

## **THE PROSPECT OF UTILISING LOCAL STARCHES AS FLUID LOSS CONTROL AGENTS IN THE PETROLEUM INDUSTRY**

**ISSHAM ISMAIL and AHMAD KAMAL IDRIS.**

**Department of Petroleum Engineering,  
Faculty of Chemical and Natural Resources Engineering,  
Universiti Teknologi Malaysia (UTM),  
Karung Berkunci 791,  
Skudai, Johor,  
Malaysia.**

### **Abstract**

Fluid loss into formation is due to the greater hydrostatic pressure exerted on the formation. This phenomenon may give severe drilling problems such as stuck pipe, formation damage and poor cementing job. Thus, the use of fluid loss control agent could reduce the tendency of fluid loss into formation. Currently, polyanionic cellulose (PAC) is one of the fluid loss control agents that are widely used to control fluid loss. Since the PAC has to be imported at a high price, thus there is a need to look for cheaper local materials to substitute PAC.

This paper discusses the prospect of utilising local starches, namely sago and tapioca, as fluid loss control agents in water-based mud. This discussion is based on the results derived from laboratory experiments.

In this study, the performance of sago and tapioca starches were compared to PAC. Experimental results revealed that sago and tapioca starches could achieve the viscosity produced by PAC. For a given mud viscosity, it was found that sago mud could give comparable gel strength and yield point as compared to PAC mud.

The significant advantage of utilising sago mud was it could produce a thinner mud cake than PAC mud. Surprisingly, both samples were found to give comparable values of fluid loss.

Based on this preliminary study, it could be concluded that local starches especially sago has the potential to be used as fluid loss control agent in drilling mud.

### **Introduction**

An oilwell has to be drilled and completed prior to producing oil from production zones. In making a hole, drilling mud is normally circulated in the hole by entering the drill string at surface, forced out of the drill string via drill bit and flows through the annulus between the hole and drill string before reaching surface. Drilling mud has many functions such as to carry cuttings to the surface, to cool drill bit, and the most important of all, is to control well pressure. Drilling mud should produce higher hydrostatic pressure than the formation pressure in order to prevent the influx of formation fluid into wellbore. Generally, barite, a standard weighting material, is used to increase mud weight

to the required value (Rabia, 1985). The overbalance phenomenon may cause fluid loss into formation.

Fluid loss can cause several problems. Thus, amongst the main reasons to minimize the volume of mud filtrate are:

- invasion of filtrate may create a zone of reduced permeability around the wellbore and may results in lower production rate.
- filtrate may penetrated shale sections of the formation and cause swelling and subsequently sloughing into the wellbore. This could lead to pipe sticking problem.

Fluid loss control agent has been used widely since early 1930 to overcome the problem. Generally, most of the control agents used are of polymer-based materials and have been modified in order to prevent those agents from damaging production zones (Gray and Darley, 1981). Amongst the standard fluid loss control agents used are hydroxyl ethyl cellulose (HEC), sodium carboxyl methyl cellulose (CMC) and polyanionic cellulose (PAC), and have to be imported at high prices.

Thus, an effort was initiated by the *Drilling Mud Engineering Research Group of UTM* by looking for an alternative fluid loss control agent from local materials - which would be more economics and also to maximise the exploitation of local materials. The research was based on laboratory experiments and two local starches, namely tapioca and sago, were studied. In order to investigate the performace of sago and tapioca starches, several basic tests were conducted namely rheological properties, fluid loss and ageing process. The experimental results of sago and tapioca were then compared to PAC, the standard fluid loss control agent used in the oilfield, prior to making concluding remarks.

Generally, PAC is derived from the reaction between cotton cellulose and sodium hydroxide and chloroacetic acid (M-I Drilling Fluid Co., 1992). PAC is found to be stable up to 300°F (149°C), but the presence of high calcium ion (i.e. more than 2000 ppm) in the formation fluid will reduce it's ability in controlling fluid loss. The chemical and physical properties of sago and tapioca starches are explained in (Beynum and Roels, 1985).

### Materials and Methods

#### Mud Preparation

The water-based mud used in this study was prepared based on the formulations used in the Malaysian oil field. For instance, to prepare *one lab barrel* (equivalent to 350 ml) of a 9.0 ppg ( $10.78 \times 10^2 \text{ kg/m}^3$ ) water-based mud sample, the composition of additives added into 350 ml of fresh water were as follow:

Additive	Composition
Sodium hydroxide	1.0 g
Bentonite	14.0 g
Barite	30.0 g

The range of mud weight used in the study was 9.0 ppg - 14.0 ppg.

