Memorandum

To:

From:

Partners:

Subject: Lab No. 5: Additives/Contaminants and pH Indicators

Date:

The main objectives of this experiment were to measure the sand content of a mud sample using a retort system and a sand content kit, use a filter press to simulate the buildup of a filter cake in a drilling system, as well as evaluate the quality of a filter cake on the basis of thickness, texture, and amount of titrate. These objectives were achieved by performing a filter press, extraction of mud solids using a retort, and sand content test of a base mud sample. Graphical analysis of filter press values as well as explanation regarding the difference between the concept of retort testing and sand content are discussed in this report.

"On my honor as an Aggie, I have neither given nor received unauthorized aid on this academic work."

Executive Summary:

The main objectives of this laboratory were to recognize the effects of lime, salt, and gypsum treatment on a drilling fluid as well as measure alkalinity of a mud using pH sticks. These were achieved by collecting viscosity readings at various speeds using a viscometer for each of the three additives/contaminants tested. These data collections were repeated every time the mass of additive in the base mud sample was increased in addition to the recording of their specific yield points and 10-second gel strengths. After each increase, pH sticks were used to measure the relative acidity or basicity of the drilling fluid. The main conclusions involve how each of the additives/contaminants used affect the pH of drilling mud as well as how they affect apparent viscosity. These observations can be used to conclude how each of the three substances can be considered additives in one circumstance, but contaminants in another.

Conclusions:

- pH can be used to help determine an additive/contaminant effects on drilling fluids
  - High pH fluids help neutralize high acidity gases that can be present in certain drilling conditions.
  - High and low pH fluids can both be corrosive, which can cause damage to drilling equipment.
- Addition of lime to drilling mud causes a rapid rate of increase for pH levels, gel strength, and viscosity.
- Addition of gypsum to drilling mud causes a moderate rate of increase for viscosity and gel strength, as well as a slow decrease in pH levels.
- Addition of salt to drilling mud causes a slow rate of increase for viscosity and gel strength, as well as a moderate decrease in pH levels.

Results and Discussion:

The effects of lime on drilling mud were analyzed through studying the rheological changes to yield point, viscosity, and gel strength which were measured by the viscometer in laboratory. The initial yield point of the 400 cc base drilling mud sample was between 3 and 3.5, but after the addition of 1.5 grams of lime, the yield point drastically increased to nearly 100. Adding another 0.5 grams increased the yield point to approximately 150, which identifies it as a non-Newtonian fluid. This high yield point allows a lime saturated drilling fluid to suspend cuttings from the drill bit extremely well. This is due to having a higher viscosity than that of a fluid with a similar density and lower yield point like water. However, it was observed during the mixing process that any amount over the tipping point of 1.0 grams of lime in 400 cc of base mud, yielded a fluid which did not mix properly and had the consistency of pudding. In a drilling scenario, this can slow or cease the drilling process which makes lime both an additive and a contaminant. The lab group was first tasked with recording viscometer readings for the addition of lime to a 400 cc sample of base drilling mud. These readings were performed in descending order from 600 rpm to 6 rmp, and repeated after every incremental addition of lime. The laboratory handout initially required the addition of lime to the base mud sample in 2 gram increments, however previous lab groups determined this produced a fluid too difficult to properly analyze using the viscometer.

