUID; PARTICLE SIZE; PHYSICAL PROPERTY; POROUS MEDIA; RECOVERY; RESEARCH; RESERVOIR ENG + REC METHOD; RESERVOIR FLUID FLOW; *RHEOLOGY; SLIP VELOCITY; STABILITY; TESTING; TUBE; TUBULAR GOODS; VELOCITY; VISCOSITY

ACCESSION NUMBER 145845
TITLE USES OF AIR & GAS IN ROTARY DRILLING
AUTHORS PUGH J B
SOURCE CAN PETROL V 12, NO 4, PP 22-23, APRIL 1971
ENTRY YEAR 1971
INDEX TERMS ADDITIVE; AERATED MUD; *AIR DRILLING; ARTIFICIAL LIFT; BIT LIFE; BUSINESS OPERATION; CANADA; CASING SETTING; CASING STRING DESIGN; CEMENTING; CONTROL; CORROSION CONTROL; CORROSION INHIBITOR; COST; DESIGN; *DRILLING COST; DRILLING FLUID; DRILLING PROBLEM; DRILLING RATE; DRILLING (WELL); ECONOMIC FACTOR; ENGINEERING; ENGLISH; EVALUATION; *FOAM LIFTING; FOAMING AGENT; FORMATION DAMAGE; FORMATION EVALUATION; *GAS DRILLING; INHIBITOR; LIFE SPAN; *MIST DRILLING; RATE; ROTARY DRILLING; USA; WELL COMPLETION COST

ACCESSION NUMBER 145524
TITLE ATTAPULGITE CLAYS FOR FUTURE INDUSTRIAL MINERAL MARKETS
AUTHORS HAAS C Y
SOURCE CENTEN ANNU SME OF AIME MTG PREPRINT NO 71-H-54, 14 PP, 1971
ENTRY YEAR 1971
INDEX TERMS ADDITIVE; AREA; *ATTAPULGITE; CLAY MINERAL; *CLAY MUD; *COLLOIDAL DISPERSION; COMPOSITION; CRYSTALLIZATION; DRILLING FLUID; DRILLING (WELL); ENGLISH; FLOW PROPERTY; GELLING AGENT; MINERAL; MIXTURE; MUD SALINITY; MUD VISCOSITY; PHASE BEHAVIOR; PHASE CHANGE; PHYSICAL PROPERTY; ROTARY DRILLING; SALT CONTENT; *SALT WATER MUD; SILICATE MINERAL; SOLIDIFICATION; STABILITY; SURFACE AREA; THICKENER; THIXOTROPY; VISCOSITY; WATER BASE MUD; WELL WORKOVER; *WORKOVER FLUID

ACCESSION NUMBER 144940
TITLE OIL WELL DRILLING AND TREATING FLUIDS
AUTHORS BETTY R J; MARSH B E; MARSH F S
SOURCE CAN 868,817, C 4/20/71, F 6/20/68, PR US 6/30/67; ARMOUR INDUSTRIAL CHEM CO
ENTRY YEAR 1971
INDEX TERMS ADDITIVE; AMINE; ARMOUR INDUSTRIAL CHEM CO; CHEMICAL; CHEMICAL REACTION; COMPOUND; *DRILLING FLUID; DRILLING (WELL); ENGLISH; *FRACTURING FLUID; GELLING AGENT; *HYDROCARBON COMPOUND; ISOCYANATE RESIN; *OIL

ACCESSION NUMBER	144099
TITLE	EFFECT OF ORGANIC ADDITIVES ON IMPREGNATED DIAMOND DRILLING
AUTHORS	SCHULTZ C W; SELIM A A; STREBIG K C
SOURCE	U S BUR MINES REP INVEST NO 7494, 35 PP. MARCH 1971
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; BIT COST; BIT LIFE; *BIT PERFORMANCE; BIT WEAR; BIT WEIGHT; BIT (ROCK); BUSINESS OPERATION; CHEMICAL; COMPARISON TEST; COMPOSITION; COST; DATA; *DIAMOND BIT; *DIAMOND DRILLING; DRILL STEM TORQUE; DRILLING COST; DRILLING FLUID; DRILLING RATE; *DRILLING RESEARCH; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; ETHYLENE GLYCOL; EXPERIMENTAL DATA; FORCE; FRICTION; GLYCEROL; GLYCOL; INSTRUMENTATION; LABORATORY EQUIPMENT; LABORATORY SCALE; LIFE SPAN; MATHEMATICAL ANALYSIS; MATHEMATICS; MINERAL; *MUD ADDITIVE; MUD COMPOSITION; ORGANIC; OXIDE MINERAL; PERFORMANCE; QUARTZ; RATE; RESEARCH; ROTARY DRILLING; ROTARY SPEED; STATISTICAL ANALYSIS; STRESS; SURFACE ACTIVE AGENT; TESTING; TORQUE; WATER; WATER BASE MUD; WEAR; WEIGHT

ACCESSION NUMBER	144092
TITLE	USES OF AIR & GAS IN ROTARY DRILLING
AUTHORS	PUGH J E
SOURCE	9TH ANNU ONTARIO PETROL INST INC CONF PROC PAPER NO 10, 6 PP, 1970
ENTRY YEAR	1971
INDEX TERMS	AERATED MUD; *AIR DRILLING; ARCTIC DRILLING; BIT LIFE; CLIMATE; CORROSION; COST; DRILL PIPE CORROSION; DRILLING COST; DRILLING FLUID; DRILLING IN; DRILLING PROGRAM; DRILLING RATE; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; *FOAM DRILLING; FORMATION DAMAGE; *GAS DRILLING; HYDROSTATIC PRESSURE; LIFE SPAN; LOSS; LOST CIRCULATION; METEOROLOGICAL PHENOMENON; *MIST DRILLING; PERMAFROST; PERMAFROST ZONE; PLUGGING; PRESSURE; PROGRAM; RATE; *ROTARY DRILLING; WATER ENTRY; WATER SHUTOFF; WELL COMPLETION COST; WELL PLUGGING

ACCESSION NUMBER	141975
TITLE	DRILLING FLUID ADDITIVES
AUTHORS	STRATTON C A
SOURCE	U S 3,558,487, C 1/26/71, F 12/31/63; PHILLIPS PETROLEUM CO
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; COMPOSITION; DRILLING FLUID; DRILLING (WELL); ENGLISH; FLOW PROPERTY; FLUID PROPERTY; MUD ADDITIVE; MUD COMPOSITION; MUD PROPERTY; MUD PUMPABILITY; *MUD THINNER; *MUD VISCOSITY; NAPHTHOL; PATENT; PHENOL; PHILLIPS PETROLEUM CO; PHYSICAL PROPERTY; PUMPABILITY; QUINONE; RHEOLOGY; SULFONATE; VISCOSITY; *WATER BASE MUD; (P) UNITED STATES