The fluid loss control agents used were either PAC, sago starch or tapioca starch, and were added separately in proportion into mud samples to form the required mud viscosity (Irwan, 1997). The range of mud viscosity used in this study was 10 cp ( $10 \times 10^{-3}$  Pa.s) to 25 cp ( $25 \times 10^{-3}$  Pa.s) at temperatures of 160°F (71°C), 180°F (82°C), 190°F (88°C) and 200°F (93°C).

#### Equipments and Procedures

Each of the additives was added steadily into the fresh water, which was placed in a multimixer's cup. The mixture of fresh water and additives were then stirred thoroughly for 10 minutes to prevent the formation of *fish eye*. The mud samples were then heated to 160°F via a hot plate to enable the tapioca and sago starches to form starch paste. Generally, tapioca and sago do not swell in cold water as compared to PAC, due to the presence of hydrogen bonds. PAC could viscosify water at room temperature.

The rheological properties of mud with starch paste or PAC were measured by using the *Baroid* rheometer. Apart from the viscosity, other rheological properties measured were yield point and gel strength.

The fluid loss properties of the mud samples were evaluated by using the *High pressure-high temperature filter press* (Hudson and Coffey, 1983). The data gathered in this laboratory experiment were volume of filtrate collected against time and filter cake thickness. The thickness of filter cake produced at the end of the 30 minutes filtration test was measured electronically via a vernier caliper. The filtration test was conducted as per the *API RP 13B*.

In this study, the stability of each of the mud samples at high temperatures was also investigated with the viscosity of each mud was maintained at 20 cp prior to the ageing process. All the muds were heated up from 160°F to 300°F for 16 hours before the end products could be analysed. The experiment was conducted as per the *API RP 13B*.

## Results and Discussion

From this preliminary study, several encouraging results were obtained. These results might provide a strong basis for further studies.

#### The Effect of Temperature on Viscosity

Figures 1 and 2 show that at temperatures of 160°F and 200°F, the gelatinised tapioca and sago starches were capable of producing equivalent viscosity as PAC. Generally, the granules of sago and tapioca starches are insoluble in water below 122°F (50°C) due to the hydrogen bonds. When sago and tapioca starches in water-based muds are heated beyond a critical temperature, the starch granules absorb water and swell to many times

their original size. As heating is continued, the swollen starch granules begin to disintegrate into swollen starch aggregates.

In these tests, it was found that larger amount of sago and tapioca starches were utilised to form the required viscosity for a given mud viscosity and constant temperature. For instance, to produce a viscosity of 20 cp at 180°F, 12.0 gram of sago starch was required compared to tapioca (10.0 gram) and PAC (7.2 gram).

#### The Effect of Temperature on Yield Point

From Figure 3, it could be seen the relationship between yield point and temperature for all the fluid loss agents. It was shown that the yield points of tapioca mud and PAC mud decreased as temperature increased, but sago mud's yield point was found to increase with temperature. This was due to the deflocculation of solid particles as temperature decreased and flocculation of solid particles as temperature was increased respectively. Nevertheless, experimental results revealed that the yield point produced by the PAC and sago muds were in the optimal range. Generally, drilling mud with optimal yield point could carry drill cuttings to the surface effectively.

#### The Effect of Temperature on Gel Strength

The effect of temperature on 10 seconds and 10 minutes gel strength were shown in Figures 4 through 6. The experimental results revealed that gel strength of PAC, tapioca and sago increased with temperature. This was due to the greater attraction between polymer and mud particles at higher temperatures. PAC gave better performance than sago and tapioca, as its results located below the recommended gel profile. Drilling mud with optimal gel strength could suspend mud particles and drill cuttings when mud pump was stopped temporarily. However, high gel strength mud would give problems such as increase torque on drill string and high power pump is required to initiate mud circulation.

#### The Effect of Temperature on Fluid Loss

Figure 7 shows the fluid loss experienced by drilling muds without fluid loss control agents and with fluid loss control agents, namely PAC, sago and tapioca starches. It was found that when fluid loss control agents were added into the base mud, fluid loss could be reduced to about 90%, which were well below the maximum allowable fluid loss level. Excessive fluid loss into formation could cause pipe sticking problems. The experimental results revealed that the significant advantage of using sago starch as fluid loss control agent was its ability of producing lower fluid loss and thinner mud cakes as compared to PAC tapioca, as shown in Figure 8 and 9 respectively.

