Modified Asphalt Testing and Characterization

Understanding Modified Asphalt Binder Technology Workshop

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Paramount Petroleum

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Objectives

- Gain a basic understanding of modified asphalt, it's testing and characterization.
- Know the basic purpose of the more common asphalt material tests, including PG, Viscosity and Pen test.
- Be an active participant, ask questions and have fun!

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But first, a word about asphalt rheology*

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*(*From the standpoint of a civil engineer.)*

Rheology

The study of materials whose flow properties exhibit elastic, viscous, and plastic behavior, and whose flow properties may be dependent on the rate at which they are loaded.

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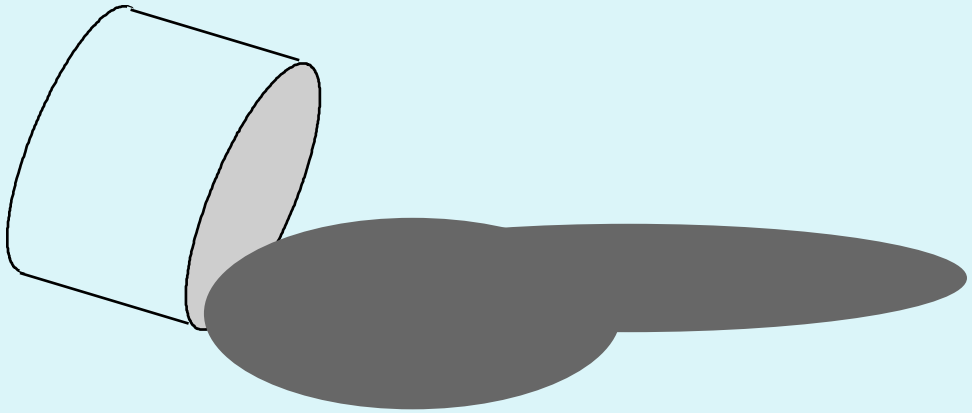

Asphalt is a material whose behavior is explained by rheological principles.

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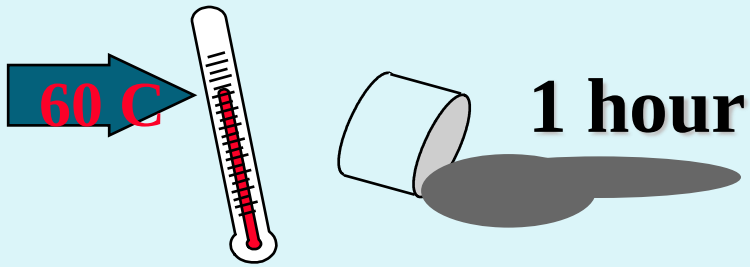
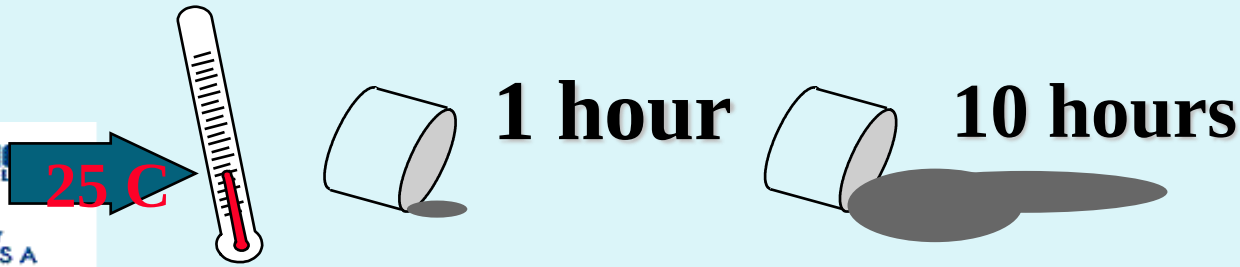
How Asphalt Behaves

- Asphalt behavior depends on:
  - temperature
  - time of loading
  - age is also important



Time/Temperature Dependency



Viscous Behavior

- High Temperature
  - desert climate
  - summer season
- Sustained Loads
  - slow moving trucks
    - intersections
    - uphill grades

Asphalt tries to act like viscous fluid

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Elastic Behavior

- Low Temperature
  - cold climate
  - winter weather
- Rapid Loads
  - fast moving trucks

Asphalt tries to act like elastic solid

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Okay, which is it viscous or elastic?

Asphalt is Viscoelastic

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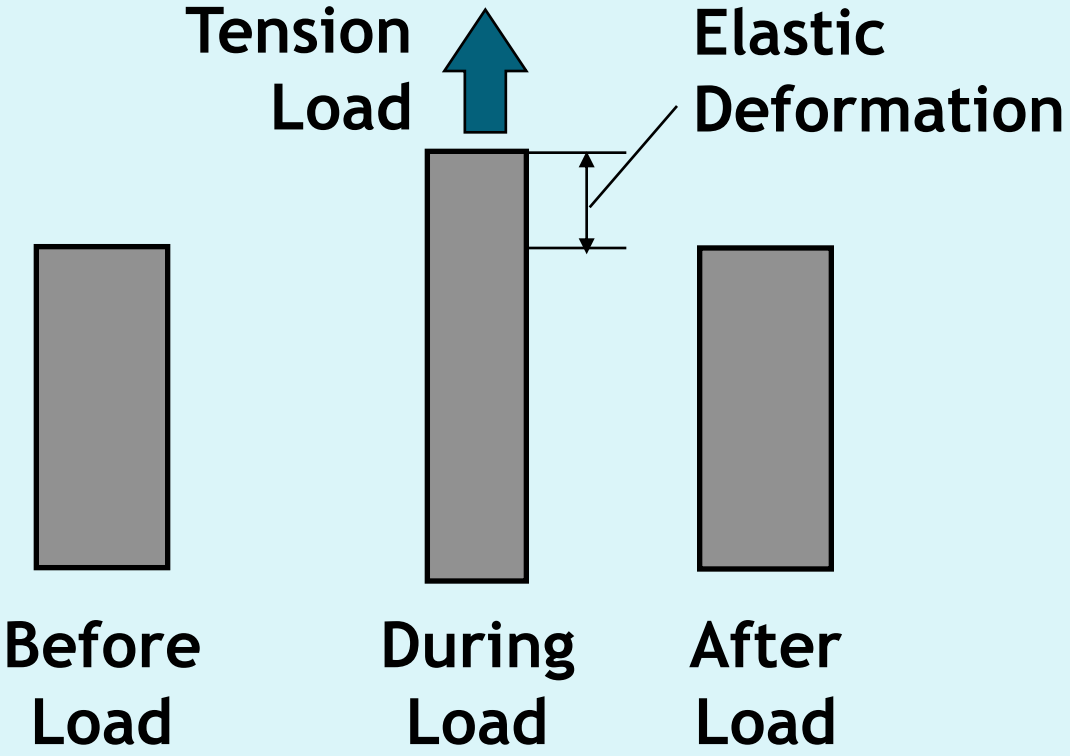
Elastic Solids



