LAOS with MITlaos: What I did This Summer

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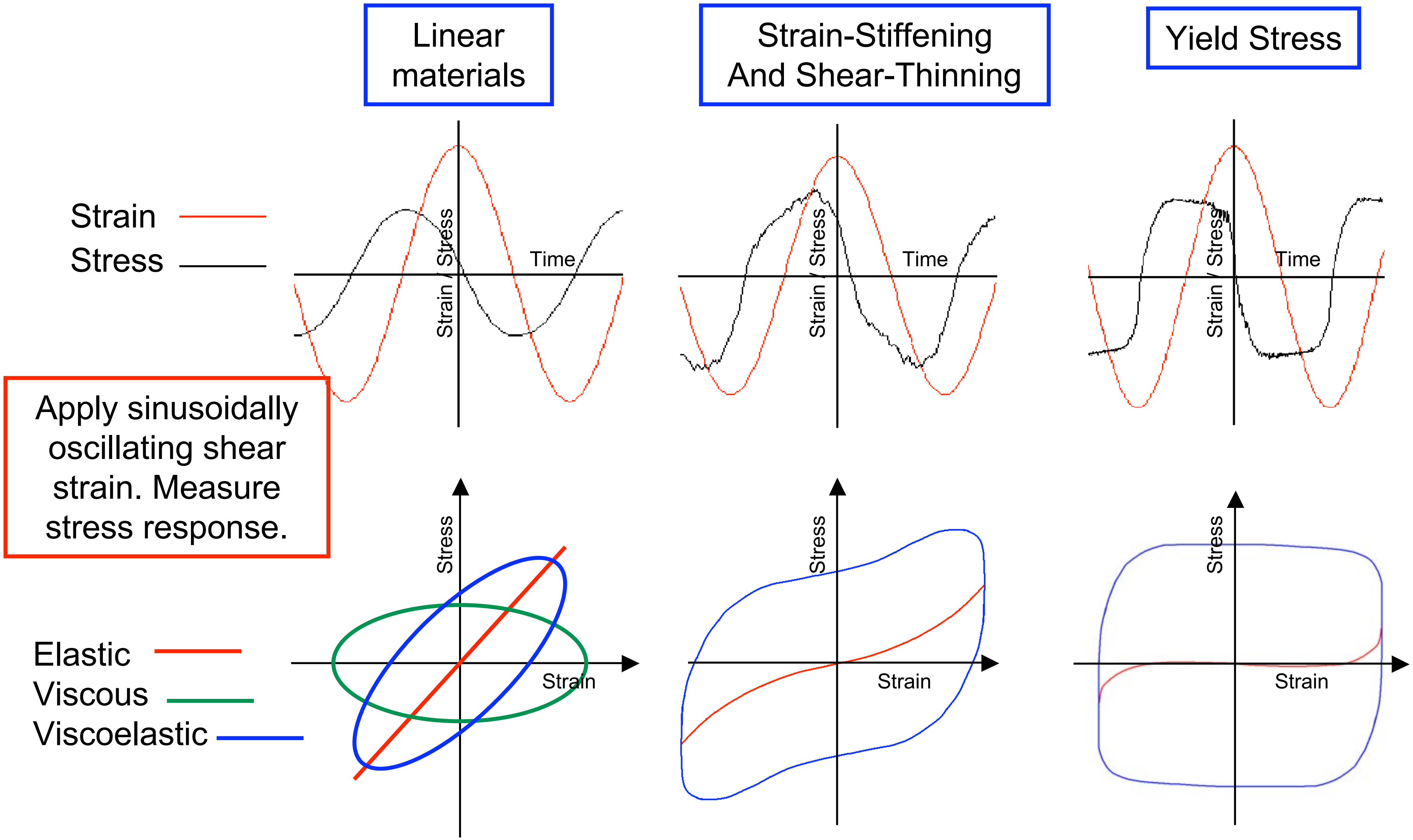
Large Amplitude Oscillatory Shear



Apply sinusoidally oscillating shear strain. Measure stress response.