#### Ageing Process

In the ageing process, Figure 10 shows that the experimental results revealed that PAC mud could sustain its viscosity when the sample was heated up to 275°F for 16 hours, but degraded completely as temperature elevated to 300°F. Whilst the viscosity of sago and tapioca muds were found to be reduced by more than 50% at the end of ageing process. As the sago and tapioca muds were heated further, the starch pastes crossed their peak viscosity, thus the cohesive forces in the swollen granules become excessively weak and the structure of the pastes collapsed. Eventually, the fragile swollen granules broke out and thinned out due to granule fragmentation.

### Conclusion

1. Tapioca and sago starches have the potential to be used as fluid loss control agents in drilling mud.
2. The presence of tapioca and sago starch in drilling mud could reduced fluid loss up to 90%.
3. Sago mud experienced lower fluid loss than PAC and tapioca muds.
4. The mud cake produced by PAC was thicker than sago starch.
5. The sago and tapioca starches could yield the required viscosity as produced by PAC, but larger amount was needed.
6. The rheological properties produced by sago starch and PAC were found to be in optimal range.
7. In the ageing process, PAC was found to be capable of maintaining it's stability until 275°F, but the local starches' granules structure broke out at temperature of 212°F, thus reducing viscosity.

### Acknowledgement

The authors would like to express their gratitude to the Research and Development Unit of Universiti Teknologi Malaysia for the permission and financial support given to enable this paper to be presented at the Regional Symposium on Chemical Engineering, 13-15 October 1997, Hyatt Regency, Johor. Special thank was also delivered to En. Irwan Abdul Latif for his efforts in assisting the authors in accomplishing this project.

### References

1. Gray, G.R. and Darley, H.C.H. (1981). *Composition and Properties of Oil Well Drilling Fluids*. 4th Ed., London, Gulf Publishing.
2. Hudson, T.E. and Coffey, M.D. (1983). *Fluid Loss Control Through The Use of A Liquid Thickened Completion and Workover Brine*. Journal of Petroleum Technology. October, 1983. pg. 1776-1782.
3. Irwan Abdul Latif. (1997). *Penggunaan Kanji Tempatan Sebagai Bahan Pengawal Kehilangan Bendalir Dalam Lumpur Gerudi Dasar Air*. Tesis Sarjana Muda. Universiti Teknologi Malaysia, Skudai.
4. M-I Drilling Fluids Co. (1992). *Drilling Fluid Engineering Manual*. Texas.

5. Rabia, H. (1985). *Oilwell Drilling Engineering: Principles & Practice*. Graham & Trotman, London.
6. Van Beynum, G.M.A. and Roels, J.A. (1985). *Starch Conversion Technology*. Marcel Dekker Inc. New York.

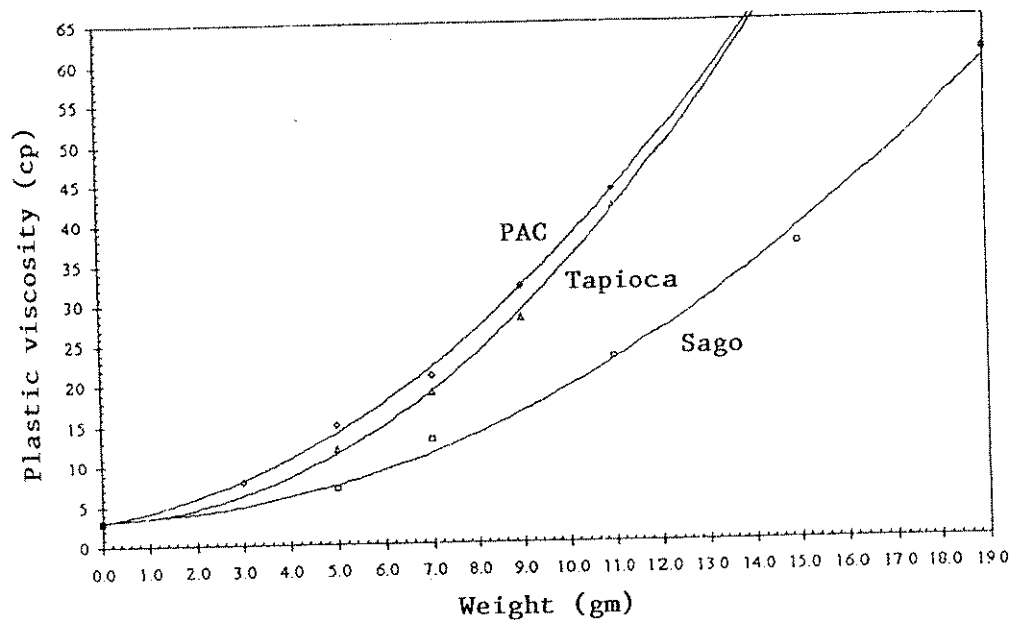


Figure 1: Plastic viscosity vs additives weight at 160°F.