ACCESSION NUMBER	141363
TITLE	VISCOSITY OF FOAM
AUTHORS	MITCHELL B J
SOURCE	OKLAHOMA UNIV PHD THESIS, 155 PP, 1970
ENTRY YEAR	1971
INDEX TERMS	ARTIFICIAL LIFT; CHART; *CUTTINGS REMOVAL; DRILLING (WELL); ENGLISH; FLOW PROPERTY; FOAM; *FOAM DRILLING; *FOAM LIFTING; FOAMING; FORCE; MIXTURE; PHYSICAL PROPERTY; REMOVAL; SHEAR; STRESS; *SURFACE ACTIVITY; SURFACE PROPERTY; THESIS; *VISCOSITY

ACCESSION NUMBER	141097
TITLE	RECOVERY OF HEAVY METALS FROM BITUMINOUS SANDS
AUTHORS	BOWMAN C W
SOURCE	CAN 861,580, C 1/19/71, F 10/7/68, PR US 12/27/67; CITIES SERV ATHABASCA INC, IMPERIAL OIL LTD,
ENTRY YEAR	1971
INDEX TERMS	ATLANTIC RICHFIELD CO; *BITUMINOUS DEPOSIT; BITUMINOUS SANDSTONE; CITIES SERV ATHABASCA INC; DEPOSIT (GEOLOGY); ENGLISH; *FLOTATION; FOAM; FOAMING; GRAVITATIONAL SEPARATION; *HEAVY MINERAL; IMPERIAL OIL LTD; METAL; MINERAL; MIXTURE; PATENT; PHYSICAL SEPARATION; *RECOVERY; REMOVAL; RESERVOIR ENG + REC METHOD; ROCK; ROYALITE OIL CO LTD; SANDSTONE; SEDIMENTARY ROCK; TAR SAND; (P) CANADA

ACCESSION NUMBER	140702
TITLE	SURFACE MUD SYSTEMS. PT. 2. UNWEIGHTED MUDS - ADDITIONS AND REMOVALS
AUTHORS	BOBO R
SOURCE	OIL GAS J V 69, NO 5, PP 78-81, 84-87, 2/1/71
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; BENTONITE; CARBOXYMETHYL CELLULOSE; CENTRIFUGE; *CIRCULATING EQUIPMENT; CIRCULATING SYSTEM; CLAY; COAL; COLLOIDAL DISPERSION; COMPOSITION; CYCLONE SEPARATOR; DENSITY; DEPOSIT (GEOLOGY); DRILLING FLUID; DRILLING FLUID SYSTEM; DRILLING RATE; DRILLING (WELL); ENGLISH; FILTER CAKE; FLOW PROPERTY; FLUID LOSS ADDITIVE; FLUID PROPERTY; GAS SEPARATOR; GEL STRENGTH; LIGNIN; LIGNITE; LIGNOSULFONATE; MIXTURE; *MUD ADDITIVE; MUD CENTRIFUGE; MUD COMPOSITION; MUD CYCLONE; MUD DEGASSER; MUD DESANDER; MUD DESANDING; MUD PIT; MUD PROPERTY; MUD SEPARATOR; *MUD SYSTEM; *MUD TREATING; MUD VISCOSITY; MUD WEIGHT; NATURAL RESIN; PHOSPHATE; PHYSICAL PROPERTY; PHYSICAL SEPARATION; QUEBRACHO; RATE; ROTARY DRILLING; SEPARATION EQUIPMENT; SHALE SHAKER; STARCH; STORAGE FACILITY; STORAGE PIT; SYSTEM (ASSEMBLAGE); VISCOSITY; *WATER BASE MUD; WATER CONTENT; WEIGHTING MATERIAL

ACCESSION NUMBER	140045
TITLE	PREFORMED STABILIZED FOAM
AUTHORS	HILLMAN M
SOURCE	DRILL BIT V 17, NO 10, PP 12-13, 16-17, JAN 1971
ENTRY YEAR	1971
INDEX TERMS	ADDITIVE; APPLICATION; ARTIFICIAL LIFT; CARRYING CAPACITY; *CIRCULATING; CLEANING;

COMPATIBILITY; COST; DENSITY; DRILLING FLUID; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FLOW PROPERTY; FLUID LOSS; FLUID PROPERTY; *FOAM; FOAM DRILLING; FOAM LIFTING; FOAMING AGENT; FORMATION DAMAGE; LOW FLUID LOSS; MIXTURE; PHYSICAL PROPERTY; STABILITY; VISCOSITY; WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL COMPLETION FLUID; *WELL WORKOVER; *WORKOVER FLUID
INTERPOLATION; MATHEMATICAL ANALYSIS; MATHEMATICS; METER; *MUD VISCOSITY; OIL BASE MUD; PHYSICAL PROPERTY; PROCEDURE; *REFERENCE DATUM; RHEOLOGY; TEMPERATURE; TEMPERATURE COMPENSATION; VISCOMETER; VISCOSITY; WATER BASE MUD

ACCESSION NUMBER	136200
TITLE	INCREASING FOAM STABILITY IN EARTH FORMATIONS
AUTHORS	DAUBEN D L; RAZA S H
SOURCE	U S 3,530,940, C 9/29/70, F 2/5/69, PAN AMERICAN PETR CORP
ENTRY YEAR	1970
INDEX TERMS	ADDITIVE; ENGLISH; FOAM; FOAMING; *FOAMING AGENT; MIXTURE; PAN AMERICAN PETR CORP; PATENT; PHYSICAL PROPERTY; PLUGGING; *PLUGGING AGENT; POLYMER; STABILITY; *STABILIZER (ADDITIVE); *TEMPORARY PLUGGING; VINYL ALCOHOL HOMOPOLYMER; WELL COMPL SERV + WORKOVER; WELL COMPLETION; WELL PLUGGING; WELL WORKOVER; (P) UNITED STATES; 2-PYRROLIDINONE

ACCESSION NUMBER	136165
TITLE	DRILLING FLUID
AUTHORS	KOLAIAN J H
SOURCE	U S 3,531,408, C 9/29/70, F 4/25/67, TEXACO INC
ENTRY YEAR	1970
INDEX TERMS	ADDITIVE; CARBOXYNAPHTHALENE, DIHYDR; CHEMICAL; COMPOUND; DERIVATIVE (CHEMICAL); *DISPERSANT; DISPERSING; DISULFONAPHTHALENE, NITROS; DRILLING FLUID; DRILLING (WELL); ENGLISH; FLOW PROPERTY; FLUID PROPERTY; GEL; GEL STRENGTH; MIXTURE; *MUD ADDITIVE; *MUD PROPERTY; MUD VISCOSITY; NAPHTHALENE; PATENT; PHYSICAL PROPERTY; RHEOLOGY; ROTARY DRILLING; SALT; TEXACO INC; THIXOTROPY; VISCOSITY; *WATER BASE MUD; (P) UNITED STATES

