ARIZONA PAVEMENTS/ MATERIALS CONFERENCE
2022 Infrastructure Resiliency and Preservation

Polymer Modified Asphalt
A Supplier's Perspective

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HF Sinclair

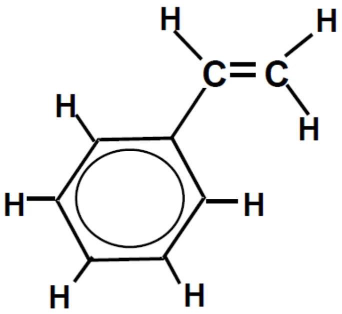
I Promise Not to
Nerd Things Up Too Much!

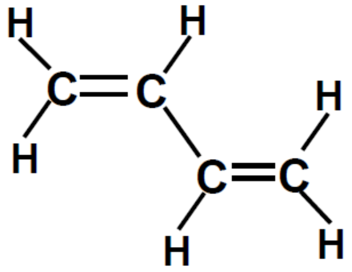
So you want modified asphalt!

Clifford Taylor, Shell Oil Co, 1986

- Answer the questions
  - ✓what HMA property needs improvement?
  - ✓what modifier will provide that?
  - ✓what property will be compromised?
  - ✓how can it be incorporated?
  - ✓should compatibility be evaluated?
  - ✓is storage stability a concern?
  - ✓how to specify…what tests are meaningful?
  - ✓will constructability be affected?
  - ✓is the modifier commercially significant and cost effective?
  - ✓mix vs binder modification?