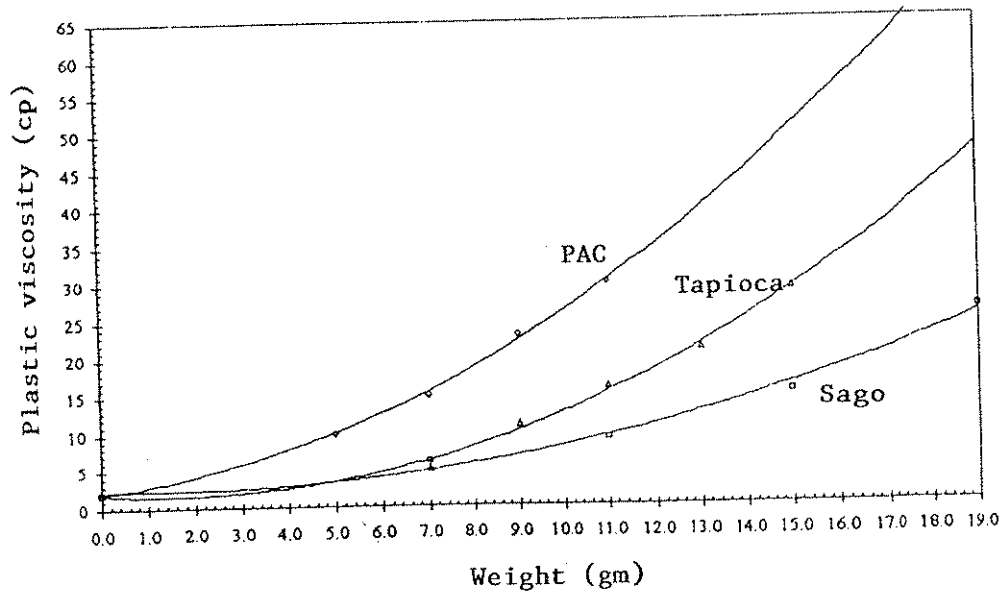


Figure 2: Plastic viscosity vs additives weight at 200°F.