ACCESSION NUMBER	135709
TITLE	METHOD OF COATING TUBULAR OBJECTS WITH POLYURETHANE FOAM
AUTHORS	STEWART S A
SOURCE	GR BRIT 1,207,110, C 9/30/70, F 5/10/69, MARTIN SWEETS CO INC
ENTRY YEAR	1970
INDEX TERMS	CLEANING; COATING MATERIAL; *COATING PROCESS; ENGLISH; EXTERNAL COATING; FILM; FLUID; FOAM; DRIVE; GAS DRIVE; *GAS OIL CONTACT; GAS RESERVOIR; GEOLOGIC STRUCTURE; INJECTION; INTERFACE; MIXTURE; OIL RECOVERY; OIL RESERVOIR; PATENT; RECOVERY; RECOVERY MECHANISM; RESERVOIR; RESERVOIR ENG + REC METHOD; *SECONDARY RECOVERY; (P) CANADA

COMPOSITION; DRILLING FLUID; ENGLISH; GLASS; INITIAL STRENGTH; MECHANICAL PROPERTY; MECHANICAL STRENGTH; MUD ADDITIVE; PATENT; PHYSICAL PROPERTY; SETTING TIME; *SILICA CEMENT; TIME; *WATER BASE MUD; WELL COMPL SERV & WORKOVER; WELL COMPLETION; (P) USA

ACCESSION NUMBER	[illegible]
TITLE	WELL SERVICING METHODS UTILIZING A FOAMED HYDROPHOBIC LIQUID
AUTHORS	KELLY J JR; BLOUNT E M
SOURCE	U S 3,495,665, C 2/17/70, F 9/15/67, MOBIL OIL CORP
ENTRY YEAR	1970
INDEX TERMS	ADDITIVE; *AIR DRILLING; *DRILLING FLUID; DRILLING (WELL); ENGLISH; *FOAM; *FOAM DRILLING; FOAMING AGENT; *LIPOPHILIC; MIXTURE; MOBIL OIL CORP; OIL WETTABILITY; PATENT; PHYSICAL PROPERTY; SURFACE ACTIVE AGENT; SURFACE PROPERTY; WETTABILITY; (P) USA DEPTH; PLUGGING; PLUGGING AGENT; POLYMER; *SAND CONSOLIDATION; SAND CONTROL; SOLID HYDROCARBON; *SYNTHETIC RESIN; *TEMPORARY PLUGGING; WEIGHTING MATERIAL; WELL COMPL SERV & WORKOVER; WELL PLUGGING; (P) USA

ACCESSION NUMBER	123923
TITLE	A NEW WAY TO COMPUTE ANNULAR FRICTION LOSS
AUTHORS	KOTB A K
SOURCE	J PETROL TECHNOL V 22, PP 8-10, JAN 1970
ENTRY YEAR	1970
INDEX TERMS	*ANNULAR FLOW; CIRCULATING SYSTEM; COMPARISON; COMPUTER; DATA; DERIVATIVE (MATHEMATICS); DIGITAL COMPUTER; DRILLING FLUID; DRILLING FLUID SYSTEM; DRILLING (WELL); EMULSION MUD; ENGLISH; EQUATION; FLOW PROPERTY; FLUID; *FLUID FLOW; FRACTURING FLUID; *FRICTION LOSS (FLUID); FUNCTION (MATHEMATICS); GEL; INVERTED EMULSION MUD; LOSS; LOW SOLIDS MUD; *MATHEMATICAL MODEL; MATHEMATICS; MIXTURE; MODEL; MUD SYSTEM; *NONNEWTONIAN FLUID; OIL BASE MUD; PHYSICAL PROPERTY; SALT WATER MUD; SYSTEM (ASSEMBLAGE); TABLE (DATA); THIXOTROPY; WATER BASE MUD

ACCESSION NUMBER	123922
TITLE	AMMONIATED FOAMED WELL CIRCULATION FLUIDS AND USES THEREOF
AUTHORS	HUTCHISON S O, ANDERSON G W; MCKINNELL J C
SOURCE	U S 3,486,560, C 12/30/69, F 4/12/68, CHEVRON RESEARCH CO
ENTRY YEAR	1970
INDEX TERMS	ADDITIVE; AMMONIA; CARRYING CAPACITY; CHEVRON RESEARCH CO; CIRCULATING; CLEANING; CUTTINGS REMOVAL; *DRILLING FLUID; DRILLING (WELL); ENGLISH; FLOW PROPERTY; *FOAM; *FOAM DRILLING; FOAMING AGENT; GAS DRILLING; MIXTURE; PATENT; PHYSICAL PROPERTY; REMOVAL; WELL CLEANOUT; (P) USA

ACCESSION NUMBER 133988

TITLE FOAM WORKOVERS ARE ALSO SUCCESSFUL IN THE PERMIAN BASIN AREA

AUTHORS MICHEL C C

SOURCE WELL SERV V 10, NO 4, PP 17, 22, JULY-AUG 1970

ENTRY YEAR 1970

INDEX TERMS ARTIFICIAL LIFT; CHANGE; CHEVRON RESEARCH CO; CIRCULATING; CIRCULATING PRESSURE; CIRCULATING RATE; CLEANING; CONTRACT; CORING; CUTTINGS REMOVAL; DECREASE; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FOAM; FOAM DRILLING; FOAM LIFTING; FORMATION DAMAGE; LEGAL CONSIDERATION; MIXTURE; NEW MEXICO; NEWS; *OIL PRODUCING; PATENT; *PERMIAN BASIN; PRESSURE; PRESSURE DECLINE; PRODUCING; RATE; REMOVAL; SAND REMOVAL; *STRIPPER WELL; TEXAS; WELL; WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL PRESSURE; *WELL SERVICING; *WELL WORKOVER