Topics

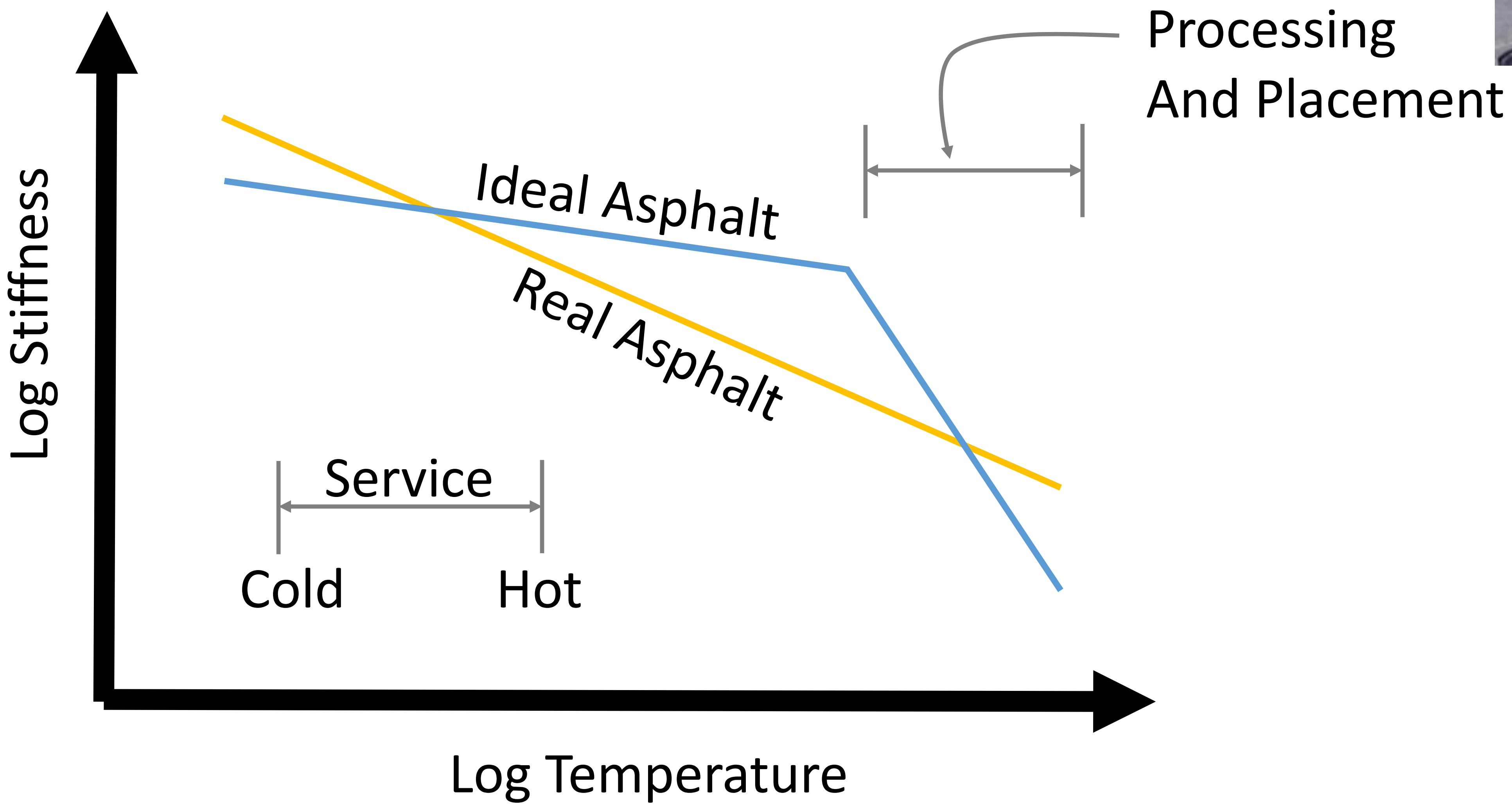




- Why modify
- Typical polymers used in asphalt
- Physical models
- Manufacturing
- Storage and handling
  - polymer
  - finished product
- Managing your position in the marketplace

The Ideal Asphalt

Source: R.D. Pavlovich, Exxon Chemical Americas, 1991



Typical Polymers Used in Asphalt

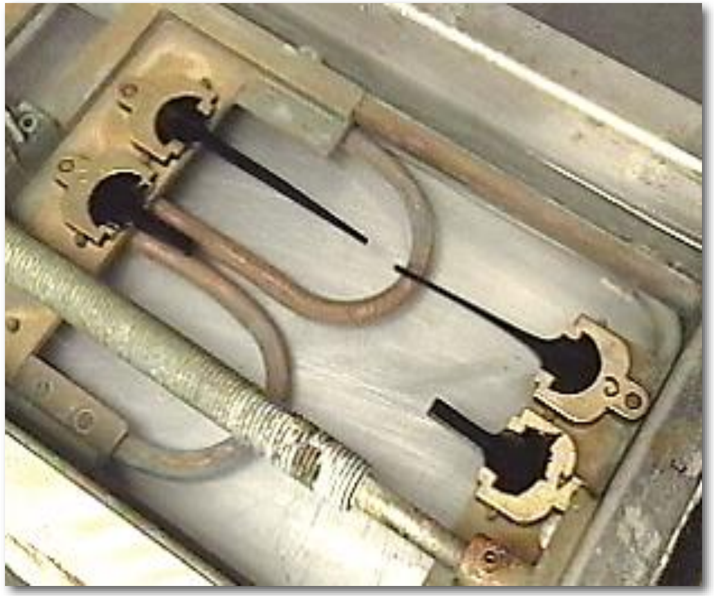
(Source: Bob Kluttz, Kraton Polymers US, 2017)

- Styrene-Diene Polymers (thermoplastic elastomers)
  - Styrenic block polymers (SBS, SB-diblock)
  - Random styrene diene polymers (SBR)
- Olefin Vinyl Polymers (thermoplastic)
  - ethylene vinyl acetate (EVA)
- Olefin Acrylic Polymers
  - Reactive elastomeric terpolymers (RET)
- Low Crystallinity Polyolefins
  - LDPE
- Thermoset Plastic
  - Tire rubber

Polymer Modified Asphalt

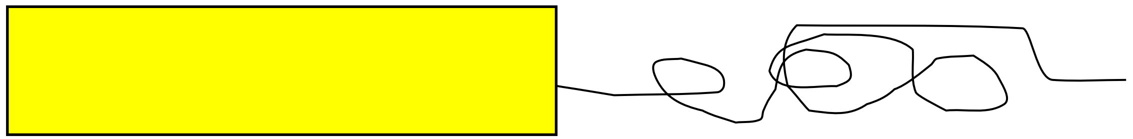
(Thermoplastic Elastomers)

- Advantages
  - Performance history
  - Elastic effect
  - Improved cohesion
  - Many specs designed around elastomeric polymers (no mysteries)
  - Favorable co-modifier with chemical modifiers (e.g., PPA, antistrip, WMA, etc.)
- Disadvangates
  - Can be challenging to manufacture
  - Compatibility can be a problem
  - Tougher to handle
  - Less heat stable
  - Challenge to emulsify
  - Sometimes supply/price not stable
  - Relatively expensive



Elastic Polymer Architecture

(A civil engineer's physical model)