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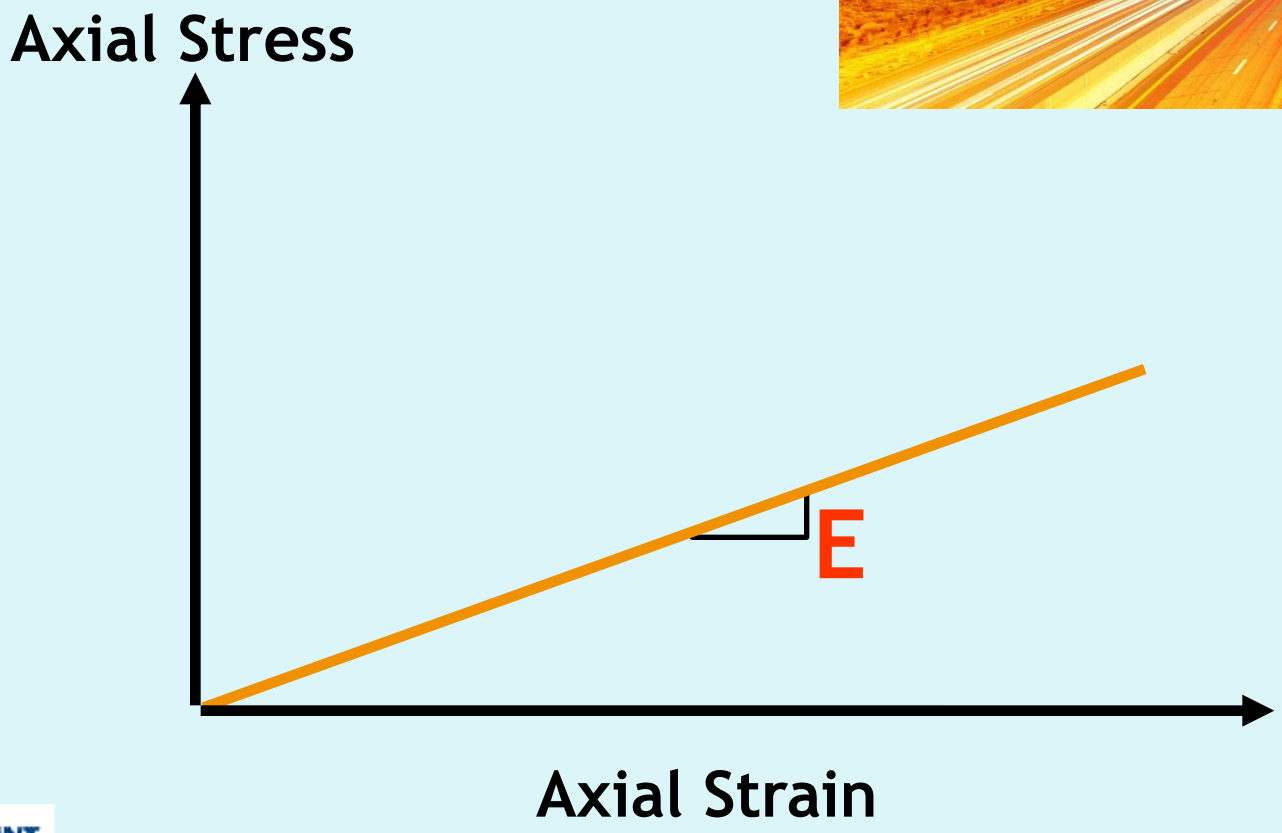
Elastic Solids



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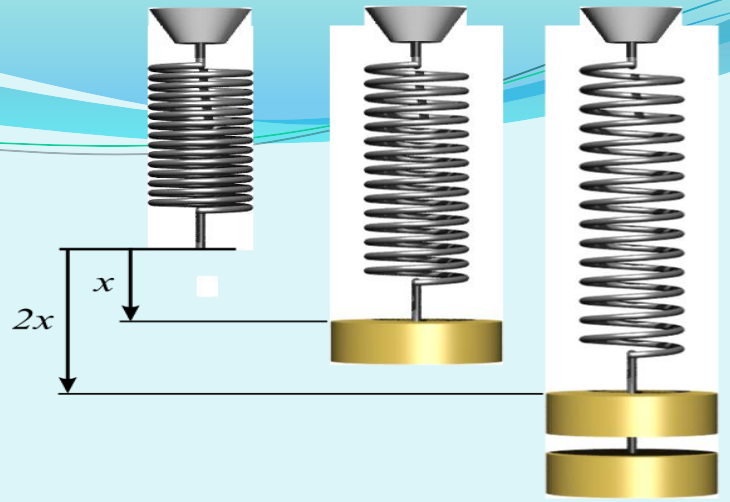
Elastic Solids
(Remember Hooke's Law)



$$\text{Stress } (\sigma) = E \times \text{strain } (\varepsilon)$$

elastic modulus

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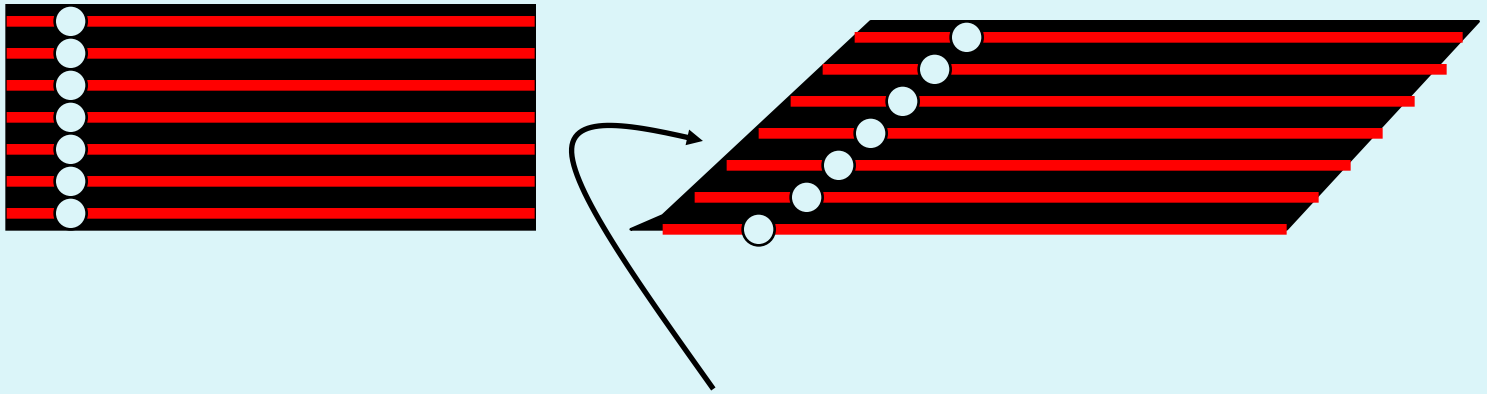
Viscous Fluids

Deck of cards



Resistance between cards is like viscosity

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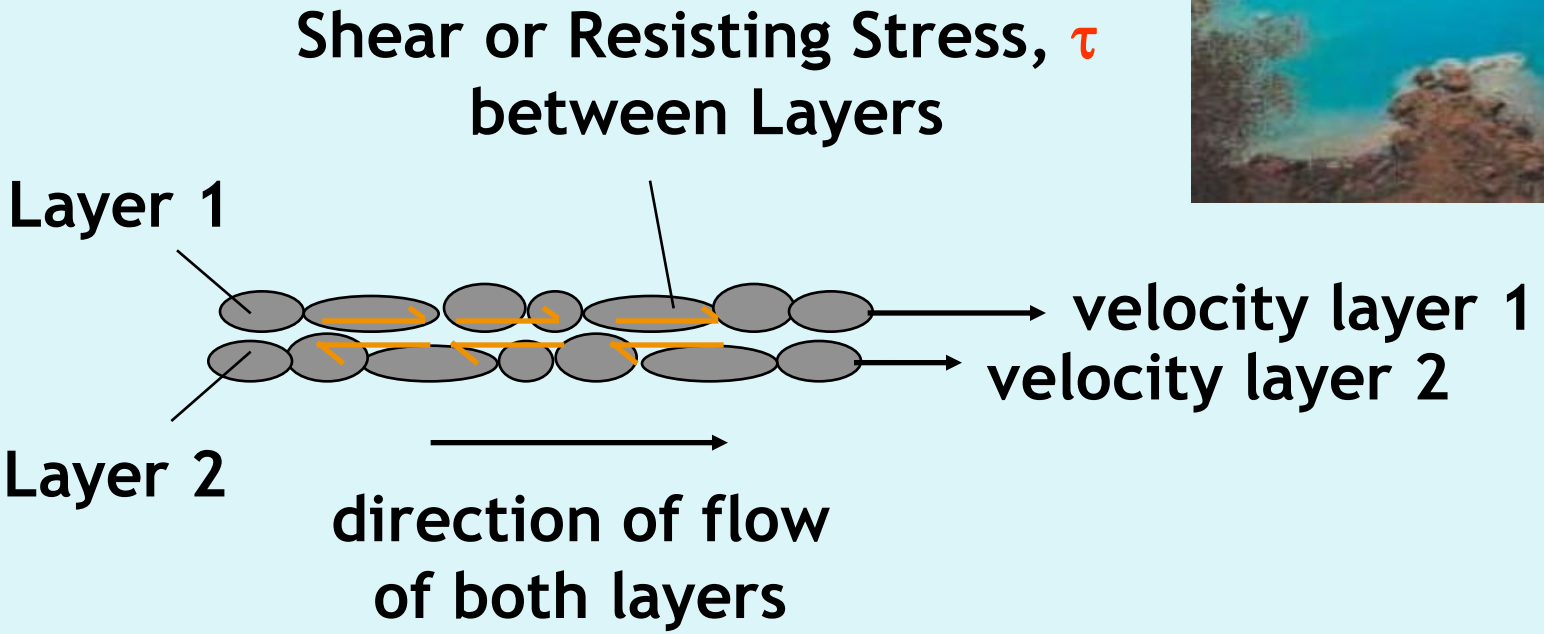
Viscous Fluids