ACCESSION NUMBER 133987

TITLE PREFORMED STABILIZED FOAM

AUTHORS HILLMAN M

SOURCE WELL SERV V 10, NO 4, PP 13, 15, 18-19, JULY-AUG 1970

ENTRY YEAR 1970

INDEX TERMS ADDITIVE; ARTIFICIAL LIFT; CEMENTING; CHEVRON RESEARCH CO; CIRCULATING PRESSURE; CIRCULATING RATE; CIRCULATING SYSTEM; CLEANING; CONTRACT; CONTROL; CORING; COST; CRUDE OIL; CUTTINGS REMOVAL; DENSITY; DRILLING (WELL); ECONOMIC FACTOR; EMULSIFICATION; ENGLISH; FLOW PROPERTY; FOAM; FOAM DRILLING; *FOAM LIFTING; FORMATION DAMAGE; INJECTION; LEGAL CONSIDERATION; LINER COMPLETION; LOW; MIXTURE; PATENT; PERFORMANCE; PETROLEUM; PHYSICAL PROPERTY; PIPE STICKING; PRESSURE; PRESSURE CONTROL; PRODUCTION RATE; RATE; REMOVAL; SAND REMOVAL; STABILITY; STABILIZATION; STABILIZER (ADDITIVE); STEAM INJECTION; SYSTEM (ASSEMBLAGE); TEMPERATURE; VISCOSITY; VISCOUS CRUDE OIL; *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL COMPLETION; WELL COMPLETION DRILLING FLUID SYSTEM; DRILLING (WELL); EMULSIFIER; ENGLISH; FLOCCULANT; FLOW PROPERTY; FLUID LOSS ADDITIVE; FOAMING AGENT; GAS DRILLING; INHIBITOR; ION EXCHANGE; LOST CIRCULATION ADDITIVE; *LOW SOLIDS MUD; LUBRICATION; MIST DRILLING; *MUD ADDITIVE; *MUD COMPOSITION; *MUD SYSTEM; MUD VISCOSITY; *OIL BASE MUD; PESTICIDE; PH; PHYSICAL PROPERTY; REVIEW OR SURVEY; ROTARY DRILLING; SHALE CONTROL; SURFACE ACTIVE AGENT; SYSTEM (ASSEMBLAGE); TABLE (DATA); VISCOSITY; *WATER BASE MUD; WEIGHTING MATERIAL

ACCESSION NUMBER 127194

TITLE METHOD AND COMPOSITION FOR CEMENTING OIL WELL CASING

AUTHORS WYANT R E; VAN DYKE O

SOURCE U S 3,499,491, C 3/10/70, F 6/28/68, DRESSER INDUSTRIES INC

ENTRY YEAR 1970

INDEX TERMS ADDITIVE; *CASING SETTING; CEMENT; CEMENT COMPOSITION; *CEMENT SLURRY; *CEMENTING;

ACCESSION NUMBER	123039
TITLE	STABLE FOAM PAYS CUT
AUTHORS	RINTOUL B
SOURCE	CALIF OIL WORLD V 62, NO 22, PP 1-4, 11/30/69
ENTRY YEAR	1970
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; *CASE HISTORY; CLEANING; DATA; DEFLECTOR; DIRECTIONAL DRILLING; DRILLING (WELL); ENGLISH; FOAM; *FOAM LIFTING; FOAMING AGENT; LINER COMPLETION; MIXTURE; NEWS; PHYSICAL PROPERTY; STABILITY; *WELL CLEANOUT; WELL COMPL SERV & WORKOVER; WELL COMPLETION; *WELL SERVICING; *WELL WORKOVER; WHIPSTOCK; WORKOVER FLUID

ACCESSION NUMBER	123037
TITLE	OIL-FIELD APPLICATION OF DETERGENTS
AUTHORS	HALLORAN T
SOURCE	KENTUCKY GEOL SURV SPEC PUBLICATION NO 15, SER 10, PP 103-104, 1968
ENTRY YEAR	1970
INDEX TERMS	ADDITIVE; AIR DRILLING; APPLICATION; ARTIFICIAL LIFT; CLEANING; DRILLING FLUID; DRILLING (WELL); DRYING; ENGLISH; FLUID; *FOAM DRILLING; FOAM LIFTING; *FOAMING AGENT; GAS WELL DEWATERING; LIQUID; PETROLEUM INDUSTRY; PHYSICAL PROPERTY; SOLUBILITY; *SURFACE ACTIVE AGENT; WATER SOLUBILITY; *WELL CLEANOUT; WELL COMPL SERV & WORKOVER

ACCESSION NUMBER	122751
TITLE	STABLE FOAM CUTS COSTS, INCREASES PRODUCTION
SOURCE	PETROL ENG V 41, NO 13, PP 61-63, DEC 1969
ENTRY YEAR	1970
INDEX TERMS	ACID; ADDITIVE; AIR; ANNULAR FLOW; ARTIFICIAL LIFT; BASE (CHEMICAL); BRINE; CARBON DIOXIDE; CARRYING CAPACITY; CEMENT; CHEMICAL; CHEVRON RESEARCH CO; CLEANING; COMPOUND; COST; CRUDE OIL; DENSITY; ECONOMIC FACTOR; ELEMENT (CHEMICAL); ENGLISH; EXHAUST GAS; FLOW PROPERTY; FLUID FLOW; *FOAM; *FOAM LIFTING; *FOAMING AGENT; IMPURITY; INERT GAS; IRON OXIDE; IRON SULFIDE, FES; MIXING; MIXTURE; NEWS; NITROGEN; PETROLEUM; PHYSICAL PROPERTY; SODIUM HYDROXIDE; STABILIZATION; STABILIZER (ADDITIVE); STANDARD OIL CO CALIFORNIA; SURFACE ACTIVE AGENT; VELOCITY; VISCOSITY; VISCOUS CRUDE OIL; WASTE MATERIAL; WATER; *WELL CLEANOUT; WELL COMPL SERV & WORKOVER; WELL SERVICING; WELL SERVICING COST; *WELL WORKOVER; WORKOVER FLUID

ACCESSION NUMBER	120959
TITLE	FOAM WORKOVERS CUT COSTS 50 PERCENT
AUTHORS	HUTCHISON S O
SOURCE	WORLD OIL V 169, NO 6, PP 73-74, NOV 1969
ENTRY YEAR	1969
INDEX TERMS	ADDITIVE; ARTIFICIAL LIFT; CIRCULATING; CLEANING; COST; DATA; DEEP WELL; DRILLING

COST; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FOAM; *FOAM DRILLING; FOAM LIFTING; FOAMING; FOAMING AGENT; MAINTENANCE; MAINTENANCE COST; MIXTURE; NEWS; PERFORMANCE; PHYSICAL PROPERTY; PRODUCTION STATISTICS; STABILITY; STABILIZATION; STABILIZER (ADDITIVE); STANDARD OIL CO CALIFORNIA; STATISTICS (DATA); TABLE (DATA); WELL; WELL CLEANOUT; WELL COMPL SERV + WORKOVER; *WELL COMPLETION; WELL COMPLETION COST; WELL PERFORMANCE; *WELL SERVICING; WELL SERVICING COST; WELL SERVICING RIG; *WELL WORKOVER; *WORKOVER FLUID