Elastic components = $f(\gamma)$

$$\gamma(t) = \gamma_o \sin(\omega t)$$

Viscous components = $f(\dot{\gamma})$

$$\dot{\gamma}(t) = \gamma_o \omega \cos(\omega t)$$

$$\tau(t;\omega,\gamma_o) = \gamma_o \{\sum_i G_i'' \cos(i\omega t) + G_i' \sin(i\omega t)\}$$

$$\tau(t;\omega,\gamma_o) \equiv \tau_{even}(\gamma(t)) + \tau_{odd}(\dot{\gamma}(t))$$

Fourier Transform

(Due to symmetry even harmonics drop out)

T_i is a Chebyshev Polynomial

$$T_i(y) \equiv T_i(\cos\omega t) = \cos(i\omega t)$$

Elastic Components

$$\tau_{even} = \gamma_o \sum_{i=1}^{N} e_i T_i(x)$$

$$x \equiv \gamma(t)/\gamma_o = \sin(\omega t)$$

$$e_1 \to G'(\omega)$$

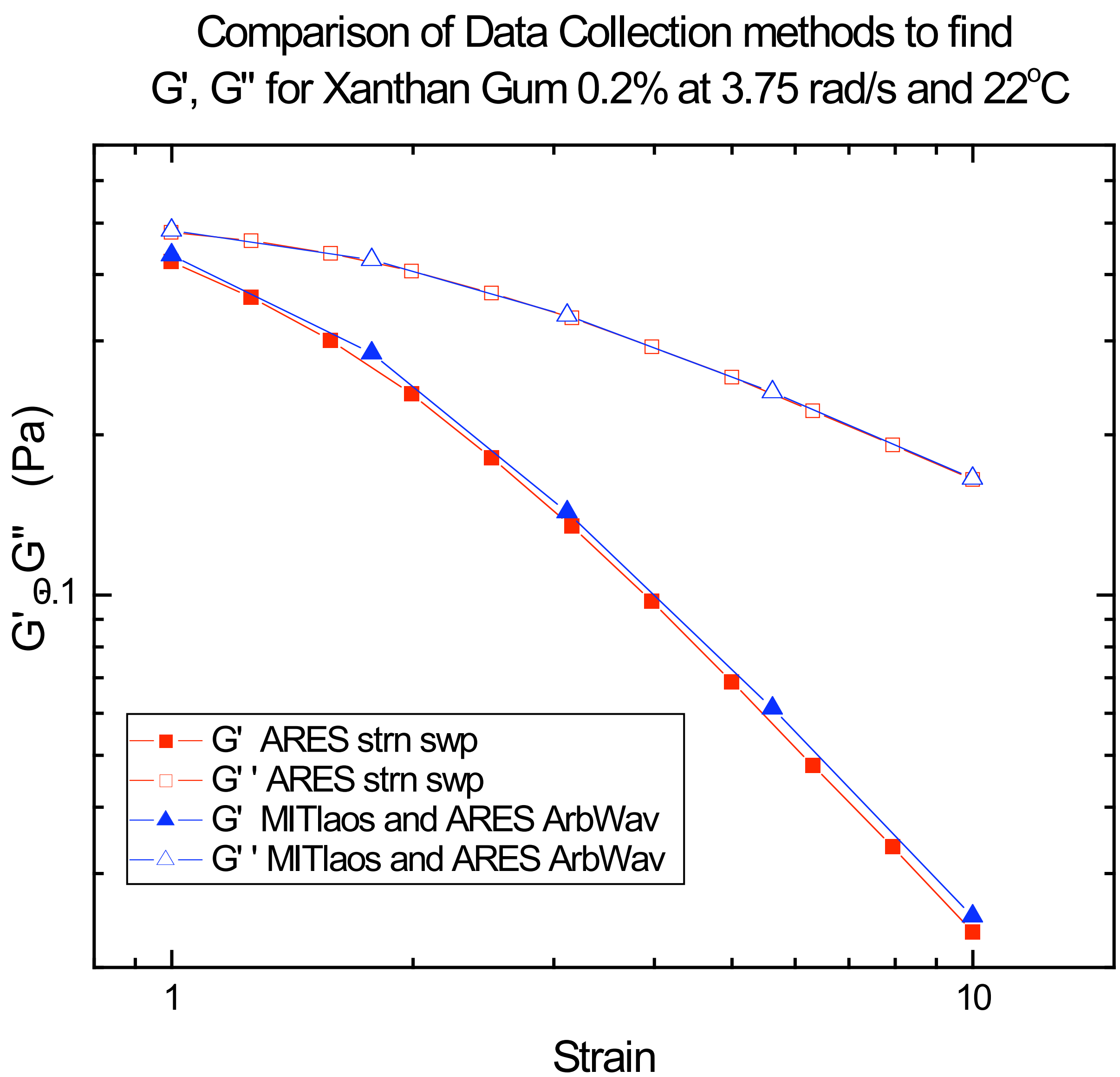
Viscous Components

$$\tau_{odd} = \gamma_o \omega \sum_{i=1}^{N} v_i T_i(y)$$

$$y \equiv \dot{\gamma}(t)/(\gamma_o \omega) = \cos(\omega t)$$

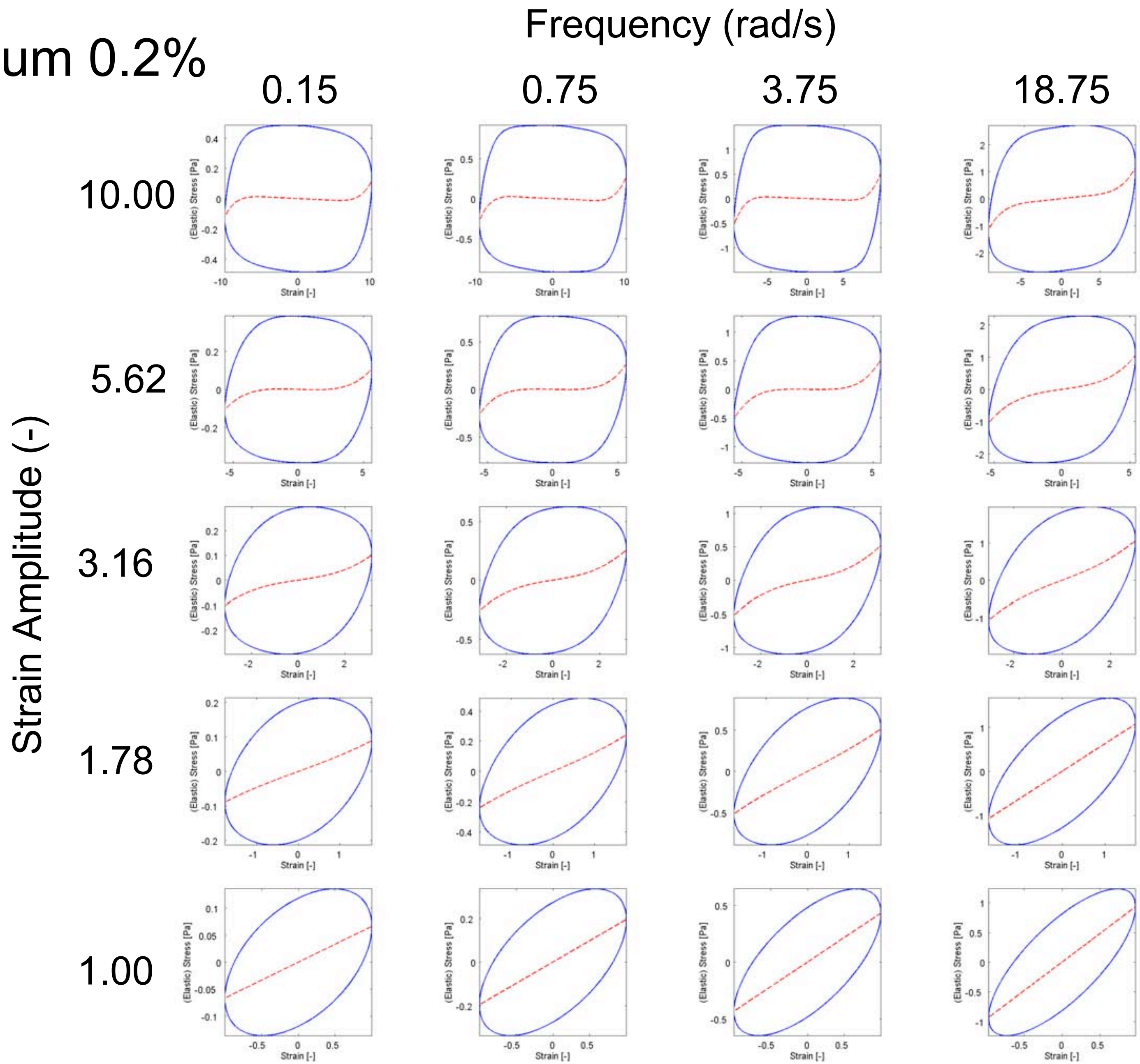
$$v_1 \to G''(\omega)$$

MITlaos Demo


Comparison of Data Collection methods to find