<u>Styrene</u>

hard stuff

T_g=100 C

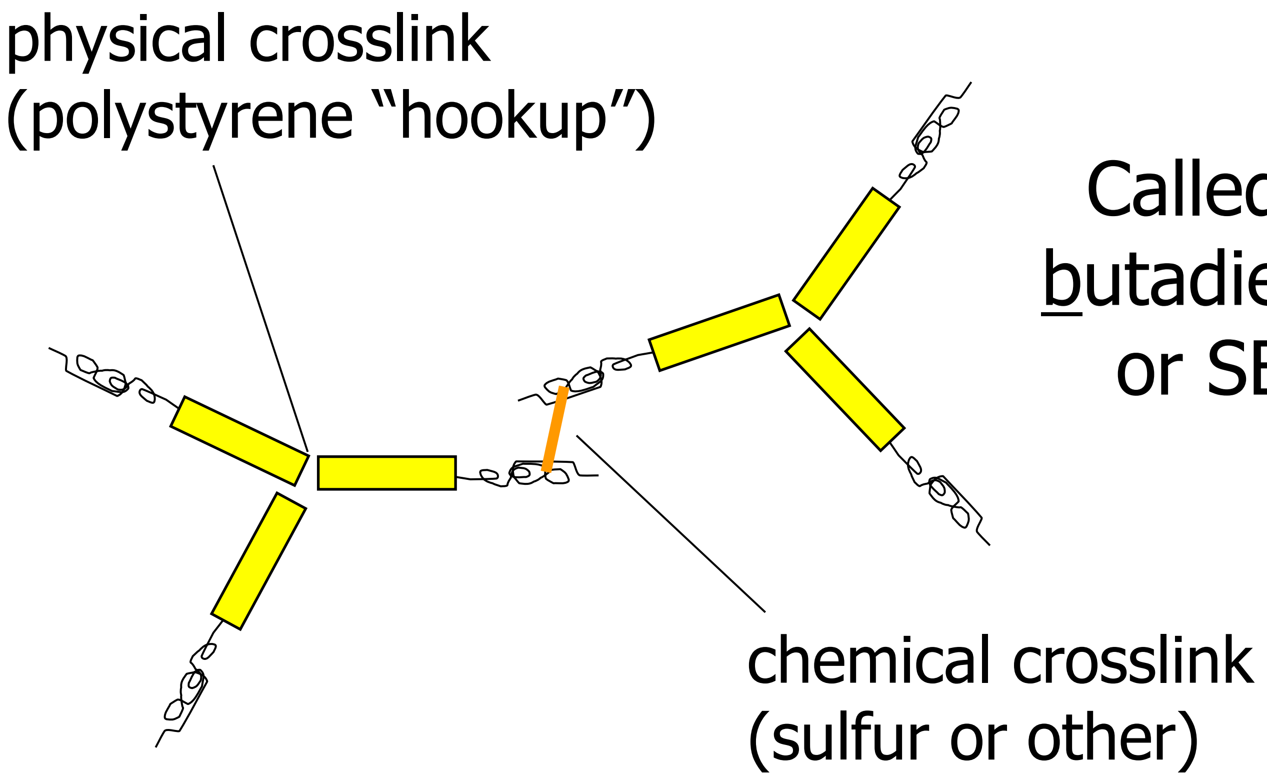
<u>Butadiene</u>

soft rubbery stuff

T_g=-80 C

Source: Joe Drbohlav, KMC, 2002

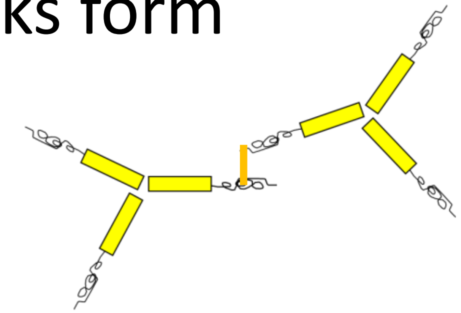
More Polymer Architecture



Called styrene butadiene diblock or SB diblock

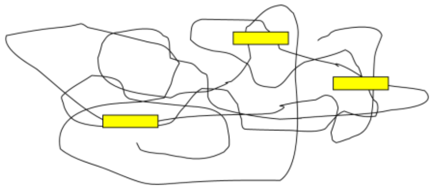
How They Work in Asphalt

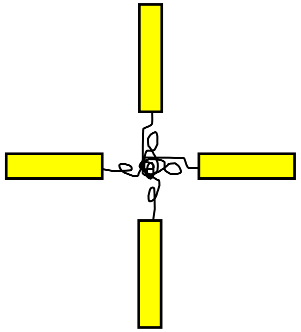
- Dissolve Polymer in Asphalt and Networks form
  - Polymer chains get tangled up
  - Physical crosslinks (polystyrene “hookup”)
  - Chemical crosslinks (sulfur crosslinking)