ACCESSION NUMBER: 12095[illegible]
TITLE: WHAT [illegible]OAM I[illegible] AND HOW IT'S USED
SOURCE: W[illegible]D OIL V 169, NO 6, PP 75-78, NOV 1969
ENTRY YEAR: [illegible]
INDEX TERMS: [illegible]VE; CIRCULATING; CIRCULATING SYSTEM; C[illegible]NG; ENGLISH; FOAM; FOAMING; FOAMING AGENT; MIXING; MIXTURE; NEWS; STABILIZATION; STABILIZER (ADDITIVE); SYSTEM (ASSEMBLAGE); *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; *WELL WORKOVER; *WORKOVER FLUID

ACCESSION NUMBER: 120955
TITLE: HOW FOAM AIDS OIL RECOVERY
SOURCE: WORLD OIL V 169, NO 6, PP 90-91, 94, NOV 1969
ENTRY YEAR: 1969
INDEX TERMS: ADDITIVE; ARTIFICIAL LIFT; BASE (CHEMICAL); CHEMICAL; CHEMICAL INJECTION; CIRCULATING; CLEANING; COMPOUND; ECONOMIC FACTOR; ENGLISH; FISHING (WELL); FOAM; *FOAM LIFTING; FOAMING; FOAMING AGENT; HYDROGEN SULFIDE; MIXTURE; NEUTRALIZER; NEWS; PHYSICAL PROPERTY; PRODUCTIVITY; PROFITABILITY; REMOVAL; SAND REMOVAL; STABILIZATION; STABILIZER (ADDITIVE); SULFIDE; *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; *WELL SERVICING; *WELL STIMULATION; *WELL WORKOVER

ACCESSION NUMBER: 120952
TITLE: STABLE FOAM SPEEDS WELL CLEANOUT
SOURCE: WORLD OIL V 169, NO 6, PP 78-82, NOV 1969
ENTRY YEAR: 1969
INDEX TERMS: ADDITIVE; ARTIFICIAL LIFT; BAILER; CASE HISTORY; CIRCULATING; CIRCULATING SYSTEM; CLEANING; COMPARISON; DATA; DRILLING (WELL); ENGLISH; FOAM; FOAM DRILLING; *FOAM LIFTING; FOAMING; MIXTURE; NEWS; REMOVAL; *SAND REMOVAL; STABILIZER (ADDITIVE); SYSTEM (ASSEMBLAGE); TABLE (DATA); *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; *WELL SERVICING; WELL SERVICING RIG; *WELL WORKOVER

ACCESSION NUMBER: 120946
TITLE: STEAM AND FOAM SIMPLIFY LINER RUNNING AND RETRIEVAL
SOURCE: WORLD OIL V 169, NO 6, PP 83-87, NOV 1969
ENTRY YEAR: 1969
INDEX TERMS: ADDITIVE; BUSINESS OPERATION; CLEANING; COMPARISON; COST; DATA; DRILLING COST; DRILLING EQUIPMENT; DRILLING (WELL); ECONOMIC FACTOR; [illegible]NGLISH; FOAM; FOAM DRILLING;

GRAPHICAL REPRESENTATION; INJECTION; LINER; *LINER COMPLETION; LINER (WELL); MATHEMATICAL ANALYSIS; MATHEMATICS; MIXTURE; NEWS; PERFORMANCE; PHYSICAL PROPERTY; PRODUCTIVITY; SALVAGING; STABILIZATION; STABILIZER (ADDITIVE); *STEAM INJECTION; TABLE (DATA); *WELL CLEANOUT; WELL COMPL SERV + WORKOVER; WELL COMPLETION; WELL COMPLETION COST; WELL PERFORMANCE; *WELL SERVICING; *WELL SERVICING COST; *WELL WORKOVER

ACCESSION NUMBER: 120448
TITLE: DRILLING FLUID
AUTHORS: SAUBER C A; SHANNON J L
SOURCE: U S 3,471,402, C 10/7/69, F 7/25/66 PR US 4/26/63, PHILLIPS PETROLEUM CO
ENTRY YEAR: 1969
INDEX TERMS: ADDITIVE; ASBESTOS; CARBOXYMETHYL CELLULOSE; COMPOSITION; CONTRACT; CONTROL; DRILLING FLUID; *DRILLING FLUID CONTROL; DRILLING (WELL); ECONOMIC FACTOR; EMULSION MUD; ENGLISH; FERROMAGNESIAN MINERAL; FLOW PROPERTY; FLUID LOSS; FLUID LOSS ADDITIVE; FLUID PROPERTY; FRESH WATER MUD; LEGAL CONSIDERATION; LOW FLUID LOSS; MINERAL; *MUD ADDITIVE; MUD COMPOSITION; MUD PROPERTY; *MUD TREATING; *MUD VISCOSITY; PATENT; PHILLIPS

*FLUID LOSS ADDITIVE; FLUID PROPERTY; LEGAL CONSIDERATION; LOW FLUID LOSS; *MUD ADDITIVE; MUD PROPERTY; OIL BASE MUD; PATENT; PHILLIPS PETROLEUM CO; PHYSICAL PROPERTY; POLYMER; POLYOXYETHYLENE; RHEOLOGY; WATER BASE MUD; (P) USA

ACCESSION NUMBER: 118307
TITLE: COMPARISON OF THE EFFICIENCY OF THE REMOVAL OF CARBON DIOXIDE FROM A GAS BY WATER UNDER PRESSURE IN A PACKED TOWER, AND IN A TOWER OPERATING UNDER
AUTHORS: GREGOR M; PALKA J; SVONAVA M
SOURCE: INT CHEM ENG V 9, NO 3, PP 480-485, JULY 1969
ENTRY YEAR: 1969
INDEX TERMS: AMMONIA; BASE (CHEMICAL); *CARBON DIOXIDE REMOVAL; CARBON MONOXIDE; *CASE HISTORY; CHEMICAL; COLUMN; COLUMN PACKING; COMPARISON; COMPOUND; CZECHOSLOVAKIA; DATA; EFFICIENCY; ELEMENT (CHEMICAL); ENGLISH; FIXED BED; FOAM; FOAMING; GAS PROCESSING; *INDUSTRIAL PLANT; MIXTURE; NATURAL GAS; NITROGEN; *OXIDATION REACTION; PETROLEUM; PRODUCING OIL + GAS; SCRUBBER; SEPARATION EQUIPMENT; SODIUM [illegible]OXIDE; *WATER SCRUBBING

ACCESSION NUMBER: 118305
TITLE: FLOW REGIMES OF STABLE FOAMS
AUTHORS: HOFFER M S; RUBIN E
SOURCE: IND ENG CHEM V 8, NO 3, PP 483-490, AUG 1969
ENTRY YEAR: 1969
INDEX TERMS: ADDITIVE; AIR DRILLING; ARTIFICIAL LIFT; *BUBBLE FLOW; CHART; COLUMN; CORRELATION; DATA; DRILLING (WELL); ENGLISH; EXPERIMENTAL DATA; FLOW PROPERTY; FLOW RATE; FLUID FLOW; FLUID VELOCITY; FOAM; FOAM DRILLING; *FOAM