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Viscous Fluids

shear stress = μ x rate of shear strain

viscosity

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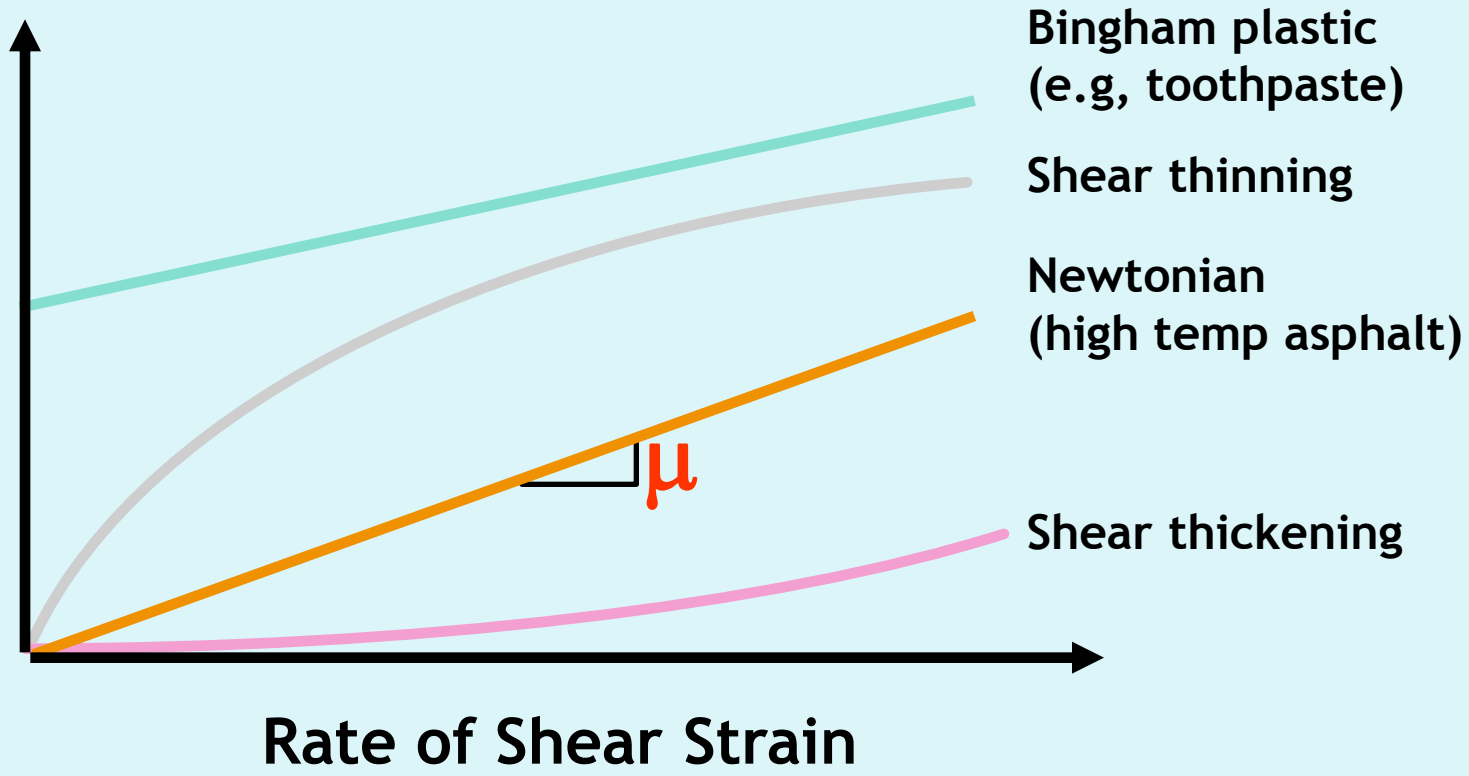
Viscous Fluids



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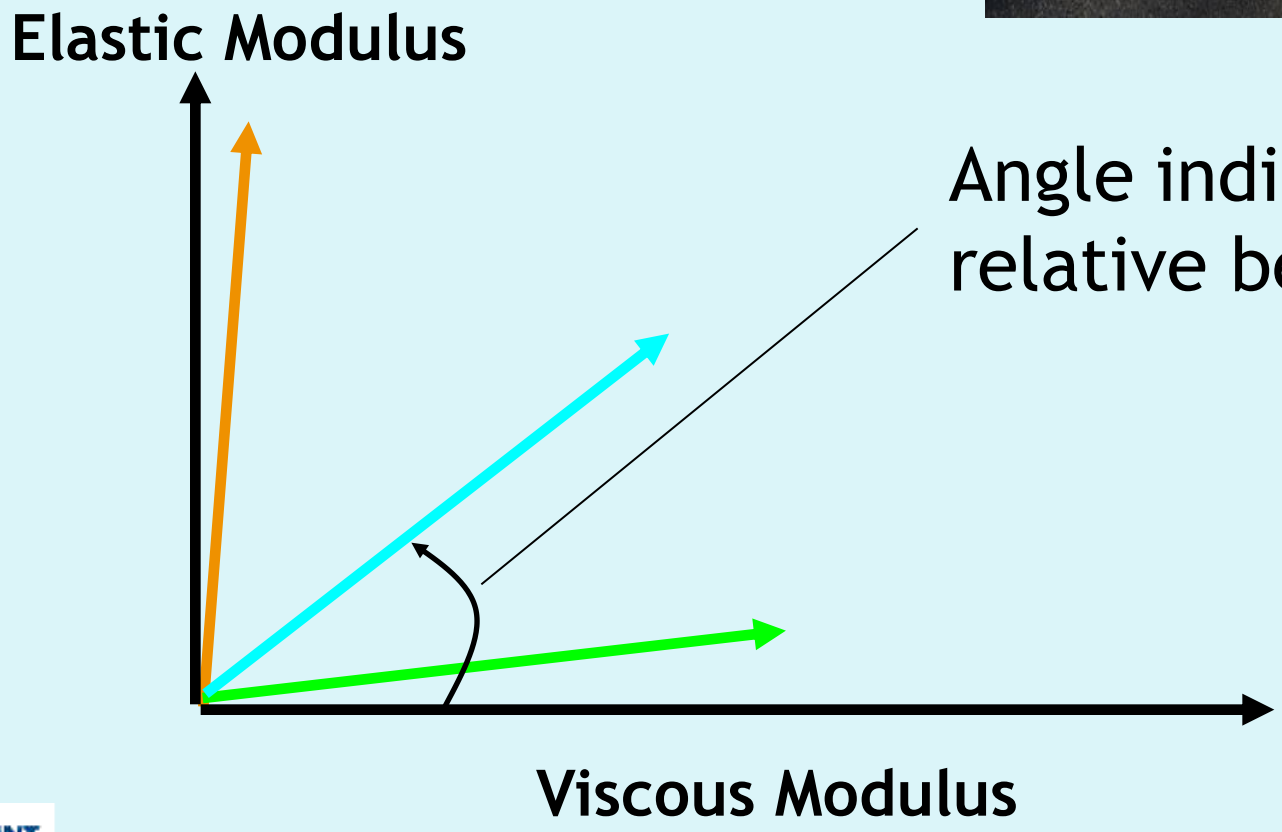
Viscoelastic Materials