- Finished properties depend on what’s going on with this network

- Random, Linear, and Radial, architecture





Essentials to Successful PMA Manufacture

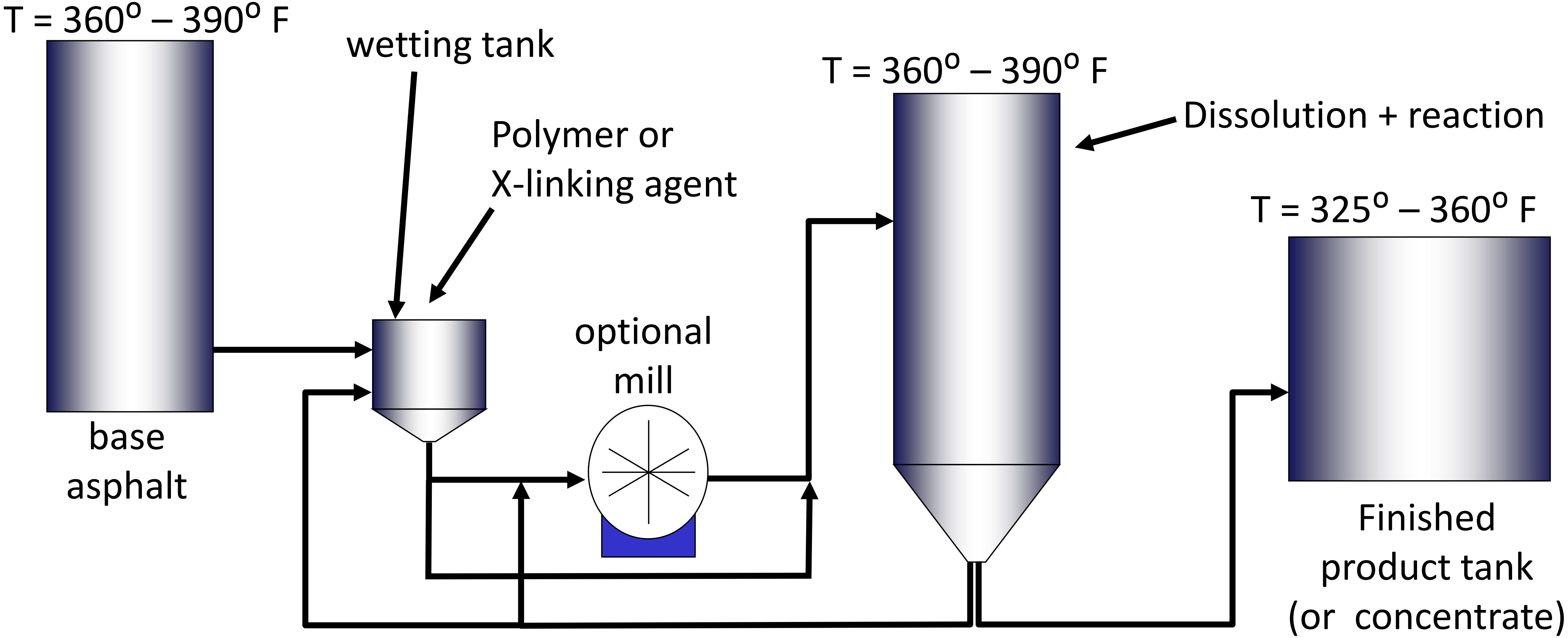
Lots of heat
(350-400°F)