LIFTING; FOAMING; FOAMING AGENT; GAS FLOW; *GAS OIL SEPARATION; *GAS OIL SEPARATOR; GAS PRODUCING; GAS SEPARATOR; GRADIENT; GRAPH; INTERFACE; LITERATURE SEARCH; MASS TRANSFER; MIXTURE; MULTIPHASE FLOW; OIL PRODUCING; PHYSICAL PROPERTY; PHYSICAL SEPARATION; *PLUG FLOW; PRESSURE GRADIENT; PRODUCING; PRODUCING OIL + GAS; PRODUCTION STATISTICS; RATE; REYNOLDS NUMBER; SEPARATION EQUIPMENT; SPRAYING; SURFACE ACTIVE AGENT; TURBULENT FLOW; VELOCITY; VERTICAL

GOODS

ACCESSION NUMBER	101917
TITLE	AIR DRILLING TO DATE
AUTHORS	GILBERT T J; TUCKER B C
SOURCE	19TH ANN PETR SOC OF CIM C I M + M TECH MTG 5/7-10/68 PREPRINT NO 6835, 3 PP
ENTRY YEAR	1968
INDEX TERMS	ADDITIVE; *AIR DRILLING; CHANGE; CONTROL; CORROSION; CORROSION CONTROL; CORROSION COST; CORROSION RESISTANCE; CORROSION THEORY; COST; COST CONTROL; DEVELOPMENT; DEVELOPMENT COST; DRILL PIPE CORROSION; DRILLING COST; DRILLING EQUIPMENT; DRILLING PROBLEM; DRILLING PROGRAM; DRILLING RATE; DRILLING THEORY; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; *FOAM DRILLING; FOAMING AGENT; *GAS DRILLING; PASSIVITY; PLUGGING; PROGRAM; *PROGRESS REPORT; RATE; REPORT; THEORY; WATER SHUTOFF; WELL PLUGGING

ACCESSION NUMBER	101732
TITLE	FATTY ALCOHOLS AS PERFORMANCE BOOSTERS AND FOAM STABILIZERS WITH FATTY ALCOHOL SULFATE SALTS
AUTHORS	ARTHUR R P; CHOCOLA L R; SHORE A; SHORE S
SOURCE	US 3,394,768, C 7/30/68, F 10/4/65 RICHARDSON CO
ENTRY YEAR	1968
INDEX TERMS	ADDITIVE; *AIR DRILLING; ALCOHOL; CARBON CONTENT; CHEMICAL; COMPOSITION; COMPOUND; CONTRACT; CUTTINGS REMOVAL; *DRILLING FLUID; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; *FOAM; *FOAM DRILLING; *FOAMING AGENT; LEGAL CONSIDERATION; MIXTURE; MUD COMPOSITION; PATENT; REMOVAL; RICHARDSON CO; SALT; STABILIZER (ADDITIVE); SULFATE; (P) USA

ACCESSION NUMBER	100942
TITLE	SURFACTANT COMPOSITION
AUTHORS	ZIKA H T
SOURCE	US 3,391,750, C 7/9/68, F 8/9/65 UNION CARBIDE CORP
ENTRY YEAR	1968
INDEX TERMS	ADDITIVE; *AIR DRILLING; ARTIFICIAL LIFT; BRINE; CLEANING; COMPOSITION; CONTRACT; DRILLING (WELL); ECONOMIC FACTOR; ENGLISH; FOAM DRILLING; *FOAM LIFTING; FOAMING; *FOAMING AGENT; GAS DRILLING; GAS PRODUCING;

QUESTIONNAIRES

APPENDIX E

Survey of Industry Authorities on Foam Drilling

A significant part of this study was to interview industry personnel on the use of foams in geothermal drilling. Initial contact was by letter, with a written questionnaire. These are included in this appendix. Because of poor written response, each of the people were contacted by phone. After discussion and assemilation of results, approximately fifteen following contacts were made to clarify points and expand information.

A cross-section of comments by persons contacted are included. It seems from the interviews that the more knowledgeable a person in geothermal drilling, the more optimistic they were on potential savings from the use of foams.

Attached is a brief questionaire which I would appreciate you, or one of your people, giving me some help on. This questionaire will be used to guide me in a foam project sponsored by the Department of Energy through Sandia Labs. Hopefully your input will ultimately lead to advanced technology which will undoubtedly be useful to your company.

One of our initial efforts will be to test the temperature stability of all currently used foaming agents. Next, we shall concentrate on evaluating lab methods used for testing foaming agents. As you can see, the information you supply us is most important.

Being this project is government sponsored, all data gathered will be available to industry when the project is finished. If your "foaming agent" is chosen to be tested, I shall gladly give you early results.

If you have any questions, or if you wish to provide the information over the phone, please feel free to call.

Sincerely,

Martin Chenevert
President

MEC/lp

CHENEVERT & ASSOCIATES, INC. 2727 KIRBY DR., SUITE 201 / HOUSTON, TEXAS 77098 / 713 522-2122

Drilling Specialists · Petroleum Consulting, Research, and Training

QUESTIONAIRE ON FOAM DRILLING FLUIDS

For Study Funded By:

Department of Energy

Division of Geothermal Energy

Foams have been used by our company under the following conditions.

1. Maximum static temperature ______________________.
2. Maximum depth ______________________.
3. Problems often encountered ______________________

____

____

4. Type of foaming agent used (if known) ____________.

   Supplied by (company) . ______________________.
5. I would like to see the following improvements made in foam. ______________________

____

6. Comments ______________________

____

____

7. Please place me on your "foam" mailing list. Yes ☐ No ☐

   Name ______________________

   Company ______________________

   Street ______________________

   City, State ______________________

   Phone ______________________

Note: If more than one drilling location is involved please use additional sheets.

QUESTIONAIRE

APPLICABILITY OF FOAM DRILLING FLUIDS

1. How much of geothermal drilling could utilize foam (by area and by resource type; if possible)?

2. What are the benefits of new foams over present drilling fluid systems (e.g. reduce drill pipe replacement, save drilling time, increase well productivity, etc.)?

3. What special problems limit utilization of foams (e.g. corrosion, disposal, equipment cost, and availability)?

4. What are the priorities for research on foams?

5. What are the chances of developing better foams (5 above) and how long will it take?

6. Are the needs for completion, fracturing, and workover foams significantly different from those of drilling foams?

7. Other comments.

GEOTHERMAL PERSONNEL CONTACTED ON FOAM DRILLING FLUID STUDY

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REPORT ON INFORMATION OBTAINED FROM GEOTHERMAL PERSONNEL

The concept suggested by Kingsolver that future DOE Projects look at the entire spectrum of inert gas and aireated fluids is a good one. This would essentially fill in the density range from air to water.