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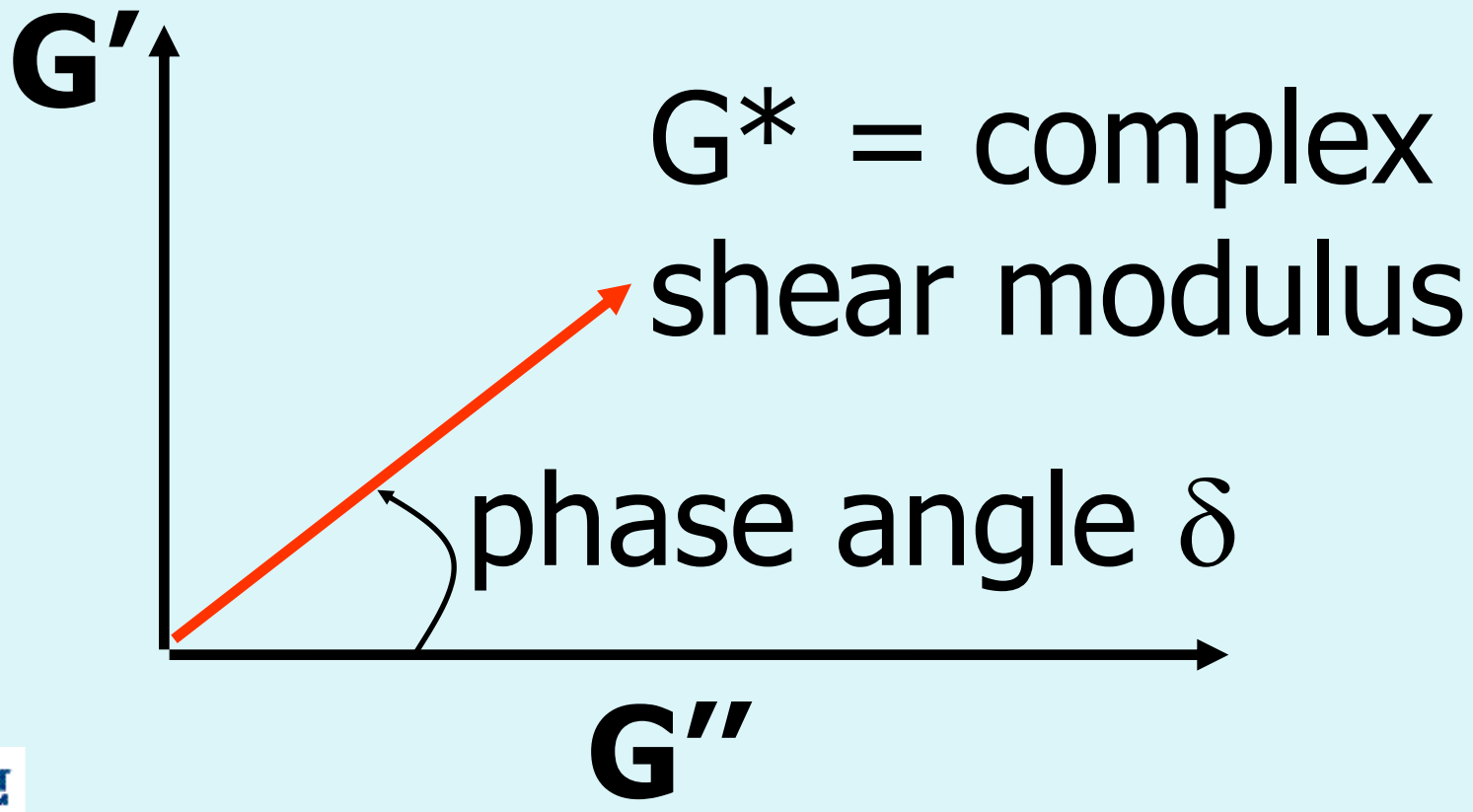
Viscoelastic Materials



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Let’s talk about specifications!

So you want to buy some asphalt…

- Tell me what you want
  - "I want it hot and sticky"
  - "It needs to remain pliable if I chew it 100 times"
  - "If I heat it to 100 F in an oven in an itty bitty cup, it *shall* not flow out after one hour ± 5 minutes"
  - "Sell me something that works"

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You Need a Specification!

- Tells important properties
- Identifies ways to measure important properties
- Part of a contract between a buyer and seller

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Early Asphalt Specs

- Early specs written around natural asphalts (Trinidad, Bermudez)
  - color
  - solubility in carbon disulfide
- Later paving specs written around consistency defined by penetration test and even later, viscosity test.

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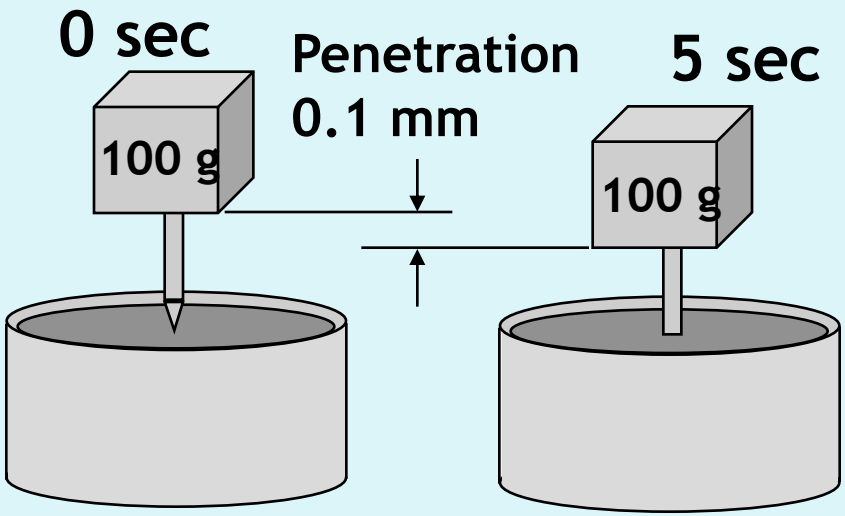
Penetration Test

Purpose

- consistency of asphalt
- intermediate temperature



77 F (25 C)

Grades:

40 - 50
60 - 70
85 - 100
120 - 150
200 - 300

harder

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Other Tests Added Later

- Flash point
- ductility
- solubility
- aging in thin films
  - pen
  - ductility

Typical Asphalt Terminal

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Flash Point (COC)

Purpose

- Safety test
- Analytical test
  - “what’s in there”
  - flammability

Ductility

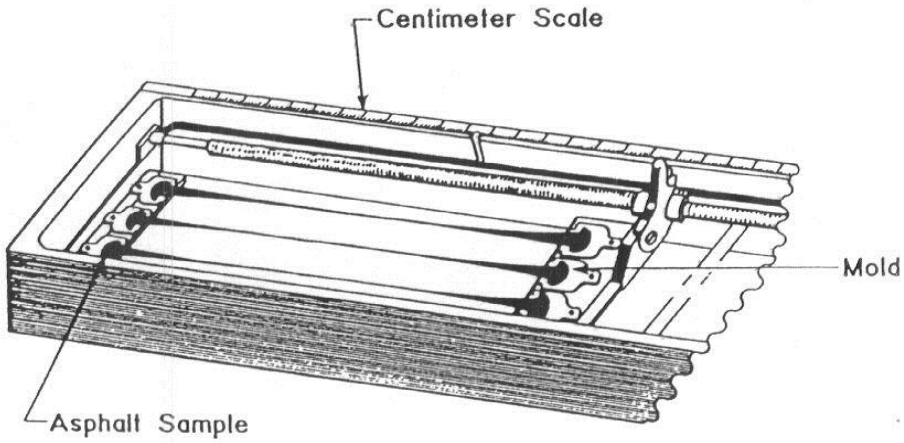
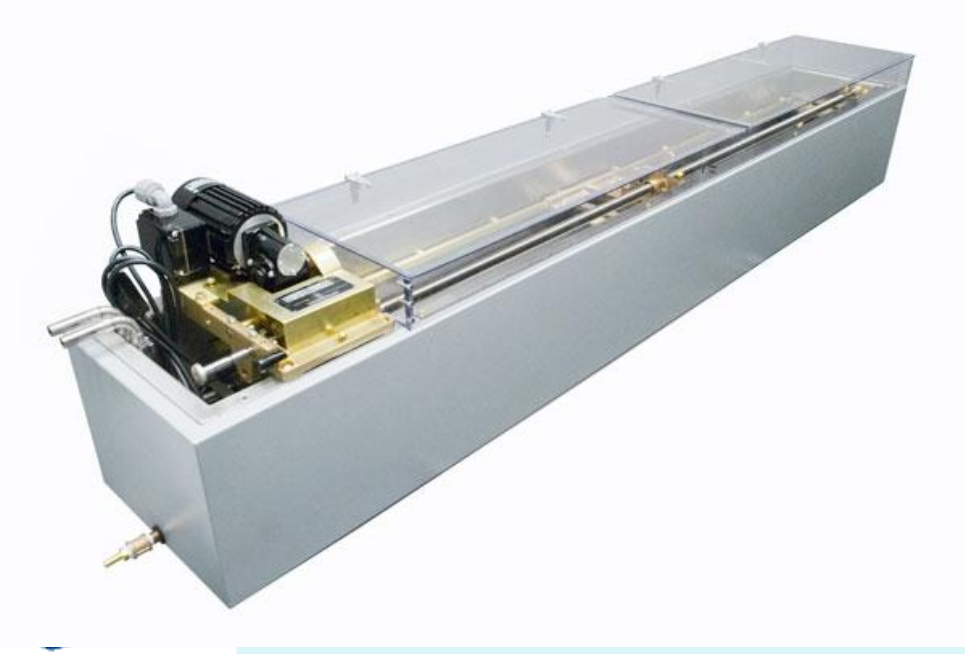


Figure 2–19. Ductility Test

- Purpose
  - tensile properties
  - cohesive properties
  - homogeneity

Force Ductility

- Purpose
  - Tensile properties
  - Cohesive properties
  - Homogeneity
  - Output is stress-strain
  - Used primarily in modified asphalts