G', G" for Xanthan Gum 0.2% at 3.75 rad/s and 22°C
G', G" (Pa)
0.1
1
10
Strain
G' ARES strn swp
G' ' ARES strn swp
G' MITlaos and ARES ArbWav
G' ' MITlaos and ARES ArbWav

Xanthan Gum 0.2%

T = 22°C
No pre-shear

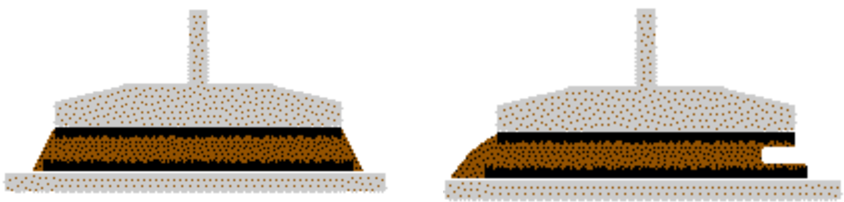


About Drilling Fluids

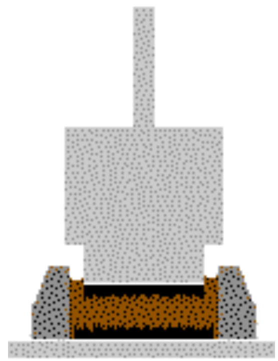
Material Components:
Mineral Oil base
Suspension of Barite Particles (average~25 micron, range: 1 to >200 micron)
(Drilling Fluid #1 has Manganese Tetraoxide)