Areas in which foam research should be carried out are listed below. This list is obtained from failures encountered with existing foams. Not in order of priority.

1. Stability of foams under water or brine intrusion.
2. Stability of foams under changing pressure (5000 feet depth maximum) and temperature (550°F max.) conditions.
3. Heat transfer/insulation properties of foams.
4. Heat capacity of foams.
5. Corrosion effects of foams, to include performance of additives.
6. Foam generators.
7. Foam disposal schemes.
8. Flow characteristics of foams in porous media and evaluation of rock alteration when in contact with foams.
9. Development of improved foamers, in particular, binary systems ala Fowkes.
10. Lifting capability of foams.
11. Sensitivity of foams to inert or stack gas with hydrocarbon impurities.
12. Improved performance parameters for physical and chemical properties of foams.

Most personnel contacted considered foams to be experimental and wanted to see lab tests and field tests performed to give themselves greater confidence in applying foams to their operations. Some proprietary R. & D. is going on but all would welcome DOE participation.

No clear cut answer on percentage of drilling to be foam. This would be very closely tied to foam performance.

The concept of binary foams was interesting and novel to most, however, the corrosion problem seemed to be of greater concern at the present time. The use of inert gas to generate foam was the most popular present concept.

Geothermal Survey

Date July 5, 1978 Address Chevron U.S.A., Inc.

Person Contacted Stan Hutchison P. O. Box 5355 Bakersfield, CA.

Phone Number 805-393-1312

Objective: Determination of the degree of applicability of drilling foams for geothermal wells and the enviromental conditions of the borehole.

Topics to be covered:

1. In the future, where will foam drilling fluids be used?

2. How will foams cut costs?

3. What are the borehole conditions for foam drilling?

4. Will foam disposal be a problem?

5. Other considerations.

Mr. Hutchinson had the following comments:

I feel there will be many uses for foams in the future. They will be needed in the following areas.

A) For drilling in areas which need low density fluids. This is particularly true in geothermal areas. At present we are having problems with shale stability when foams are used. Work should look at additives for shale stability.

B) For completions. Stable foams are very useful for removing sand and scale from wells.

C) Use as a pusher fluid in secondary recovery operations. In recent lab tests cores were flooded at 300°F using water only and only 30% of the oil in place was recovered. The next water flood was followed by stiff foam and a total of 43-48% oil was recovered.

D) Used in acidizing operations. After the primary acid job, foam is pumped into the holes formed. This plugs such holes and diverts the next acid job into less permeable zones. The bubbles which go into the formation lower the mobility of the acid. Also, the foam does not damage the zone and production is easily achieved.

E) Foams are used in more and more hydrofrac jobs.

Geothermal Survey

Date June 25, 1978 Address Loffland Brothers
P. O. Box 2847
Tulsa, Oklahoma 74101

Person Contacted Mr. Harvey Mallory

Phone Number 622-9330

Objective: Determination of the degree of applicability of drilling foams for geothermal wells and the enviromental conditions of the borehole.

Topics to be covered:

1. In the future, where will foam drilling fluids be used?

2. How will foams cut costs?

3. What are the borehole conditions for foam drilling?

4. Will foam disposal be a problem?

5. Other considerations.

Mr. Mallery had the following comments:

1. Foams are presently difficult to use as drilling fluids, they are good mainly for completions.

2. The biggest problem with foam is keeping the foam continuous in the annulus. This is a foam degredation problem and injection problem. Often the driller and air man do not work together properly; you get a slug of foam then a slug of air. If you have the foam slugging you better not come out of the hole.

3. The main user of foam is Chevron. Contact them.

4. On one early well near Ft. Stockton the chips fell back during connections, packed off the hole, then lost circulation when the pumps were turned on.

Geothermal Survey

Date June 21, 1978 Address Smith Tool Co.

Person Contacted Mr. Jim Kingsolver P. O. Box C-19511

Phone Number 714-540-7010 Irvine, CA. 92713

Objective: Determination of the degree of applicability of drilling foams for geothermal wells and the enviromental conditions of the borehole.

Topics to be covered:

1. In the future, where will foam drilling fluids be used?

2. How will foams cut costs?

3. What are the borehole conditions for foam drilling?

4. Will foam disposal be a problem?

5. Other considerations.

Comments:

1. In the next 5 yrs, 75-80% of all geothermal wells drilled will have aerated water in one or more sections of the hole.

2. The reason for the aerated water system is to prevent lost circulation which therefore prevents problems and insures a producer.

3. Foam will be used, when possible, because of the lower cost.

4. Problems with todays foams are:

   a. Low yield (ie, foam does not form)

   b. The pH is wrong. You get either 3 or 13, nothing in between.

   c. Bit life is very low.

Geothermal Survey

Date June 21, 1978 Address Union Oil Co.

Person Contacted Mr. Del Pyle P. O. Box 7600

Phone Number 213-486-6262 Los Angeles, CA.

Objective: Determination of the degree of applicability of drilling foams for geothermal wells and the enviromental conditions of the borehole.

Topics to be covered:

1. In the future, where will foam drilling fluids be used?

2. How will foams cut costs?

3. What are the borehole conditions for foam drilling?

4. Will foam disposal be a problem?

5. Other considerations.

Comments: The following points were made by Mr. Del Pyle and Mr. Bill Glass in a joint meeting.

Mr. Bill Glass Big Chief Drilling Co.
405-843-5721 Oklahoma City, OK.

1. With the exception of sedimentary type geothermal areas (ie Imperial Valley), foam fluids will be used in about 50% of all other geothermal wells. (See attached Table 1)

2. Foams look very good becuase of savings over air. They will be used where air is presently being used.

Other advantages of foam over air are:

a. Fewer compressors will be needed. Can reduce number from three to one. This will save between $1500 to $2000/day.

b. Pipe corrosion and erosion will be reduced. With air you need to retire one foot of drill pipe for every 6 feet of hole drilled. With foam you retire one foot of drill pipe for every 250 of hole drilled. At $20/foot of drill pipe, considerable savings can be achieved

c. Hard banding. We presently spend (in Geyser Area) about $10,000 to $15,000 per hole for hard banding when air is used. Foam might cut this back to $8000 to $12,000 per hole.

d. Fishing jobs with air is about 4 jobs/year/rig. At $250,000 per job this amounts to $1,000,000/year/rig. Foam might reduce this value by 10 times. Its main contribution would be in hole stability.

e. Pipe inspection costs. Drill collars would be checked every 30 days, instead of every 20 days. It presently costs $12/joint to inspect.