Lots of tanks

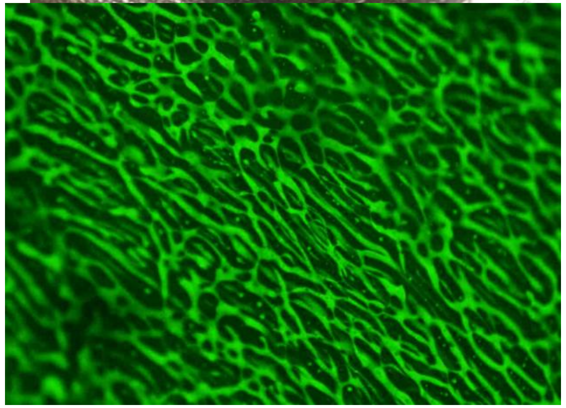
Smart people

Generic PMA Manufacture

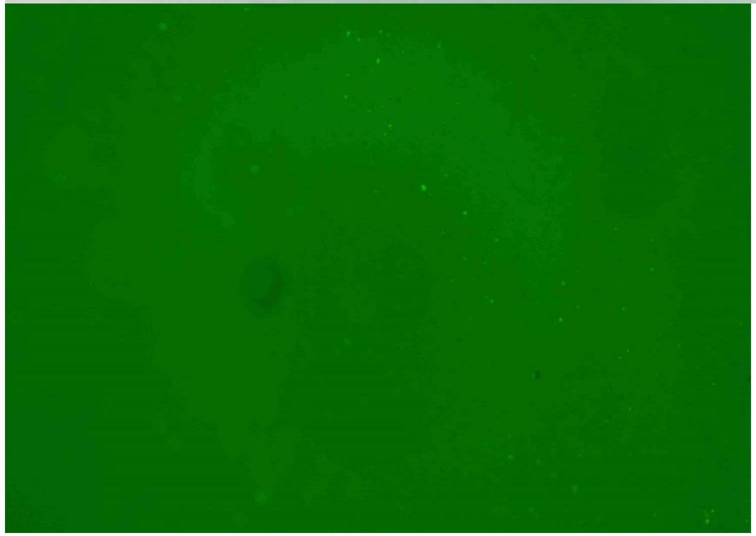
(High Shear vs Dump & Stir)



Polymer Dissolution

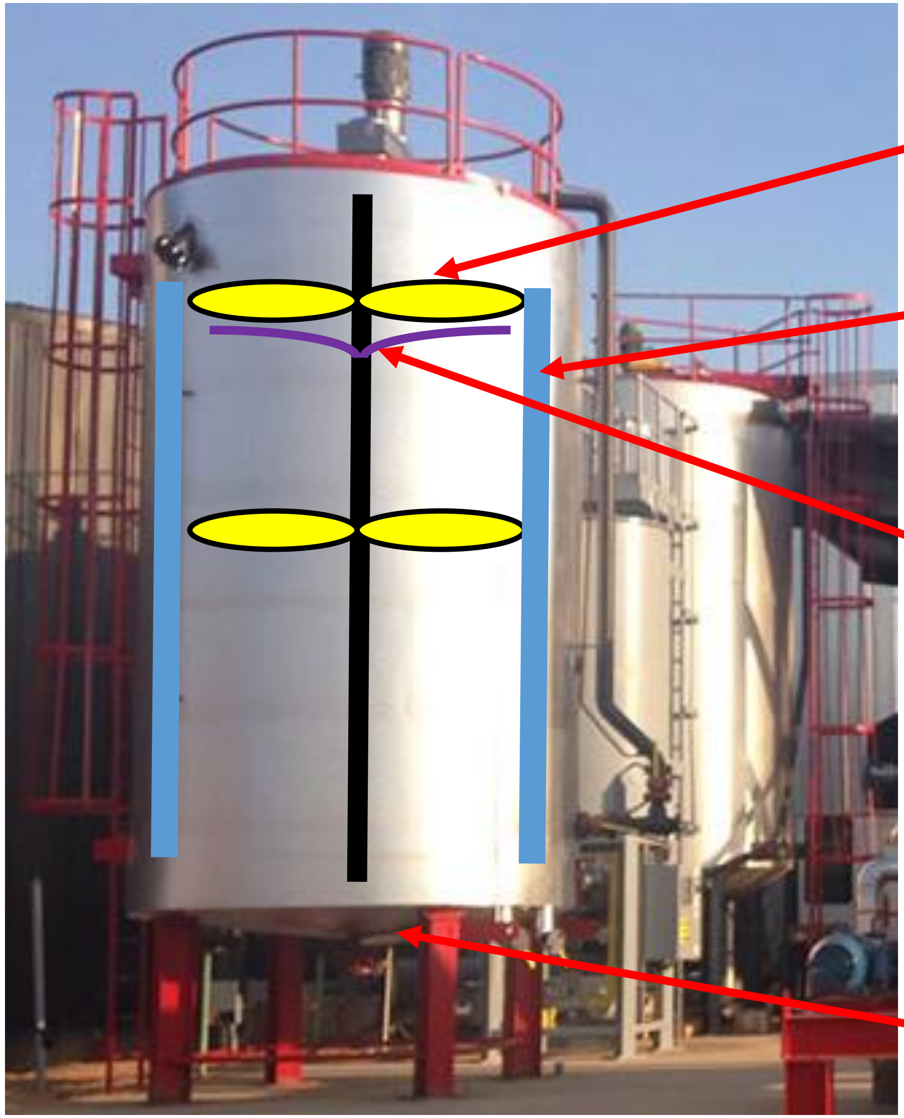







Tanks for Dissolution and Reaction

(Source: D&H Equipment Ltd)