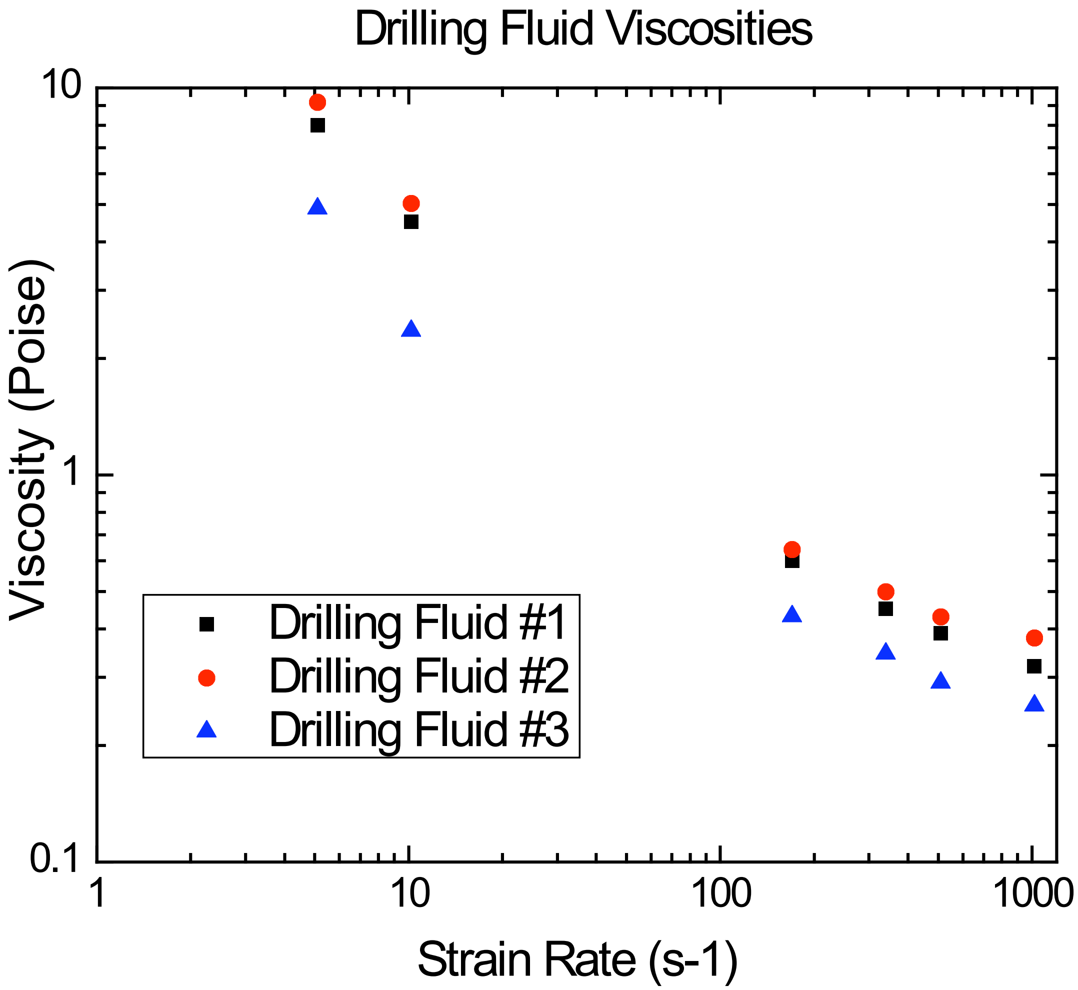
Complex Fluid Properties:
slip,Yield stress, Thixotropy,

Original Setup:
-50 mm Peltier Plate
-Sandpaper: Grid 600
-0.2 - 0.5 mm Gap



Current Setup:
-25 mm Peltier Plate
-Sandpaper: Grid 600
-0.50 mm Gap
-30 mm ring w/vacuum grease



