



# Optimized Milling Operations ECWS Fluid Rheology System

## Fluid Rheology

Essential Coil Well Service provides a Fluid Rheology System (FRS) that comprises of our Fluid Pump, Chemical Van and Engineered Job Modeling. This setup provides real-time monitoring and optimizing of Fluid Rheology by determining the Reynolds Number to maintain ideal flow regime.



## Features and Benefits

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- Optimization of Rheological metrics for solids transport
- Reduce cycle meters with less wiper trips
- Optimization of chemical consumption (eliminates gel sweeps)
- Reduced operating hours
- Real-time monitoring of Fluid Rheology

### Case Study – 8 Well Bridge Plug Mill-Out

On a recent post-frac bridge plug milling project, using the newly designed milling metrics, ECWS was able to reduce operating time, decrease chemical costs and improve overall efficiencies.

#### Comparison of Bridge Plug Mill-Out Campaigns in Montney

| Description                 | Milling using Old Metrics | Optimized Milling using FRS |
|-----------------------------|---------------------------|-----------------------------|
| Deepest Well TD (mMD)       | 5030                      | 5656                        |
| Total Plugs Milled          | 132                       | 139                         |
| Gel Pumped (L)              | 730                       | 0                           |
| Average Wiper Trips/Well    | 1.5                       | 0                           |
| Operating Hours/Plug Milled | 2.68                      | 2                           |

- 32% reduction in milling costs using the optimized milling
- Elimination of gel costs
- Elimination of wiper trips
- Reduced cycle meter charged

### Chemical Van – Technical Specifications

- 2 x Waukesha & 4 x Eagle PC Pumps
- Accurate Chemical Injection to 0.05 L/min
- 6-10 Heated 1,000 L Chemical Tote Storage
- Lab Area including OFITE 900 Automated Viscometer
- Data Recording System
- PID system allowing remote and automated operation with feedback control system to keep required chemical loading consistent under changing pump rates



### Twin Fluid Pumps – Tech. Specifications

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- 10,000-15,000 psi Operating Pressure Rating
- 660 hp to 1,500 hp Deck Engines
- Dual 2.0-5.0 m<sup>3</sup> Mixing Tanks with Overfill Alarms
- Shear Pumps and Chemical Injection Ports
- Pump-to-Coil Data Network onto OrionNET
- Fluid Rates, Fluid Totals, and Annular Velocity (AV)
- Real-Time Density Measurement
- Data Recording System



## Fluid Rheology

### Fluid Rheology Tracking Sheet

- Daily Chemical Treatment Report
- Measurements of Viscosity, Density, Annular Velocity, and Reynolds Number
- Specialized Chem Van Operator
- 24 Hour Engineering and Field Superintendent Support
- AV and Viscosity vs. Time Graph
- Reynolds Number vs. Time Graph

Fluid Rheology Metrics      AV and Reynolds Number (Input and Return Parameters)      Chemical Usage and Loading Records

**ESSENTIAL COIL WELL SERVICING TOUR REPORT**

|                 |                        |                  |           |
|-----------------|------------------------|------------------|-----------|
| Client:         | Chem Van#:             | Pump #:          | Job #:    |
| Oil Company:    | Operator:              | Rig #:           | Ticket #: |
| UWI (Downhole): | OD of CT (mm): 60.30   | Type of Service: |           |
| Province:       | Casing ID (mm): 111.90 | Date:            |           |