LIST OF GEOTHERMAL PERSONNEL CONTACTED BY TELEPHONE AND SUMMARY OF CONTACT

Mr. Frank Schuh
Atlantic Richfield Co.
Dallas, Texas
(214)651-4685

Summary:

Company has not drilled geothermal wells to date. They are interested and have leases. Suggest we review the University of Hawaii report on dry steam geothermal wells in Hawaii.

Major concern on the use of foams is ability of foam to handle water zones.

Mr. Bob Mottley
Getty Oil Co.
Houston, Texas
(713)658-9361

Summary:

No experience and no knowledge on the use of foams in geothermal drilling.

Mr. Dave Smith
Shell Oil Co.
Ventura, California
(805)648-2751

Summary:

All experience at Geysers. Not much application of foams to this location. Foams are used to clear water influx, however, at Geysers the geothermally altered rock at depth is unstable and foams could not clear the hole fast enough.

Mr. B. Wyant
Occidental Geothermal, Inc.
Bakersfield, California
(805)327-7351

Summary:

He had no direct experience with the use of foams. He considered the use of foams to be very experimental, would like to see R. & D. on foams, particularly interested in the stability of foams at depth.

His supervisor is Mr. R. A. Crewdson; Crewdson will send us the completed questionaire.

Mr. Percy Wicklund
AMAX Exploration, Inc.
Denver, Colorado
(303)433-6151

Summary:

AMAX has used foams and believes that they have a place in geothermal drilling. Because of the hazard of blind drilling, no circulation back to the surface, he feels that the drilling manager must be very conservative in the use of foams. In addition a breakdown of the foam structure can lead to water surging in the borehole under high pressure resulting in damage to the borehole. Evaluation of the sensitivity of the foam to geothermal brines is an important R. & D. parameter.

Since geothermal drilling is in hard rock he would like to see government geothermal test wells use foams to prove their utility.

Mr. R. M. Jorda
Completion Technology Co.
Houston, Texas
(713)961-5011

Summary:

This company has not used foams in the geothermal environment. They have used foams as a completion material. In this usage they have better completions with foam primarily because foams do not affect the reservoir. He is mostly interested in stiff foams, defined as one which can carry propping agents.

For future R. & D. he considers development of high temperature foamers as #1. He likes the idea of binary systems of low temperature/high temperature foaming agents. The disposal of stiff foams is a problem and reducing cost of equipment to do this job is important.

Mr. Stan Shrylock
Halliburton
Santa Fe Springs, California
(213)864-2551

Summary:

Air drilling at the Geysers is most satisfactory. In the Imperial Valley foams are O.K. Major problem with foams is lost circulation.

Suggest we review new patented process of foam utilization by Chevron Oil, U.S.A. Details of this process were presented at the API Meeting in California two weeks ago.

Mr. R. B. Allred
Sun Oil Co.
Richardson, Texas
(214)744-4411

Summary:

Unable to contact him.

Mr. R. Lane
NL Baroid
Houston, Texas
(713)527-1302

Summary:

Baroid's experience with foams is mainly lab development work oriented toward water and gas well drilling. Mostly this work is at low temperatures. They have studied the effect of water/brine chemicals on foaming agents. Their usual percentage of surfactant is 2% which implies a wet foam.

Basically air drilling is fastest, but uses foams to control water encroachment and for better lifting capability. Also equipment cost is reduced over mud drilling, provided of course that air drilling equipment is in place.

They use the API RP4G test for foams and would like to see improved test procedures.

Would welcome Govt. R. & D. in this area.

Mr. David Etter
Schwebel Petroleum Co.
Bakersfield, California
(805)324-4061

Summary:
No contact. No one else at company could provide information.

Mr. W. A. Glass
Big Chief Drilling Co.
Oklahoma City, Oklahoma
(405)843-5721

Summary:
No new comments.

Mr. L. Carney
IMCO Services
Houston, Texas
(713)671-4882

Summary:
I was unable to contact Mr. Carney or any other engineer at IMCO. I was referred to Mr. Stewart of Technical Sales.

Mr. E. E. Clear
Drilling Specialities Co.
Bartlesville, Oklahoma
(918)661-6404

Summary:
Mr. Clear reported no knowledge or familiarity with the use of foams.

Mr. P. Fisher
Union Oil Co. of California
Brea, California
(714)528-7201

Summary:

I was unable to contact him.

Mr. Tony Havlich
Havlich Associates
LaCresenta, California
(213)249-0910

Summary:

Mr. Havlich stated that most foam drilling activities were at a depth of 1000 feet with 5000 feet being the maximum. He was interested in the PVT properties of foams and would like to know more about the effects of additives such as corrosion inhibitors (Unisteam produced by Union Oil Co.) and buffers. Unisteam is a vapor phase material which settles out on steel surfaces at elevated temperatures. He suggested Texilana and Far Best Corp. as suppliers of organic sulfate chemicals. Considered film strength, flow properties in porous media and thermal insulation properties of foams as important tests. Standard Oil of Bakerfield, California has been testing foams also the IMCO Corp. is involved in foam testing. Mr. Havlich was interested in generating foams with inert gas and mentioned the NOWSCO Co. (Nitrogen Oil Well Service Co.) of Houston, Texas.

Of most use to industry would be a practical well drill test run by knowledgeable people. Suggests we look at the remedial test run at the LaHabra facility.

Mr. S. Hutchison
Chevron U.S.A., Inc.
Bakerfield, California
(805)393-1312

Summary:

No contact.

Mr. Bill Schaub
Gulf Oil Co.
Houston, Texas
(713)778-5163

Summary:
No contact.

Mr. K. Kingsolver
Smith Tool Co.
Irvine, California
(714)540-7010

Summary:
Considers corrosion the #1 problem with foams. Suggests using inert gas in particular stack gas. The company Ken Davis Ind. may be doing some work on this.

Presently the only stable foam is the one used by Chevron for completions and it is a low temperature foam. The lost circulation problem with unstable foams is very serious. He believes well tests to be useful and lab tests are a must. 75% of wells will be completed with foams or mist techniques and suggests that scope of future DOE programs be expanded to cover all inert gas and aireated fluids.

Mr. Del Pyle
Union Oil Co.
Los Angeles, California
(213)486-6262

Summary:
No new comments.

Mr. R. Wolke
Dresser Industries
Houston, Texas
(713)784-8525

Summary:

Likes inert gas to reduce corrosion but major problems exist with stack gas. Keeping the stack gas clean and reducing hydrocarbon content is difficult and expensive. Presently available catalytic converters are not cost effective.

He cites other problems with foams as lost circulation, disposal, and design of foam generators.

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