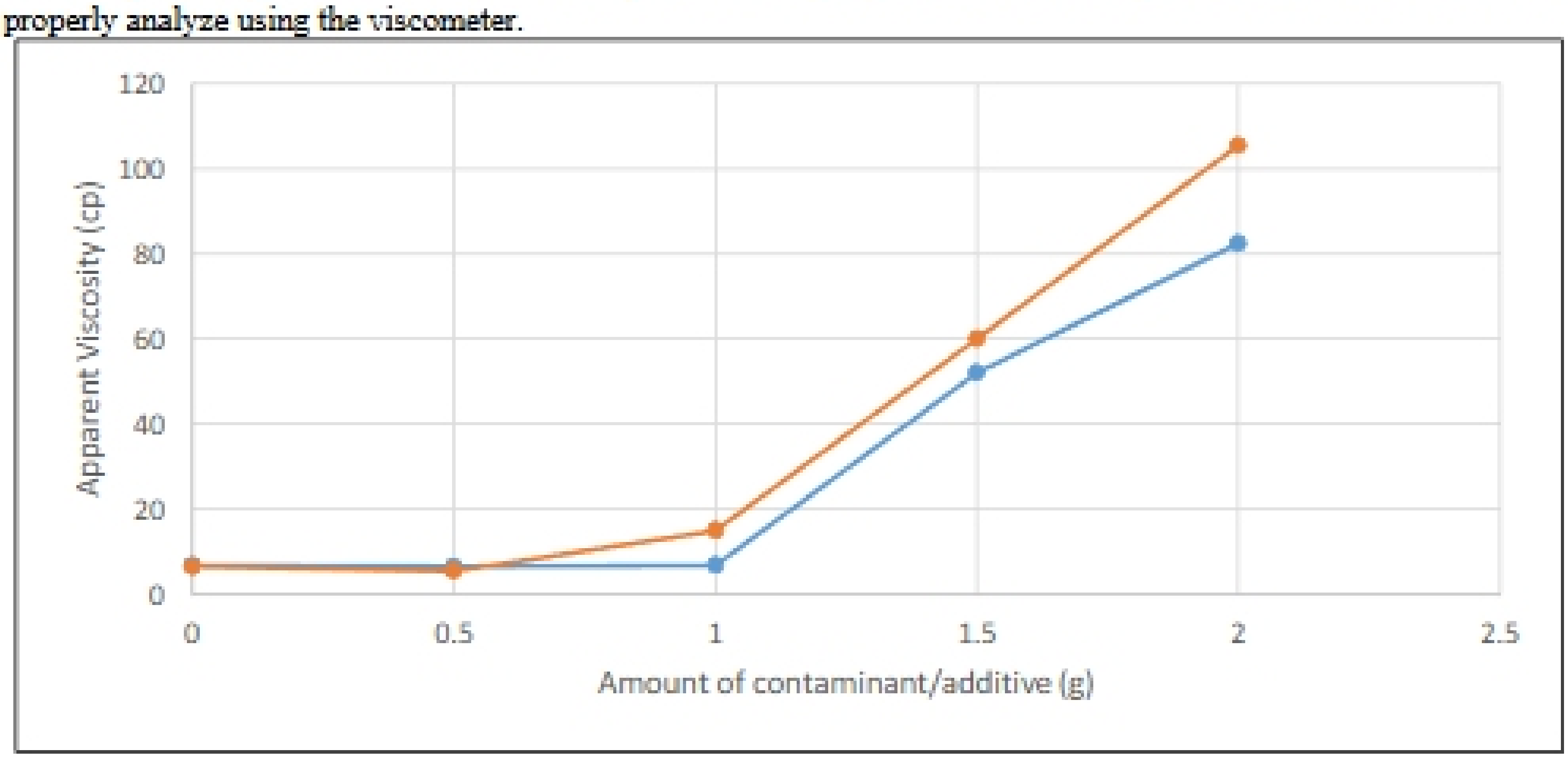

Fig. 1: Apparent Viscosity (μ_a) vs. Amount of Contaminant/Additive for Lime Addition

So the increment was changed to 0.5 grams at a time in order to produce more reliable viscometer data. The apparent viscosity was calculated for all of the fluids tested using **Eq. 1,** and involves dividing the viscometer reading at 600 rpm by 2. The apparent viscosity was plotted against the amount of lime added to the base mud and is represented in **Fig. 1**.

$$\mu_a = \frac{R_{600}}{2} \quad \ldots\ldots (1)$$

$$\mu_{a_{water}} = \frac{3.5}{2} = 1.75 \rightarrow \mu_a = 1.75$$

The figure represents two separate laboratory groups data, and it is evident after the addition of 1.0 grams of lime to the 400 cc base mud, apparent viscosity begins to increase in large increments. This furthers the groups predisposition that lime has a tipping point between an additive and a contaminant. If the lime content in a mud exceeds this tipping point, the mud will have too high of a viscosity to efficiently pump, hence temporarily crippling the drilling operation. One of the key benefits of using lime as an additive is its ability to neutralize highly acidic gases such as H_2S which can be present when drilling into reservoir rock. This is due to lime's basifying affect when added to drilling mud and is represented in **Table 1**. The table follows the same incremental addition as the viscometer tests, and helps present lime's ability to quickly increase the pH of a drilling mud.

Table 1: pH Levels for Lime Addition

Amount of Contaminant/Additive (g)	0	0.5	1	1.5	2
pH (paper) Trial 1	7.5	9	11.5	12	13
pH (paper) Trial 2	7	8	12	13	14

The table indicates the starting pH for the 400 cc sample of base mud was around 7, and after the addition of 2.0 grams of lime, the pH reading jumped to between 13 and 14. This relates back to the original predisposition that lime has a tipping point between an additive and a contaminant. A mud with too high of a pH can be corrosive and severely damage drilling equipment, but a drilling mud with too low of a pH will not be able to properly neutralize the deadly H_2S gases common in most drilling scenarios. Another characteristic of the mud pertains to the 10-second gel strength, which is determined by measuring the viscosity of the fluid after it sits undisturbed for 10 seconds. This data was recorded and plotted after each incremental addition of lime for both groups and is depicted in **Fig. 2**.