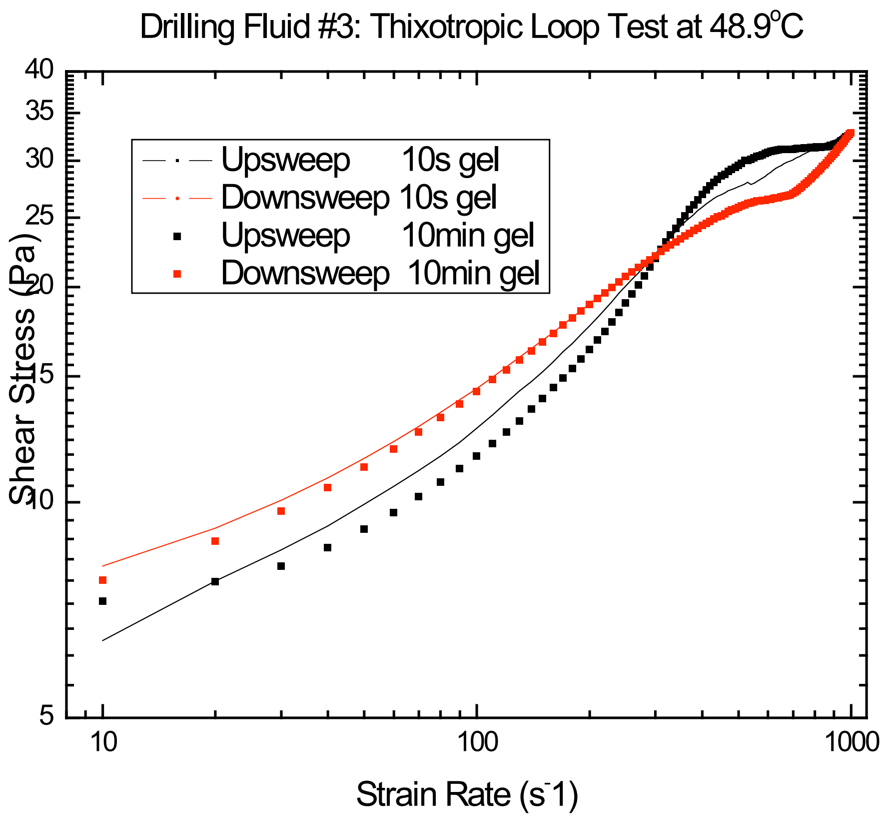


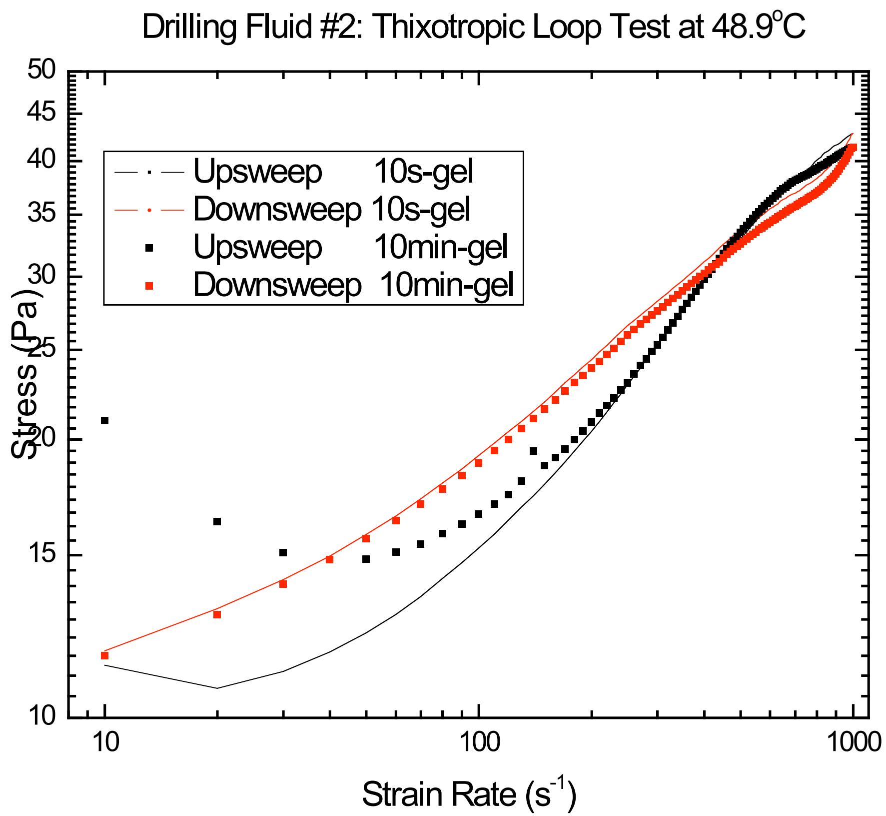
All Data Provided By
Baker Hughes

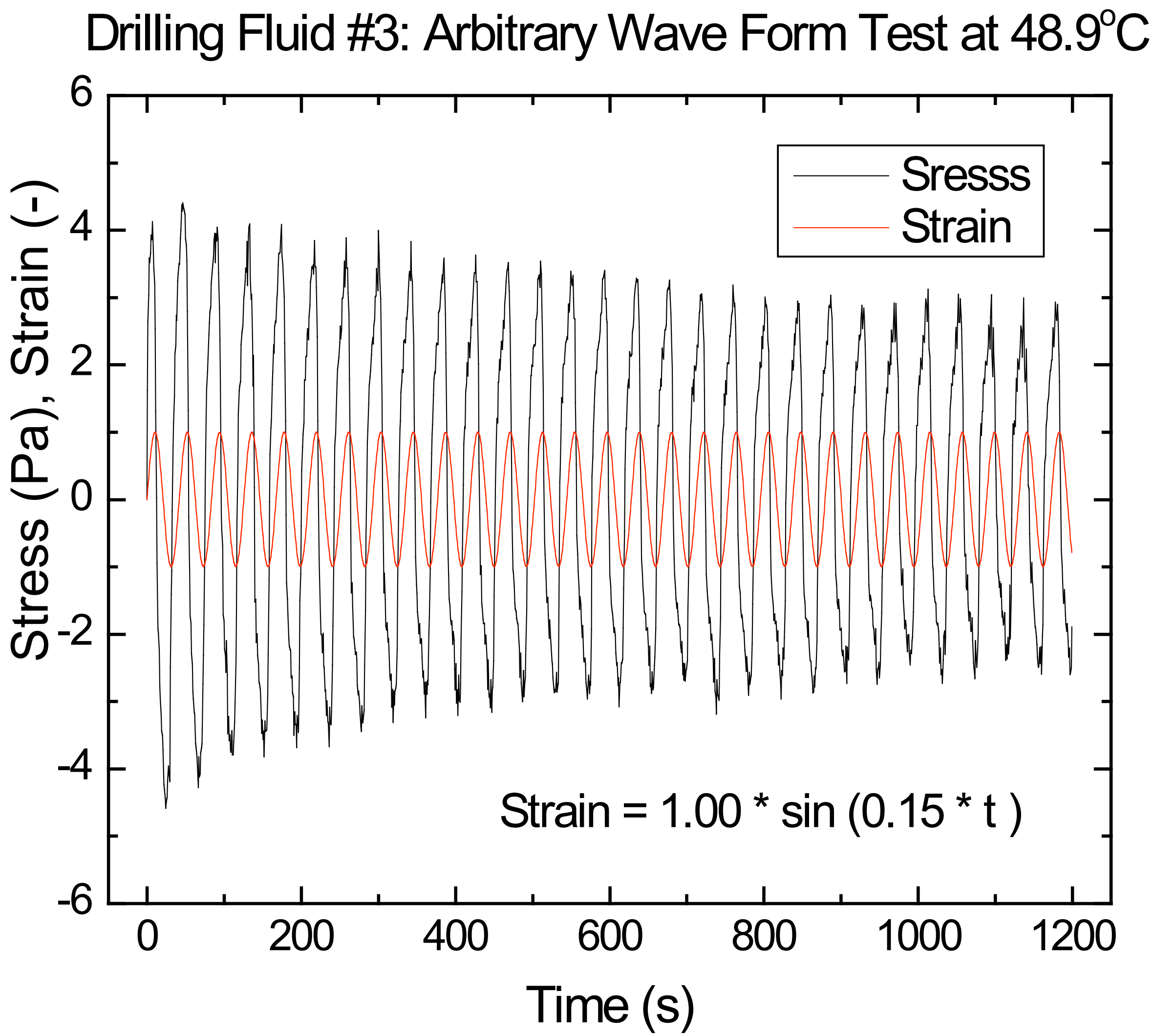
Drilling Fluid Density
Drilling Fluid #1: 1.68g/ml
Drilling Fluid #2: 1.65g/ml
Drilling Fluid #3: 1.56g/ml

Thixotropic Loop Test

1) Pre-shear of 1022 s^{-1} for 60s
2) Wait 10 s or 10 min
3) Upsweep: Linearly increase Shear Rate from 0 to 1000 s^{-1} over 450s
4) Downsweep: Linearly decrease Shear Rate back down to 0 s^{-1} over 450s