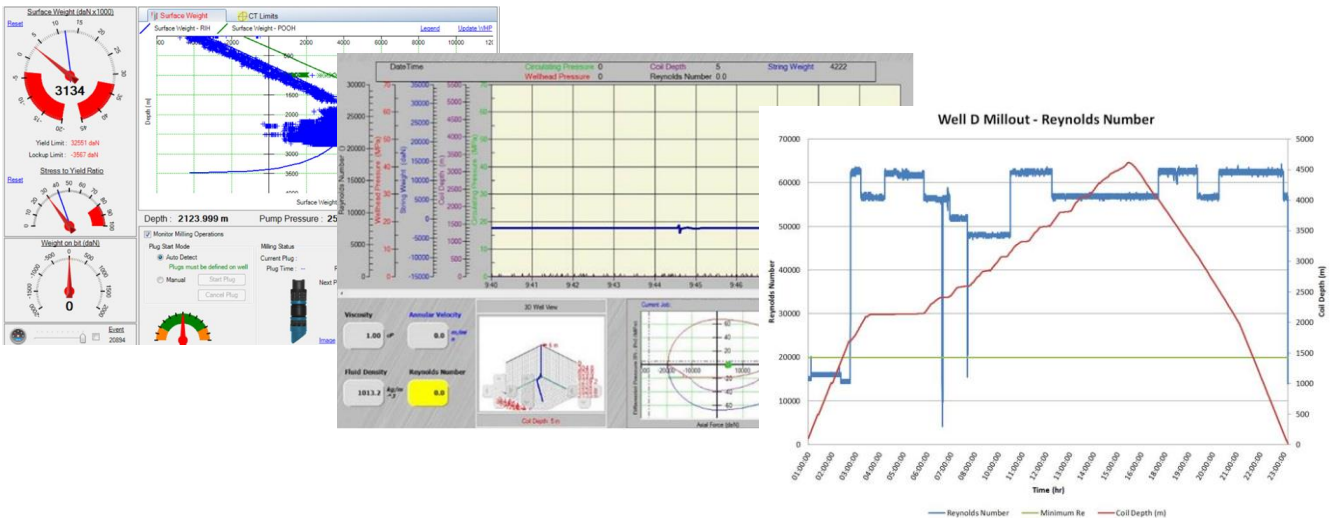
| Event # | Time  | Elapsed | Comments             | Visc. Reading: 300 rpm (SS) | Visc. Reading: 600 rpm (SS) | Visc. Reading: Marsh Funnel (SS) | Salinity (%) | pH Reading (0-14) | Fluid Temp. (°C) | Density (g/cm <sup>3</sup> ) | Dynamic Viscosity (cP) | Effective Viscosity (cP) | Annular Velocity (m/s) | Reynolds Number (Injection) | Reynolds Number (Return) | Return Rate (l/min) | Pump Press (MPa) | Pump Rate (l/min) | # of Chems | Type of Chemical | Loading (L/m <sup>2</sup> ) | Chem. Volume (L) | Coil Tube Total (L) | PPR Total (L) | HPG Total (L) |
|---------|-------|---------|----------------------|-----------------------------|-----------------------------|----------------------------------|--------------|-------------------|------------------|------------------------------|------------------------|--------------------------|------------------------|-----------------------------|--------------------------|---------------------|------------------|-------------------|------------|------------------|-----------------------------|------------------|---------------------|---------------|---------------|
| 1       | 0:01  | 0:00    | Fluid Sample         | 0.9                         | 2.0                         | 25.0                             | 0.9          | 7.0               | 90.0             | 1005.0                       | 1.0                    | 1.0                      | 0.962                  | 43,976.6                    | 43,976.6                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 5.0                 | 0.0           | 0.0           |
| 2       | 0:01  | 0:30    | Start HP Rig 0.5L/HP |                             |                             |                                  |              |                   |                  |                              |                        |                          | 0.120                  |                             |                          | 50.0                | 35.0             | 50.0              | 1          | Coil Tube        | 0.1                         | 22.0             | 22.0                | 0.0           | 0.0           |
| 3       | 1:00  | 1:00    | Return Fluid Sample  | 0.9                         | 2.5                         | 27.0                             | 1.2          | 7.0               | 21.0             | 1090.0                       | 1.3                    | 2.0                      | 0.601                  | 24,301.7                    | 24,301.7                 | 250.0               | 35.0             | 250.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 4       | 2:00  | 1:00    | Fluid Sample         | 0.9                         | 2.4                         | 26.0                             | 3.0          | 7.0               | 22.0             | 1020.0                       | 1.2                    | 1.0                      | 0.962                  | 41,964.3                    | 41,964.3                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 5       | 3:00  | 0:00    | Fluid Sample         | 1.0                         | 2.3                         | 26.0                             | 7.0          | 7.0               | 24.0             | 1040.0                       | 1.2                    | 1.0                      | 0.962                  | 44,647.5                    | 44,647.5                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 6       | 3:05  | 0:02    | Fluid Sample         | 1.0                         | 2.4                         | 26.0                             | 7.0          | 7.0               | 15.0             | 1009.0                       | 1.2                    | 1.0                      | 0.601                  | 25,944.9                    | 25,944.9                 | 250.0               | 35.0             | 250.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 7       | 4:00  | 1:00    | Fluid Sample         | 1.0                         | 2.5                         | 26.0                             | 2.0          | 7.0               | 18.0             | 1071.0                       | 1.3                    | 1.0                      | 0.962                  | 33,330.3                    | 33,330.3                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 8       | 5:00  | 1:00    | Fluid Sample         | 0.9                         | 2.6                         | 26.0                             | 4.5          | 7.0               | 22.0             | 1028.0                       | 1.3                    | 1.0                      | 0.962                  | 39,040.1                    | 39,040.1                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 9       | 6:00  | 1:00    | Fluid Sample         | 1.0                         | 2.4                         | 26.0                             | 1.2          | 7.0               | 17.0             | 1005.0                       | 1.2                    | 1.0                      | 0.601                  | 25,942.0                    | 25,942.0                 | 250.0               | 35.0             | 250.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 10      | 7:00  | 1:00    | Fluid Sample         | 0.9                         | 2.3                         | 26.0                             | 3.1          | 7.0               | 12.0             | 1052.5                       | 1.5                    | 1.0                      | 0.962                  | 34,473.7                    | 34,473.7                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 11      | 8:00  | 1:00    | Fluid Sample         | 1.0                         | 2.5                         | 26.0                             | 2.8          | 6.0               | 16.0             | 1052.5                       | 1.3                    | 1.0                      | 0.962                  | 33,369.5                    | 33,369.5                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 12      | 9:00  | 1:00    | Fluid Sample         | 1.1                         | 2.9                         | 26.0                             | 2.8          | 7.0               | 18.0             | 1005.0                       | 1.4                    | 1.0                      | 0.601                  | 21,460.5                    | 21,460.5                 | 250.0               | 35.0             | 250.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |
| 13      | 10:00 | 0:42    | Fluid Sample         | 1.0                         | 5.0                         | 26.0                             | 2.8          | 7.0               | 18.0             | 1052.5                       | 2.5                    | 1.0                      | 0.962                  | 19,594.8                    | 19,594.8                 | 400.0               | 35.0             | 400.0             |            |                  |                             |                  | 22.0                | 0.0           | 0.0           |



## Fluid Rheology

### Real-Time Reynolds Number

- Data acquisition of Fluid Density and Annular Velocity with multiple samples of Viscosity per hour to provide accurate and up to date Reynolds Number
- Data Connection between Fluid/N2 Pumps and CT Rig to display Real-Time Reynolds Number on CTES OrionNET
- Display Von Mises criteria real-time to ensure operating within CT limits
- Real-time data acquisition to generate WOB, accurate surface weight vs. depth graph and live CoF matching.



## Fluid Rheology

### P&ID

- Viscosity reading will be obtained from sample point on Fluid Pump
- Density reading will be recorded by Fluid Pump DAS
- Optimize flow regime for High AV, Low Viscosity and High Reynolds Number