Solubility

- Purpose
  - Purity
  - Foreign extraneous "stuff" in asphalt

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Thin Film Oven Aging

Rolling Thin Film Oven

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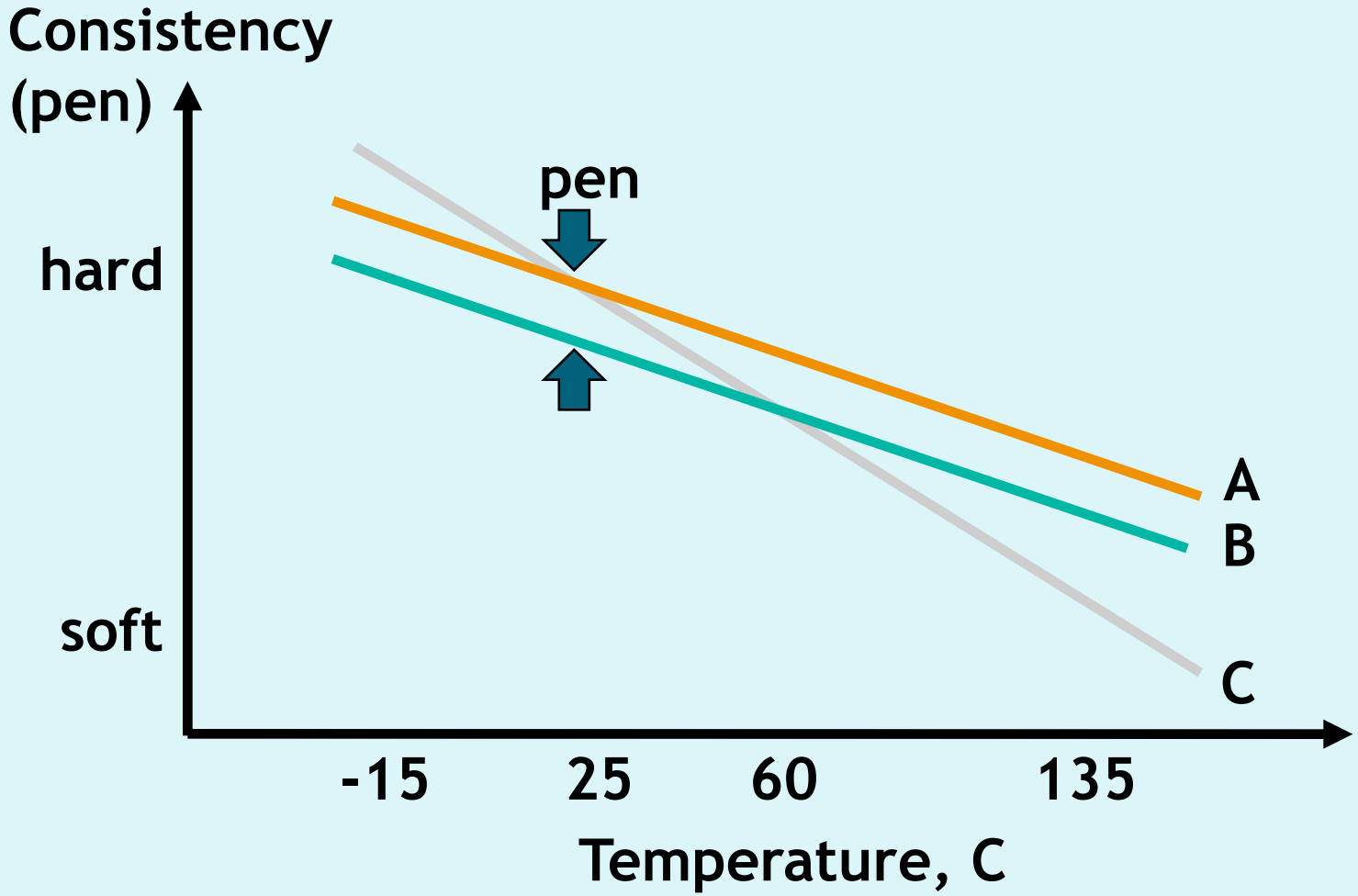
Example Pen Specs

Penetration	40 - 50	200 - 300
Flash Point, C	450+	350+
Ductility, cm	100+	100+
Solubility, %	99.0+	99.0+
Retained Pen., %	55+	37+
Ductility, cm	NA	100+



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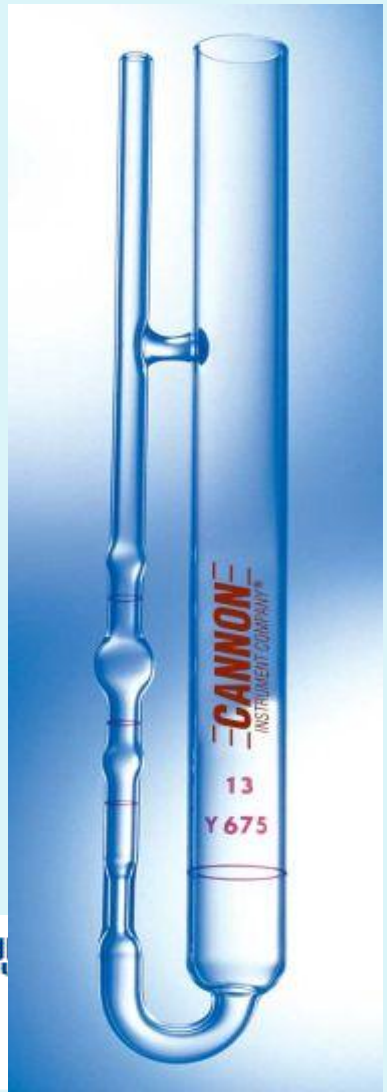
Viscosity Test and Spec



- Purpose
  - Flow properties at high pavement temperature (60 C)

Grades:

AC 2.5, AC 5, AC 10, AC 20, AC 30, AC 40

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Absolute Viscosity Test

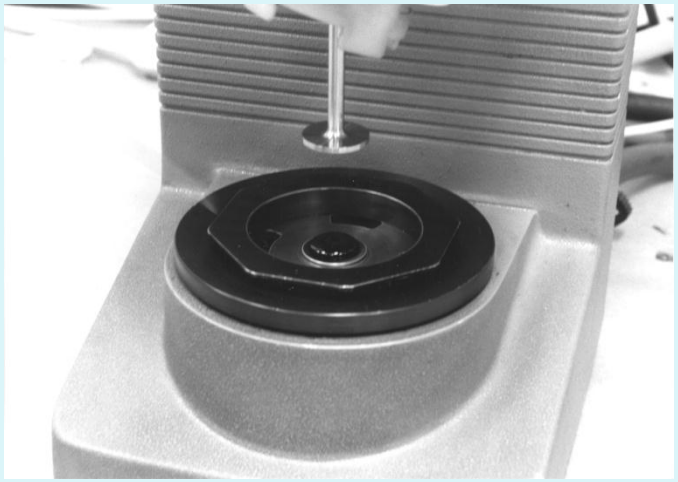
Kinematic Viscosity Test

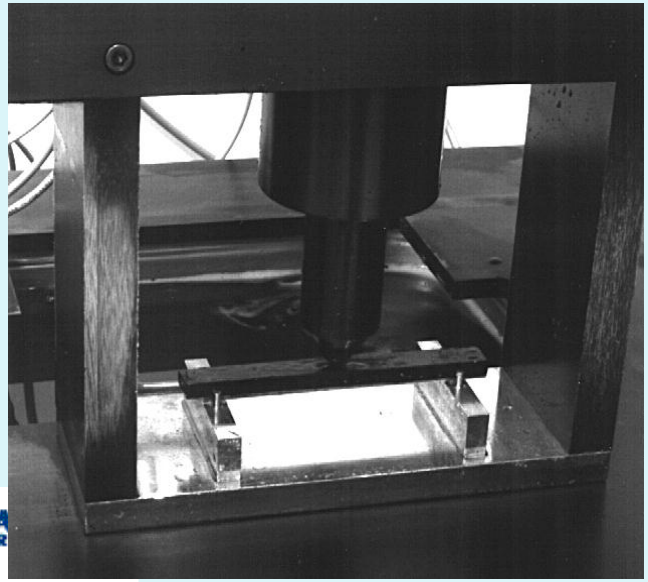
- Purpose
  - Flow properties at high temperature (135 C)

