To: Professor Hecker

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Subject: Proposal to characterize non-Newtonian fluid and evaluate piping system

**Introduction**

The plant needs to determine the rheology of the methocel solution in the Unit Operations Lab to know if the current piping system is adequate to deliver the solution to the plant (the existing system uses a 2” schedule 40 steel pipe that is 600 feet long with less than 250 psi pressure drop). If it is not adequate, another system that will work must be designed.

**Theory**

DOW Chemical lists methocel solutions as pseudoplastic fluids, which can be approximated by a relation known as the power law. It is assumed that methocel is a power law fluid. The power law is of the form:

where is shear stress, and are empirically determined constants, and is a change in velocity per change in radial distance. is calculated by the equation

which requires the pressure drop (*R*) and pipe radius, both of which are specified. In order to determine and , the relation

is used. By fitting shear stress and velocity to a line, and can be determined. This will also show the validity of the assumption that the fluid follows the power law. The equation for friction loss due to flow through a circular pipe is

where P is pressure, f is the Darcy friction factor, L is the length of the pipe, v is average velocity through the pipe, and D is the inner diameter of the pipe.

To calculate , a modified Reynolds number, given by

is used to look up the value of on a Non-Newtonian Moody chart.

In a system using water, the Reynolds number and friction factor would be given by

(turbulent).

When the viscosity and density of water are used, turbulent flow and a friction factor of 0.021 are computed, which results in a pressure drop of 26 psi over the length of the pipe in the system under scrutiny. (This is well within the safety limits of the system)

Once is acquired, an estimate of the pressure drop can be obtained with the above relations. The calculated pressure drop is expected to be below the actual pressure drop because copper piping (the pipe in the test apparatus) is smoother than schedule 40 steel. This results in a lower friction factor, and about 20% lower pressure drop for water in the existing system. To be safe, the calculated methocel pressure drop should be at least 20% lower for the existing system than the rating of the rupture disk in place.

**Experimental Design**

To find the shear stress versus velocity relation of the methocel solution, methocel will travel through two different piping systems at different flow rates and once the system has reached steady state, the pressure drop across a preset distance will be measured. A randomization table will be used to ensure statistical significance. The flow rates will be set by manipulating a control valve opening to ten different settings, and measuring from two different pipes.

**Expected Outcomes**

It is expected that n have a value of less than 1 in the power law since methocel is a pseudoplastic fluid. Pipe size should not change n or K. Because of the small pressure drop predicted for water flowing through the pipe, it is somewhat likely that a 1% methocel solution should flow through the pipe without too much pressure drop.