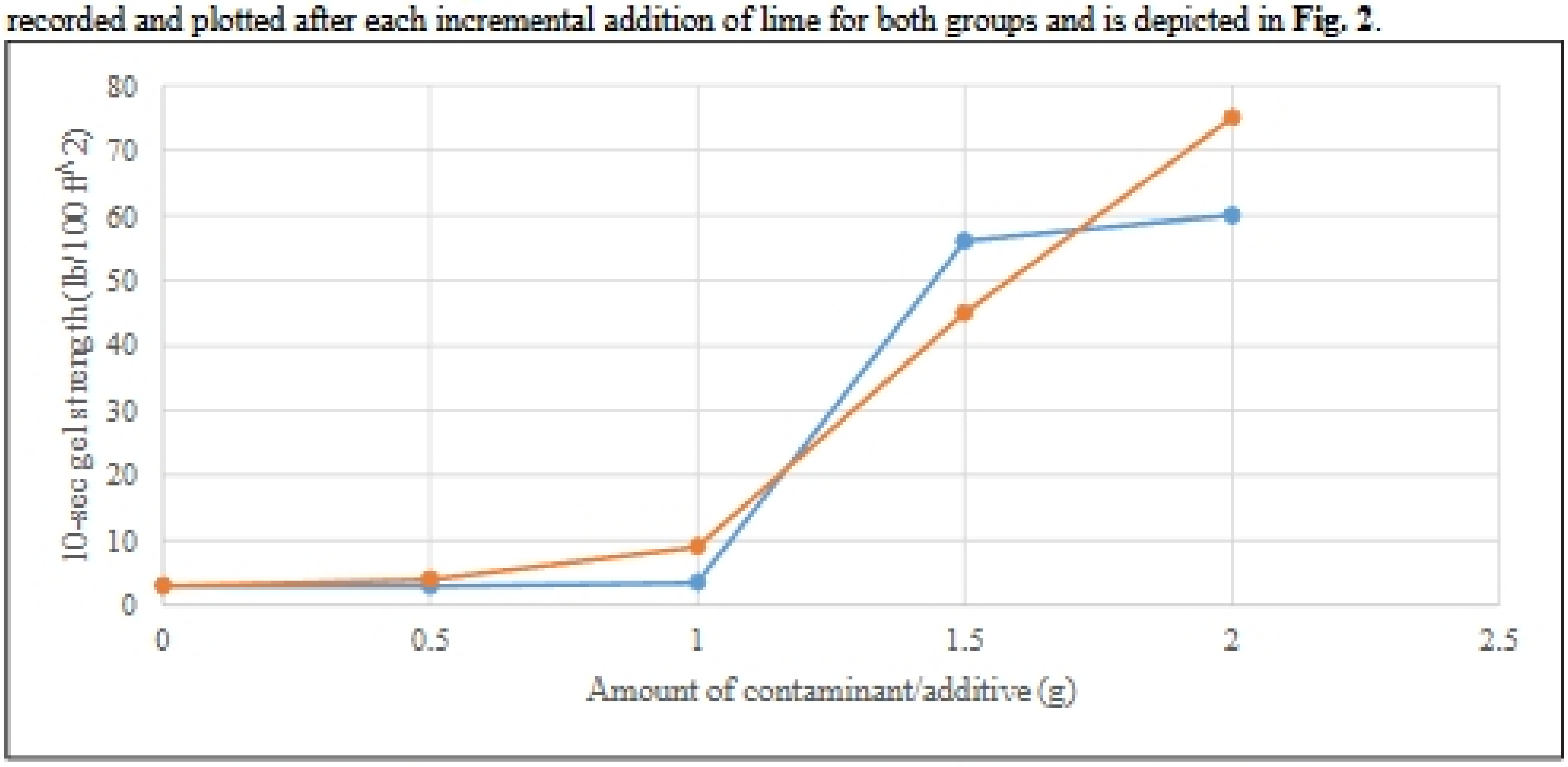

Fig. 2: 10-sec Gel Strength vs. Amount of Contaminant/Additive for Lime Addition

The gel strength vs. lime content figure closely resembles the trend of Fig. 1, in that the gel strength drastically increases after more than 1.0 gram of lime was added to the 400 cc base mud sample. This again presents the idea that there is a point at which lime becomes more of a contaminant than an additive, because too high of a lime content generates a gel strength which is incredibly hard for a pump to overcome and resume circulation. The gel strength tested in this particular lab only tested the fluids behavior after 10 seconds of stativity, whereas in a real life drilling scenario, drilling fluids can stand static for minutes to hours. Lime can serve its purpose as an additive in this laboratory below levels of 1.0 gram per 400 cc of base mud, in contrast to its contaminant behavior near and beyond 1.5 grams per 400 cc of base mud. Lime's additive behavior based upon the data collected for this laboratory setting consist of a pH range of 7 to 11.5, an approximate apparent viscosity of 6.75 (cp), and a gel strength between 3 $\frac{lb}{100\,ft^2}$