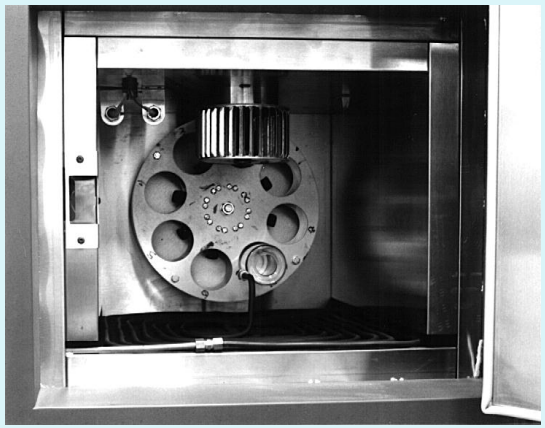
Elastic Recovery Test

- Purpose
  - Detect presence of stretchy polymer dissolved in asphalt
  - Ability of asphalt to snap back to original shape

PG Tests

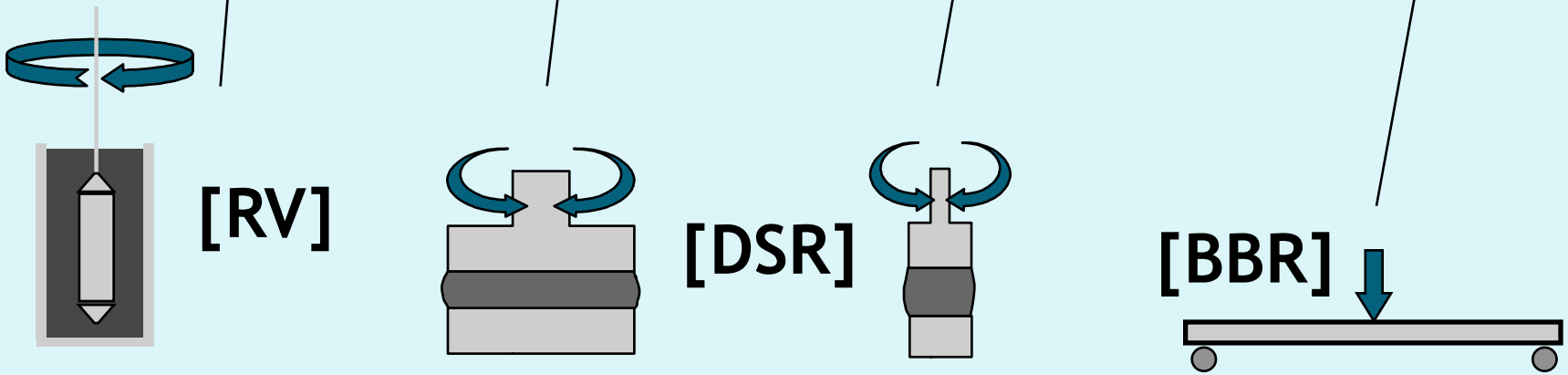






PG Binder Tests

Construction ***Rutting*** ***Fatigue Cracking*** ***Low Temp Cracking***



Pavement Age

No aging ***RTFO - aging*** ***PAV - aging***

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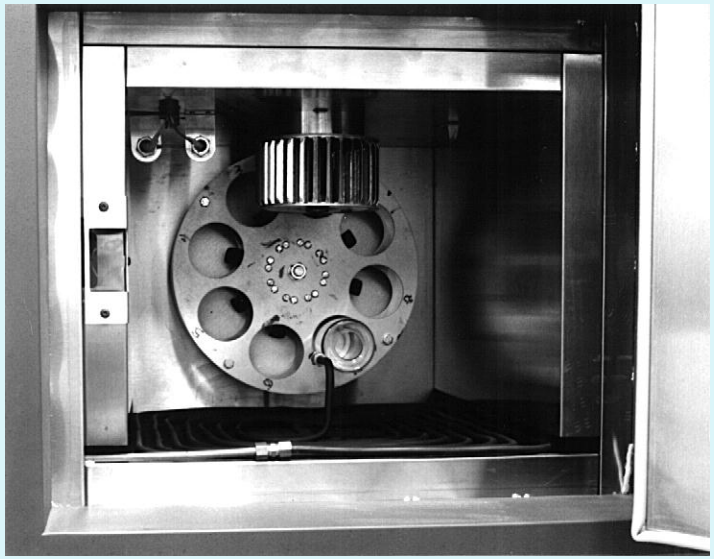
Aged Residue

- Purpose
  - Create lab aged sample
  - Plant aging
  - Pavement aging



Rolling Thin Film Oven
(HMA Plant Aging)

Pressure Aging Vessel
(In-Service Aging)

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Dynamic Shear Rheometer

- Purpose
  - Flow characteristics at high temps (52-76 C)
  - Evaluates viscous and elastic characteristics

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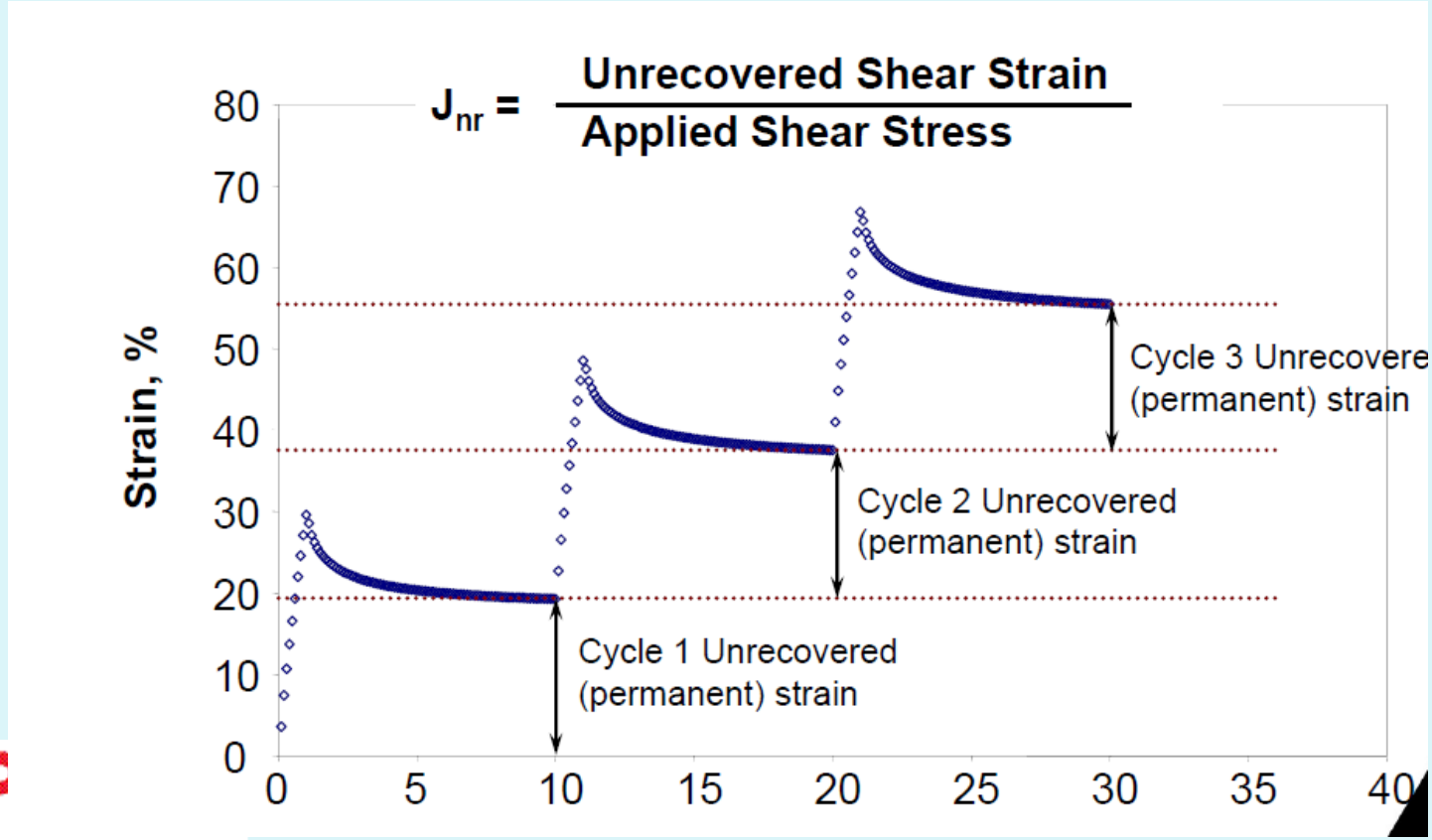
Dynamic Shear Rheometer

(high temp rutting, intermediate temp fatigue cracking)

Output is complex shear modulus (G*) and phase angle (δ)