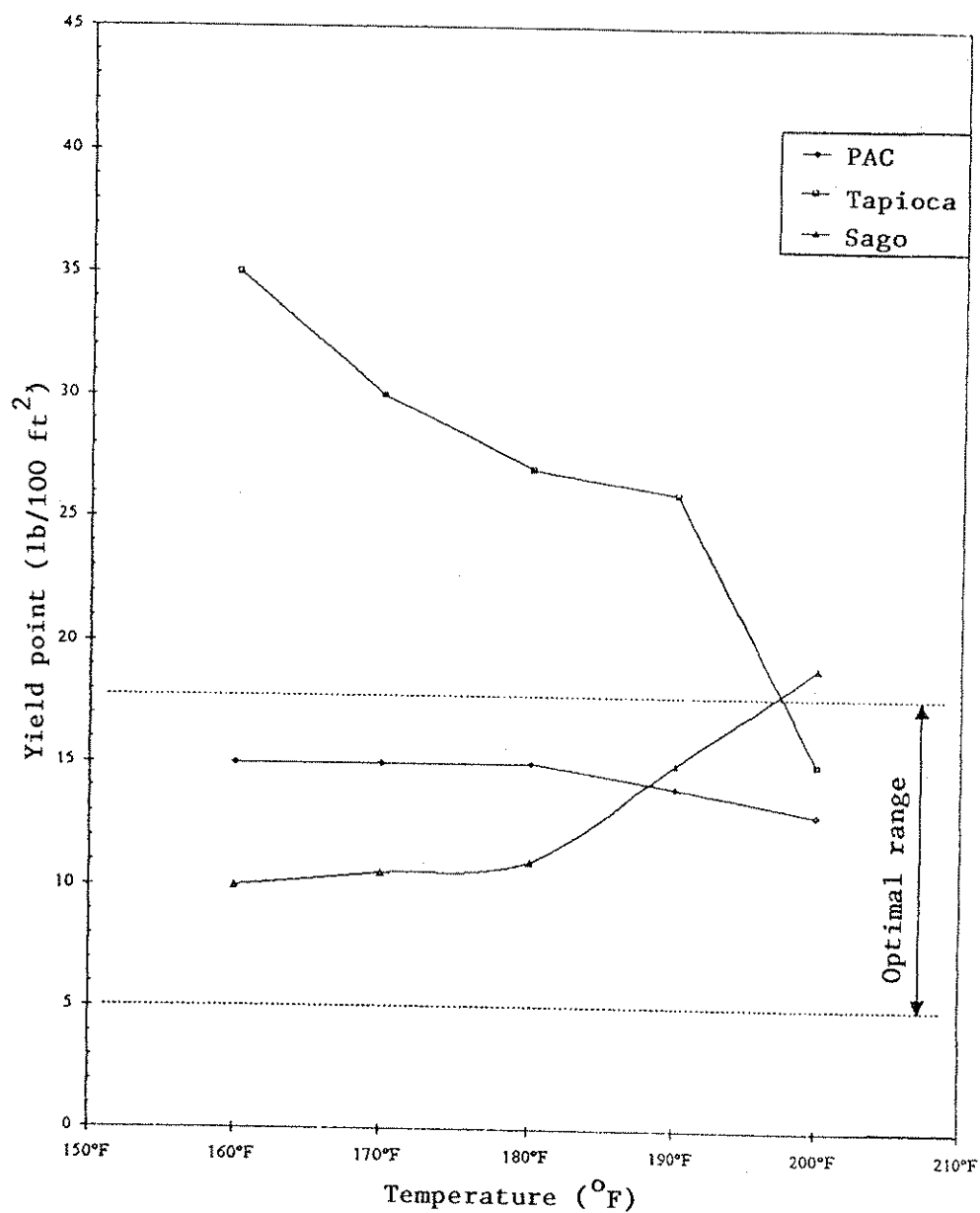


Figure 3: Yield point vs temperature for PAC, sago and tapioca at 20 cp.



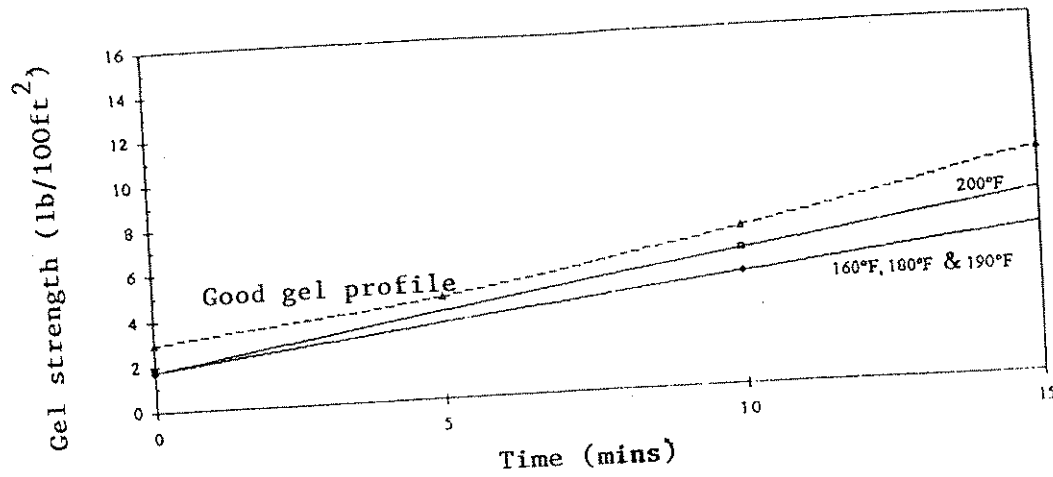


Figure 4: Gel strength vs time for PAC mud.