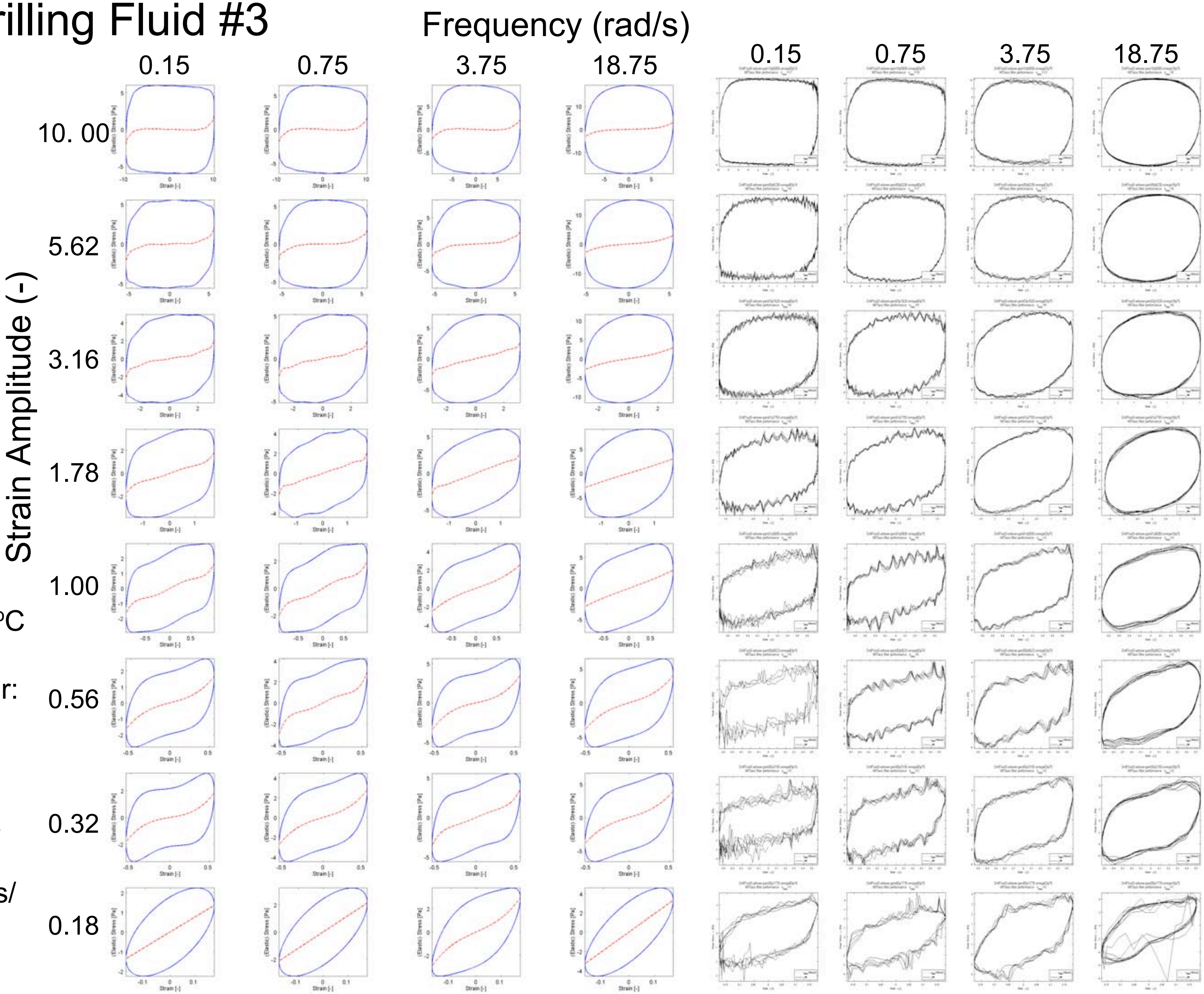






Drilling Fluid #3: Arbitrary Wave Form Test at 48.9°C
Stress (Pa), Strain (-)
Time (s)
Sresss
Strain
Strain = 1.00 * sin (0.15 * t)
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000
1200

Drilling Fluid #3



T = 48.9°C

pre-shear:
1022 s^{-1}
for 60s

Rest 10s

~7 cycles/
test