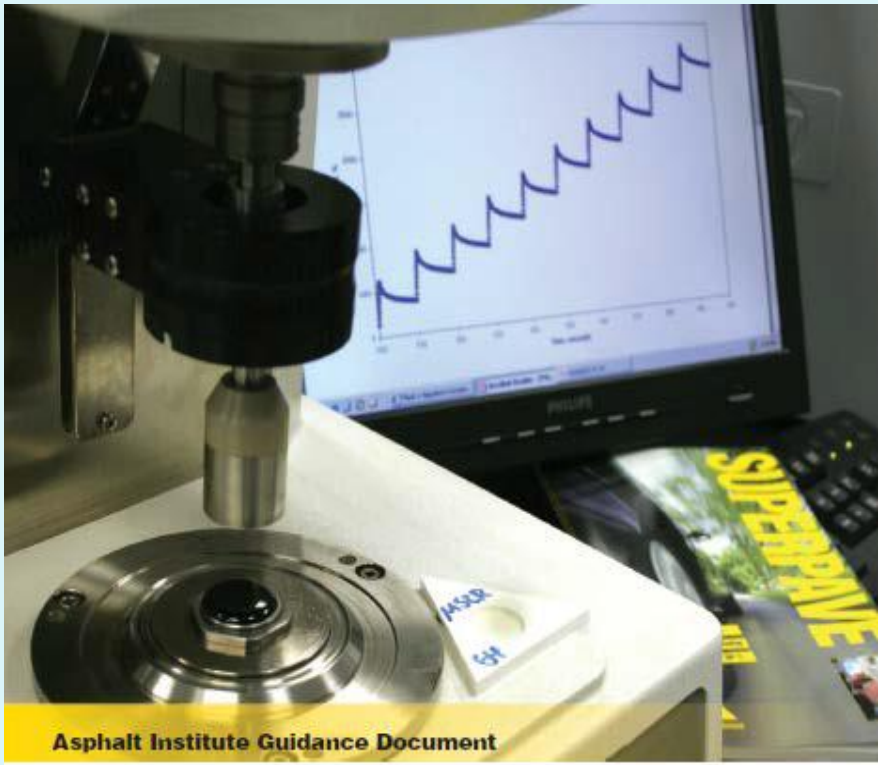
Multiple Stress Creep Recovery Test (MSCR)

- Measure ability of binder to recover shear strain after repeated shear stress cycles
- Potentially an analog for elastic recovery and/or replace G*/sin δ



MSCR Guidance

- "Implementation of the Multiple-Stress Creep-Recovery Test and Specification" "It is the Asphalt Institute's opinion that the MSCR test and specification represent a technical advancement over the current PG specification that will allow for better characterization of the high temperature performance-related properties of an asphalt binder."



Asphalt Institute Guidance Document

Implementation of the Multiple Stress Creep Recovery Test and Specification

The purpose of this document is to provide guidance to the asphalt industry, users and producers, regarding the implementation of the new high temperature binder test and specification using the Multiple Stress Creep Recovery (MSCR) test. The MSCR test replaces the existing AASHTO M320 Dynamic Shear Rheometer (DSR) test used for characterizing the high temperature performance properties of an asphalt binder after short-term aging. It is the Asphalt Institute's opinion that the MSCR test and specification represent a technical advancement over the current PG specification that will allow for better characterization of the high temperature performance-related properties of an asphalt binder.

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Rotational Viscometer

(high temp handling, pumping)

Output is vis at 135 C and temp/vis chart

Bending Beam Rheometer

- Purpose
  - Stiffness at low pavement temperatures (-34 – 0 C)
  - Stress relaxation at low pavement temperatures

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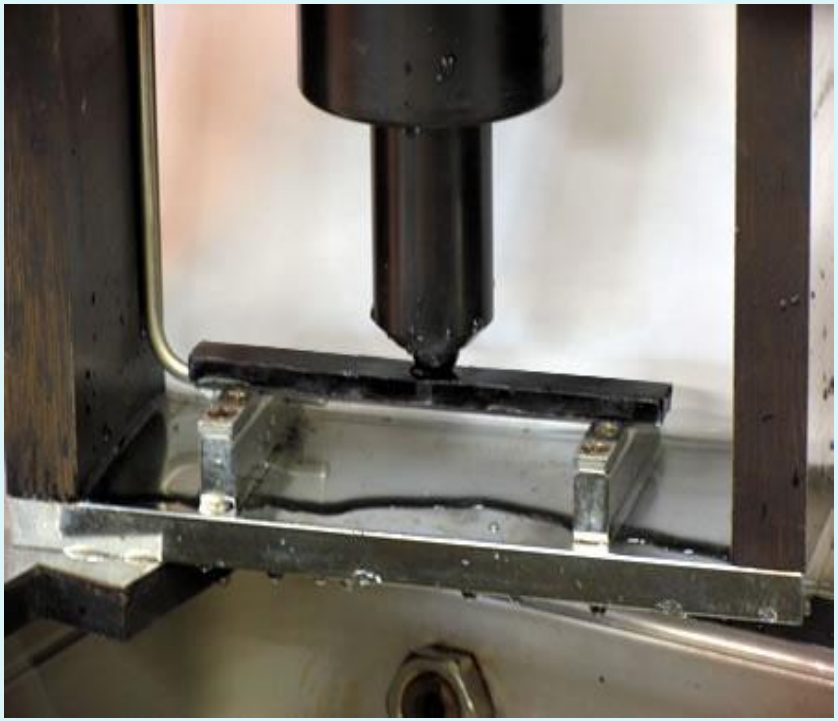
Bending Beam Rheometer



Output is creep stiffness (S) and creep rate/slope (m value)

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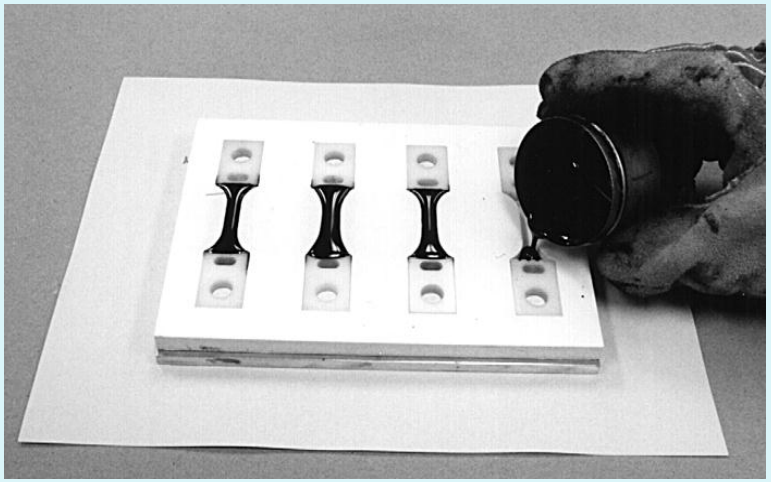
Direct Tension Tester

- Purpose
  - Determine fracture properties at low pavement temperatures (-34 – 0 C)
  - tensile failure strain
- No longer a common test…but it is in the PG spec



Other Tests on Modified Asphalt

- Specific Gravity
  - Performed on any type of binder for mass/volume calculation
- Toughness & Tenacity
  - Material is stretched vertically to determine load until it breaks. Load deformation curve is plotted
- Screen Test
  - To determine the homogeneity of binder
- Separation
  - To check the binder susceptibility to separation

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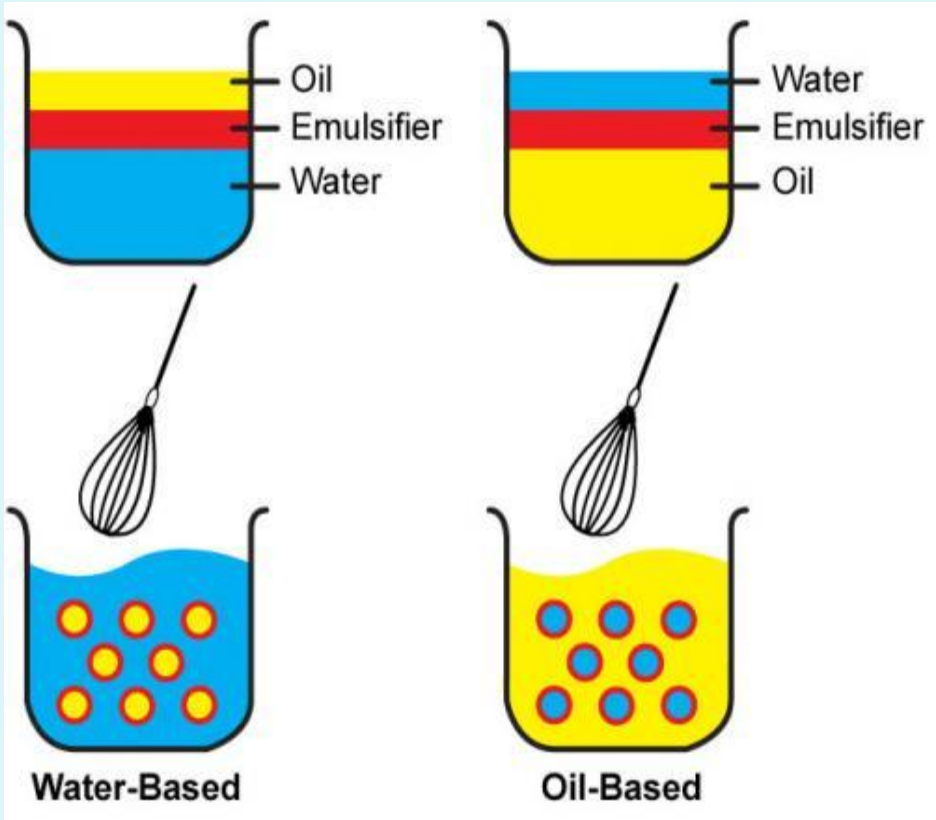
Emulsion