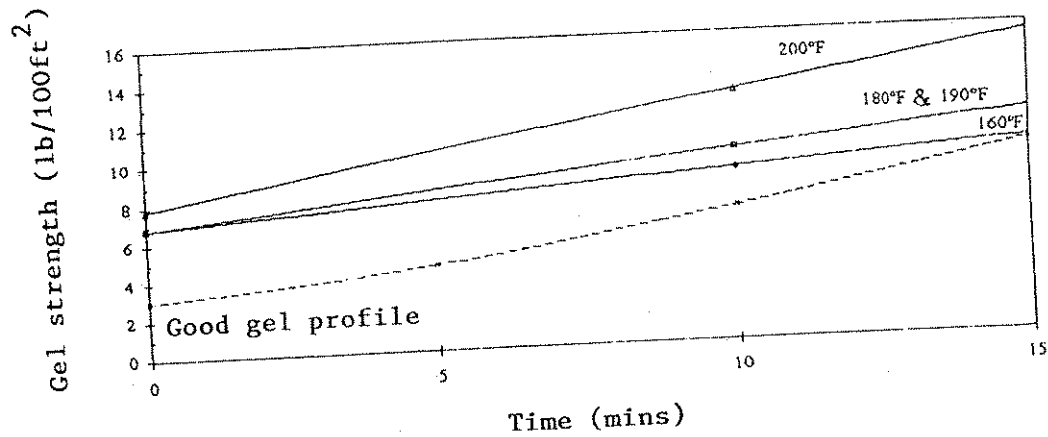


Figure 5: Gel strength vs time for tapioca mud

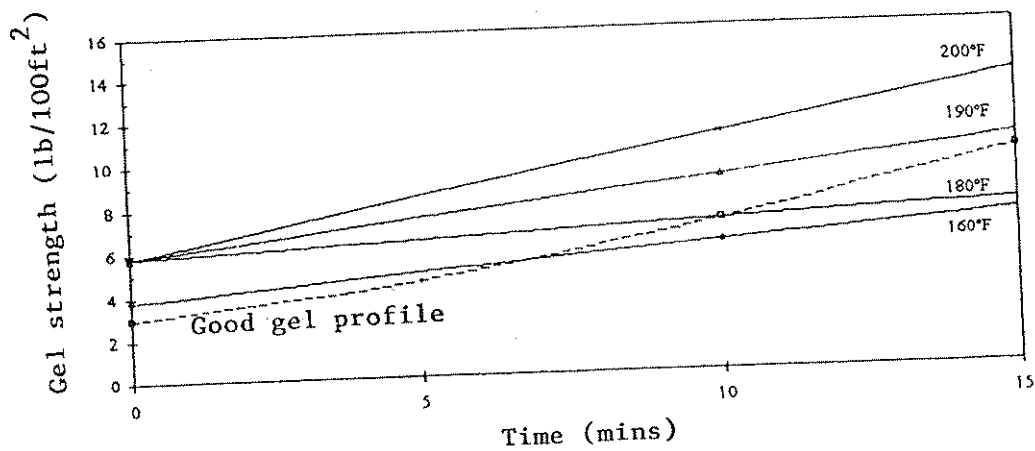


Figure 6: Gel strength vs time for sago mud

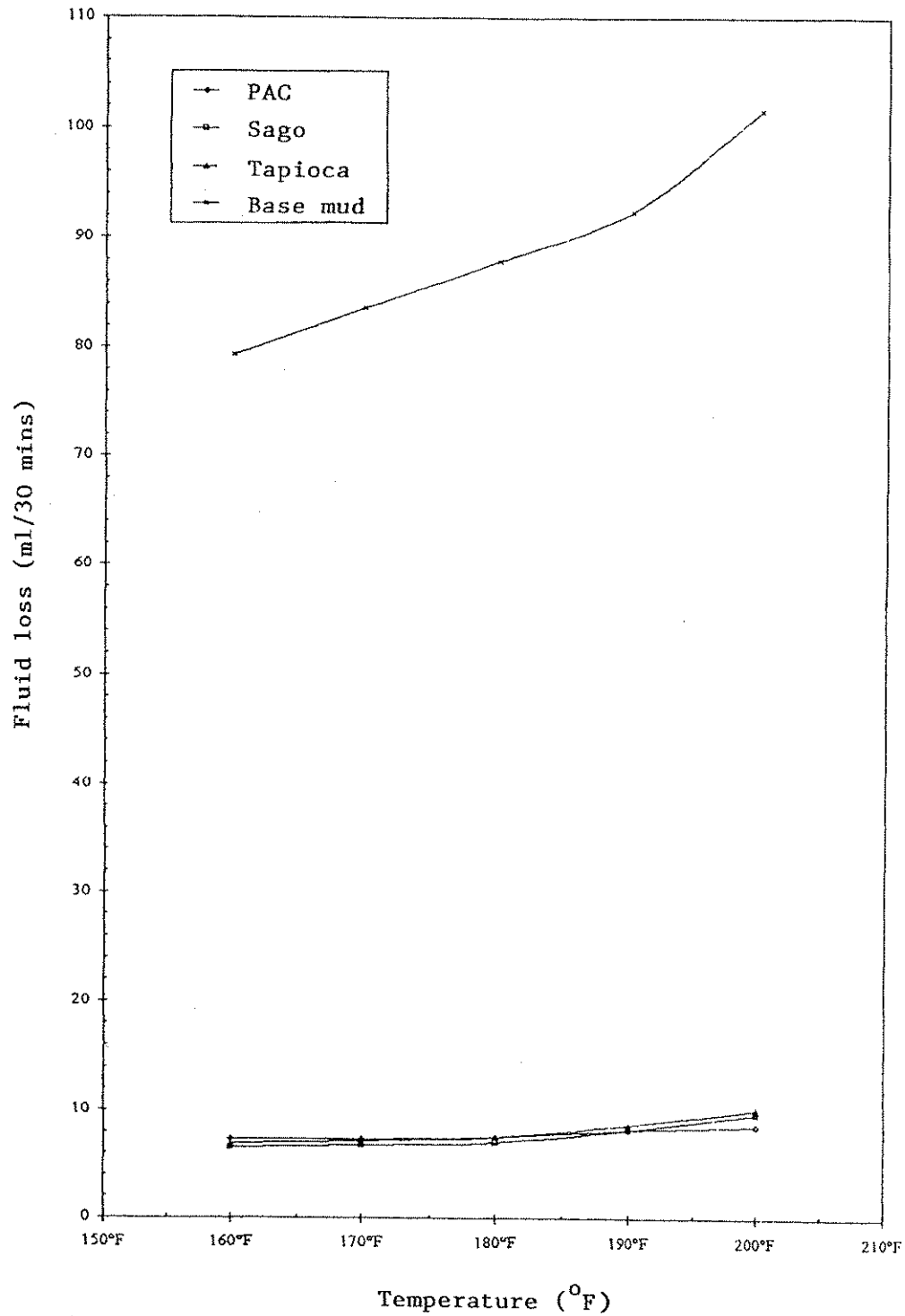


