Dynamic Shear Rheometer

- **Purpose**
  - viscous and elastic properties
  - effect of temperature
- **Output**
  - Complex Shear Modulus ($G^*$)
  - Phase Angle ($\delta$)
Pavement Temperature, C

-20 20 60 135

Y- axis

Viscous Behavior

Elastic Behavior

High Temperatures

Low Temperatures
Viscous Behavior

\[ G_{1}^{*} \]

Elastic Behavior

\[ G_{2}^{*} \]

both viscous and elastic behavior

\[ \sin \delta = \frac{\text{Viscous Part}}{G^{*}} \]

Asphalt 1

Elastic Part

Viscous Part

Asphalt 2

Elastic Part

Viscous Part
Specimen Preparation

- Set “Gap” Between Spindle Base
  - gap controls specimen thickness
  - micrometer wheel adjusts gap
  - set at test temperature
  - high temperature gap = 1000 microns (1mm)
  - intermediate temperature gap = 2000 microns (2mm)
  - use extra 50 microns (0.05 mm)
Plate Geometry

- 25 mm plate diameter with 1 mm gap
  - original binder
  - RTFO residue
- 8 mm plate diameter with 2 mm gap
  - PAV residue
25 mm Plate with Sample

Initial Gap Setting

Micrometer Wheel
Spindle
Fixed Base

1000 or 2000 micron + 50 microns (sample shape)
1050 microns or 2050 microns
Specimen Preparation

- Use mold
Spindle
Excess Asphalt
Fixed Base

Spindle
After trimming
Fixed Base
Remove the extra 50 microns

Spindle

Proper Amount of Asphalt

Fixed Base

Motor

Parallel Plates with Sample

Area for Liquid Bath
Test Equipment

- Motor
- Parallel Plates
- Area for Liquid Bath

Applied Constant Stress

Oscillating Spindle

Binder Sample

Fixed Base
Spindle Begins at A

Start of Cycle ...

Spindle Moves From A to B
Spindle Moves From B to A

Spindle Moves From A to C
One cycle is completed...

**Spindle Moves From C to A**

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**Spindle Position**

- A
- B
- C

- Time

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**Applied Shear Stress**

- $\tau_{\text{max}}$

**Resulting Shear Strain**

- $\gamma_{\text{max}}$

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**lag time, $\delta = 0 \text{ deg} = \text{(Elastic)}**

- Time lag = $\delta$

**lag time, $\delta = 90 \text{ deg} = \text{(Viscous)}**

- Time lag = $\delta$

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H.A.W 1.4 29

H.A.W 1.4 30
Shear Stress ($\tau$) and Shear Strain ($\gamma$)

\[
\tau = \frac{2T}{\pi r^3}
\]

\[
\gamma = \frac{\Theta r}{h}
\]

Tester Equipment

- **Temperature Control**
  - ± 0.1 degrees C
  - circulating water bath
Overview of Procedure

- **Specimen Temperature**
  - stabilize temperature
  - equilibrate temperature (5+ minutes)

- **Initialize Software**

- **Set / Verify Software Settings**
  - set stain
  - strain rate = 10 rad/sec (1.59 Hz \(\cong\) 90 kph)

Set Strain

![Complex Modulus, G * vs Shear Strain (\(\gamma\)), %](image)

- "Linear Viscoelastic Limit"
Overview of Procedure

- **Run Test**
  - condition specimen for 10 cycles
  - obtain data from 10 addition cycles
- **Print Results**
  - $G^*$ and $\delta$

Data Analysis and Presentation

- **Calculate $G^*/\sin \delta$**
  - stiffness at high service temp.
  - $\geq 1.00$ kPa for unaged binders
  - $\geq 2.20$ kPa for RTFO aged binders
- **Calculate $G^* \sin \delta$**
  - viscous part at intermediate temps
  - $\leq 5000$ kPa for PAV aged binders
Calibration and Standardization

- **Temperature**
  -- dummy specimen
- **Load and Strain Transducers**
  -- manufacturer
- **Overall Calibration**
  -- reference Asphalt

THANK YOU