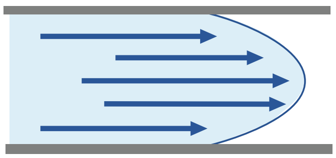
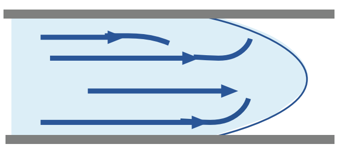
Friction Flow Loop Testing

General Guidelines

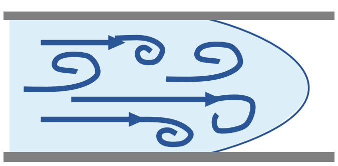
Flow Patterns and Reynolds Number



Laminar Re<2300

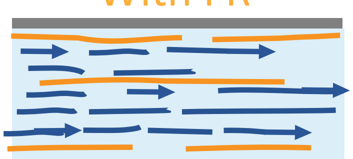


Transition Re=2300-2400



Turbulent Re>4000

With FR



Turbulent Re>4000

During hydraulic fracturing operations, large amounts of slickwater fluid and sand are pumped downhole at flow rates up 100 bbl./min. At these pump rates, the use of a friction reducer (FR) enables the pumpers to achieve those high rates while reducing friction pressures. The Reynolds number (Re) is used to describe the rate of flow and the amount of force that is being generated. In the field, those Re values can be greater than 1 million.

The Reynolds number is calculated from the fluid's velocity, density, viscosity and the pipe's diameter. Fluid flow can be characterized by one of three flow regions quantified by the Re. The laminar region (Re < 2300), where fluid flows through a pipe in an orderly manner, the transition region (Re = 2300-4000), where fluid flow becomes more erratic, and the turbulent region (Re > 4000), where flow becomes erratic and disorderly. The irregular flow pattern under turbulent conditions increases pipe friction and reduces fluid pressure. To overcome these pressures, higher pumping rates, i.e. more horsepower, are required. When a FR is used, the polymer stretches out in the direction of flow, stabilizing the flow patterns, reducing pipe friction, and as result higher pump rates are obtained at lower horsepower.

Simulating field conditions (i.e. 100 bbl./min) in the lab would be costly and unrealistic. To transition from the field to the lab, the testing equipment is scaled down to make the measurements feasible. These changes reduce the Re value and shear rates that can be achieved under lab conditions. To ensure that these flow characteristics are still applicable to field conditions, the Re in the friction loop must be above turbulent region threshold of 4000. However, once above 4000, the range at which testing should be completed (10,000 or 100,000) is not standardized and still magnitudes smaller than the field.

As a result, the Re value of a friction flow loop should not be the sole criteria for validation of the results. Measurements taken at higher Reynolds number will report higher % friction reduction achieved in the instrument, but do not indicate better sensitivity than other equipment.

Friction Flow Loop Testing

20+

Friction Loop Design

0

Standards

>4

Design Variables

No lab instrumentation can currently match field conditions, therefore the results generated can only provide general guidance on performance of one product vs. another. While these results help users select the right FR for the application, they cannot be used as a direct value for friction reduction observed in the field. Many institutions have built friction flow loops to measure FR performance in the lab. To quantify the performance of FRs, the pressure drop across a length of pipe is monitored at a controlled flow rate. Pressure changes are measured before and after the addition of the FR. The resulting pressure change is reported as % friction reduction.

A literature search on these units showed that over 20 different flow loop designs are currently in use. This highlights the lack of standardization for friction reducer testing across the industry. Differences in equipment design include pipe diameter, length, and flow rate, which impact the Re and shear generated. A change in one parameter, will affect the % friction reduction measured and create variability in data reported. Measuring a single FR on multiple equipment designs would provide a range of values. Each test result is specific only to the friction loop used. This results in variations that do not allow an apple-to-apples comparison of product performance from one unit to another.

When performing FR evaluations, it is important to use the same equipment for all rounds of testing. This allows for a direct comparison of performance between products and water types. While results outputs will vary by instrument when properly correlated to the field, the data generated provides valuable information on a friction reducer's performance range and fit for a specific frac application. To learn more about performing test or interpreting results, contact us today to learn about our training services.

General Schematic of a Friction Loop