Figure 7: Fluid loss vs temperature for base mud with and without fluid loss control agent.

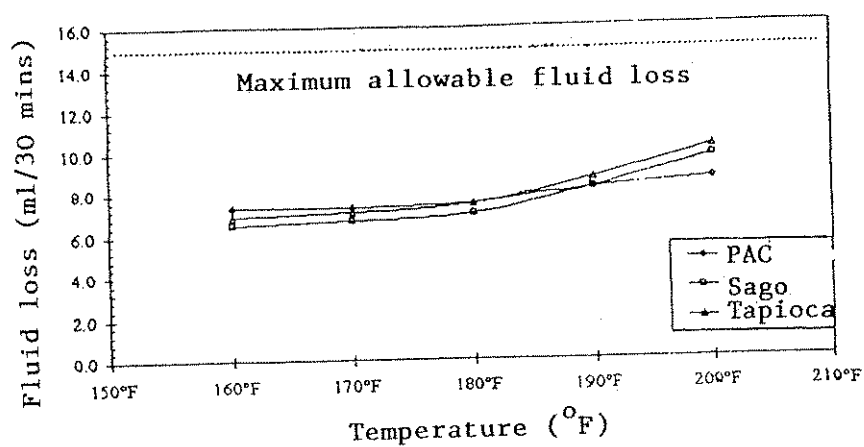


Figure 8: Fluid loss vs temperature for 20 cp mud.

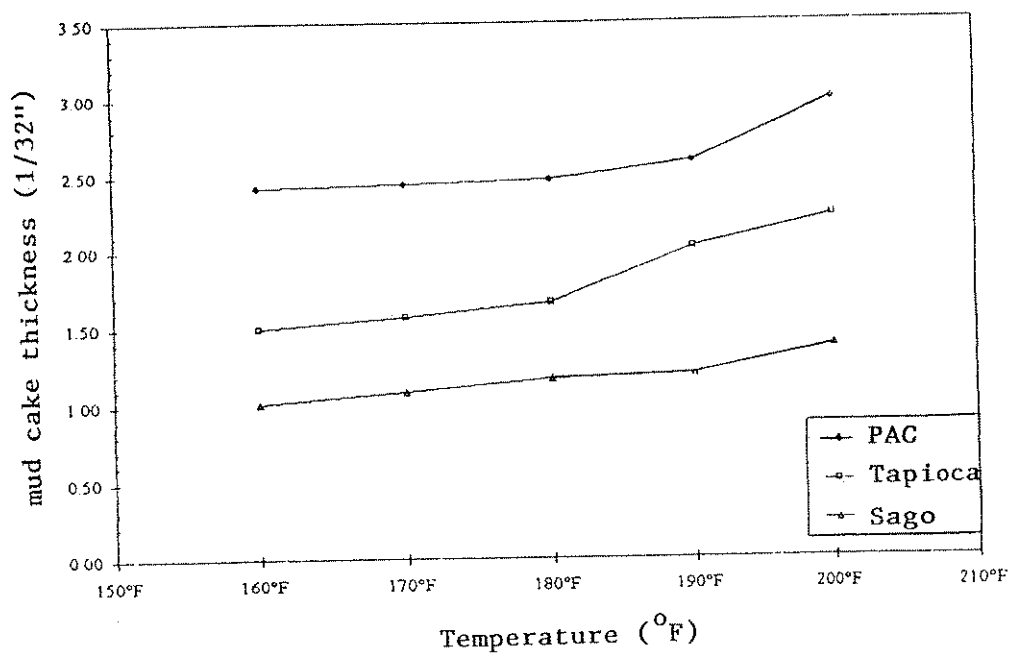


Figure 9: Mud cake thickness vs temperature for 20 cp mud.