- Emulsion is a system with 2 or more non-miscible liquids

- 1 liquid phase acts as dispersing agent, in which other liquid phase is scattered as fine droplets



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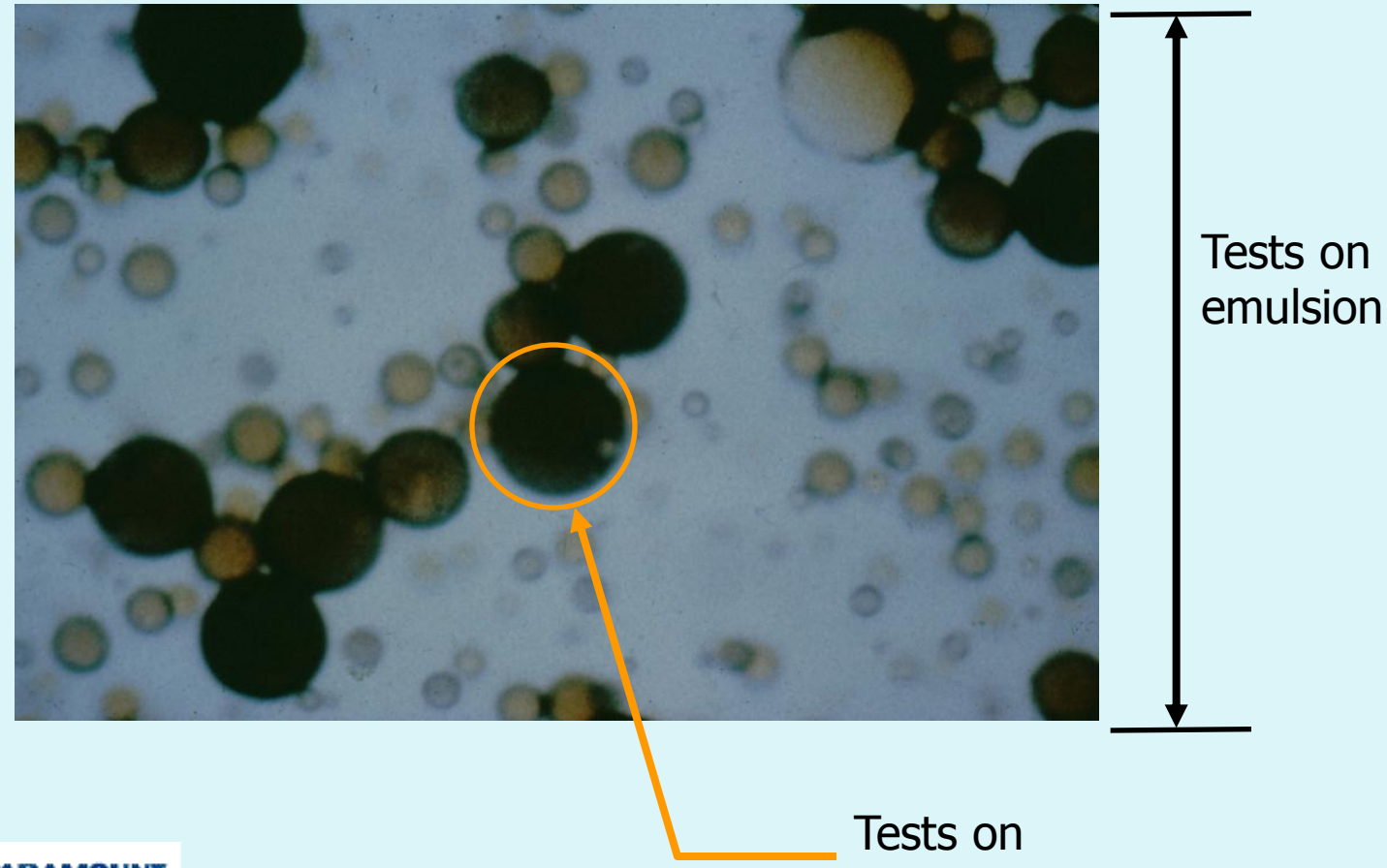
Emulsion Tests



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Emulsion Tests

- Tests on Emulsion
  - viscosity
  - Sieve
  - demulsibility
  - cement mixing
  - storage stability
  - particle charge
  - coating ability
  - percent residue
    - various methods
- Tests on Residue
  - $G^*/\sin \delta$
  - penetration
  - ductility
  - float
  - elastic recovery
  - softening point
  - toughness/tenacity

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Emulsion Viscosity

- Purpose
  - Flow characteristics at application temps (25 or 50 C)

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Emulsion Sieve Test

- Purpose
  - Detect presence of coalesced asphalt particles in emulsion
  - Indirect indicator of emulsion chemistry problems

Measure weight of particles that get caught on No. 20 sieve - 20 openings in a linear inch.

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Emulsion Percent Residue Test

- Purpose
  - measure amount of asphalt binder in emulsion, typically 60%+
- Many recovery procedures
  - distillation (177, 200, 230, 260 C)
  - high temp evaporation (163 C)
  - low temp evaporation (60 C)
- WARNING – method of recovery affects properties of recovered binder!

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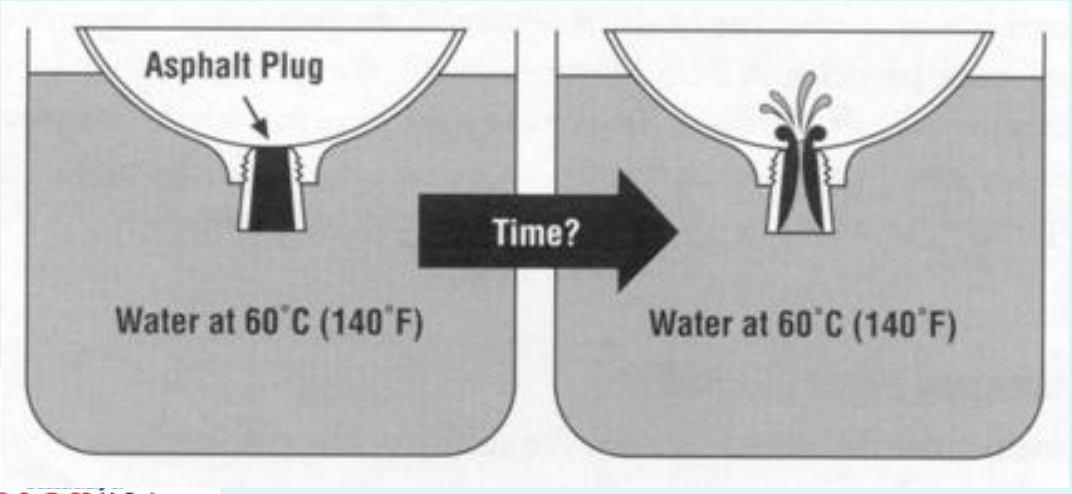
Emulsion Percent Residue Test

Float Test

- Purpose
  - Detect the presence of gelled structure in “high float” emulsion residue



Ring and Ball Softening Point Test

- Purpose
  - gross indicator of high temperature stiffness
  - Detect presence of elastic or plastic asphalt modifier

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Automatic Ring and Ball Softening Point Tester

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Storage Stability/Settlement Test

- Purpose
  - Determine if there is any settlement of the material inside the storage tank
  - Consistency/uniformity

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Simple Laboratory Emulsion Mill

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Questions?

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THANK YOU

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