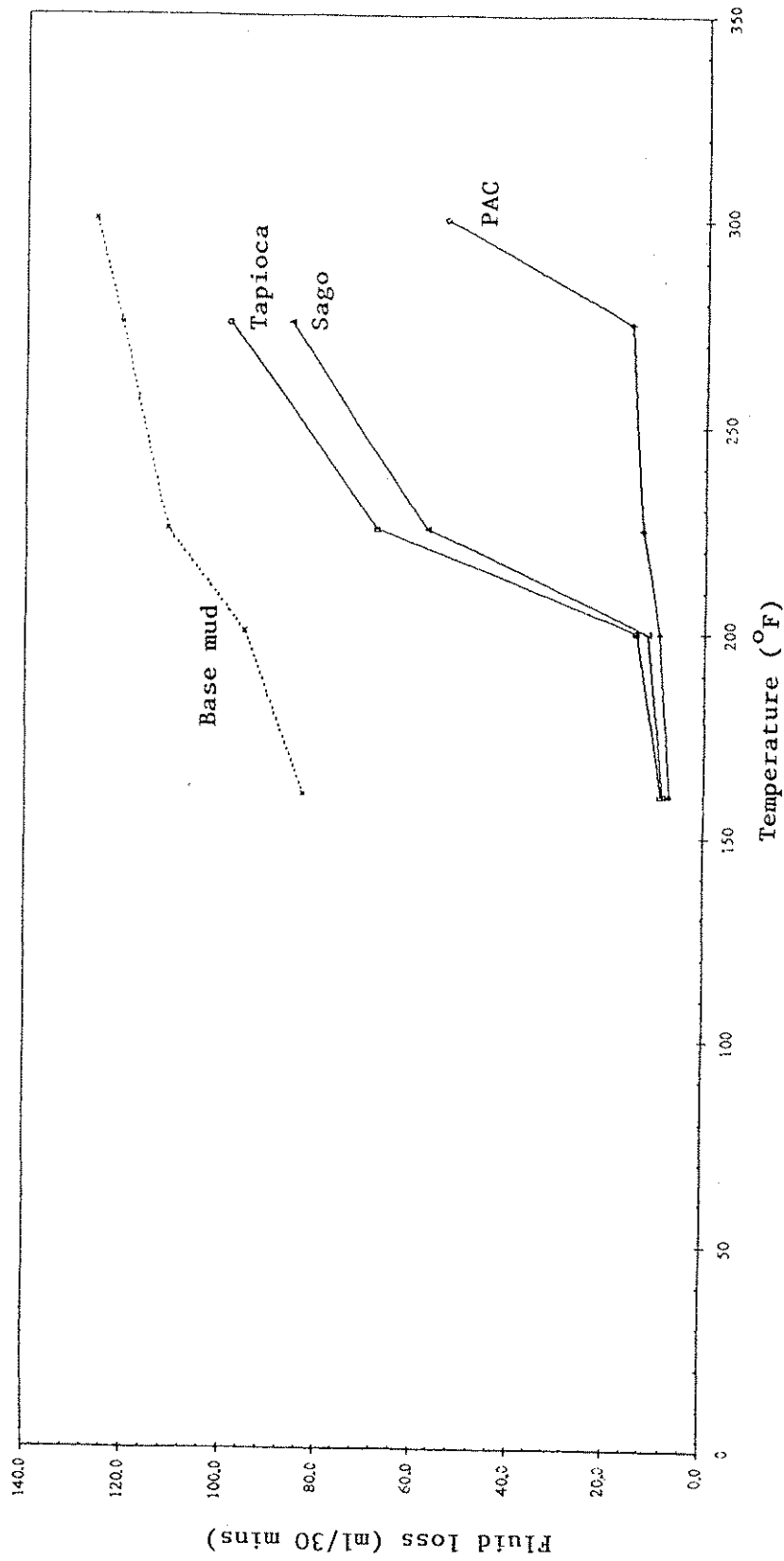


Figure 10: Fluid loss experienced by base, PAC, sago and tapioca muds vs temperature after ageing process.