Agitators

Baffle

Vortex

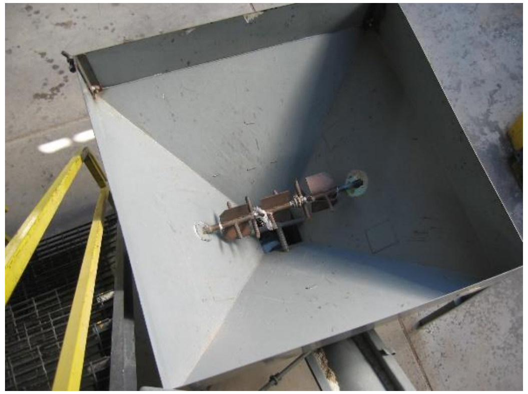
Cone bottom

Well designed dissolution tanks

- Height/diameter ~ 1.5/1
- agitators
- baffling for mild vortex

Other Manufacturing Stuff You Need

- Unloading facilities for delivered polymer
  - forklift 2200+ lb forklift
- Covered storage for polymer (warehousing)
- High capacity pumps (jacketed w/hot oil)
  - sufficient horsepower to move concentrates
- Well designed hopper

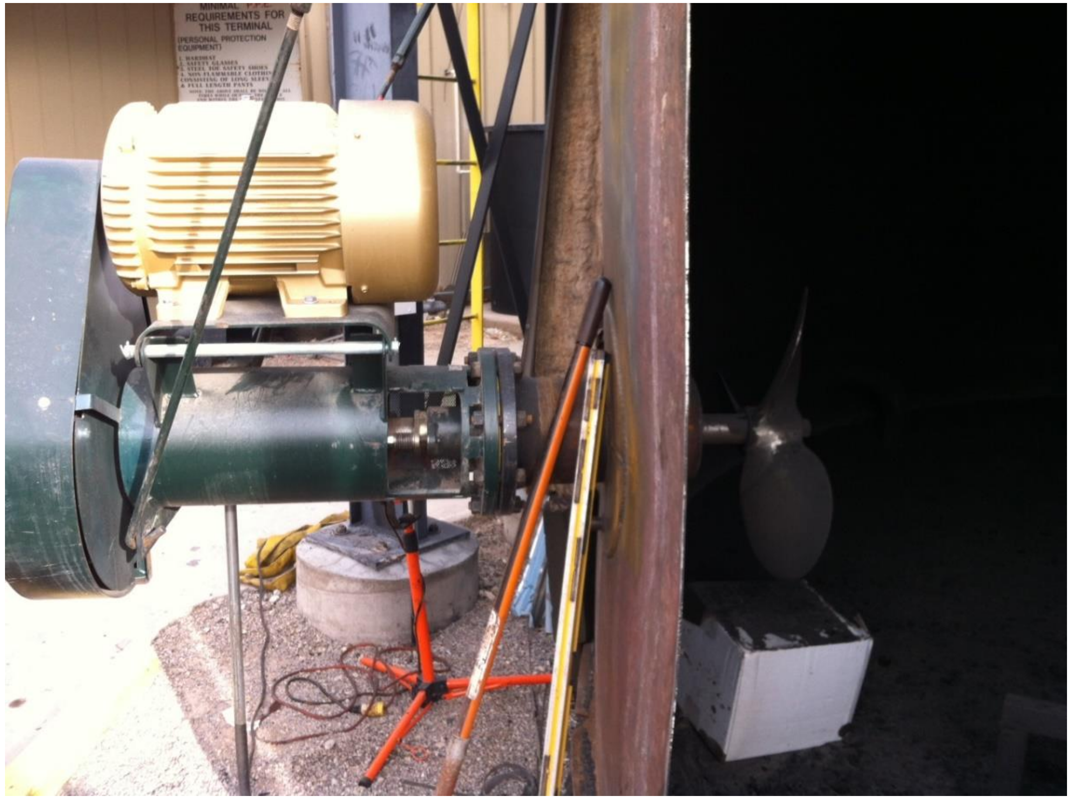


About those finished product tanks…

Heating coils

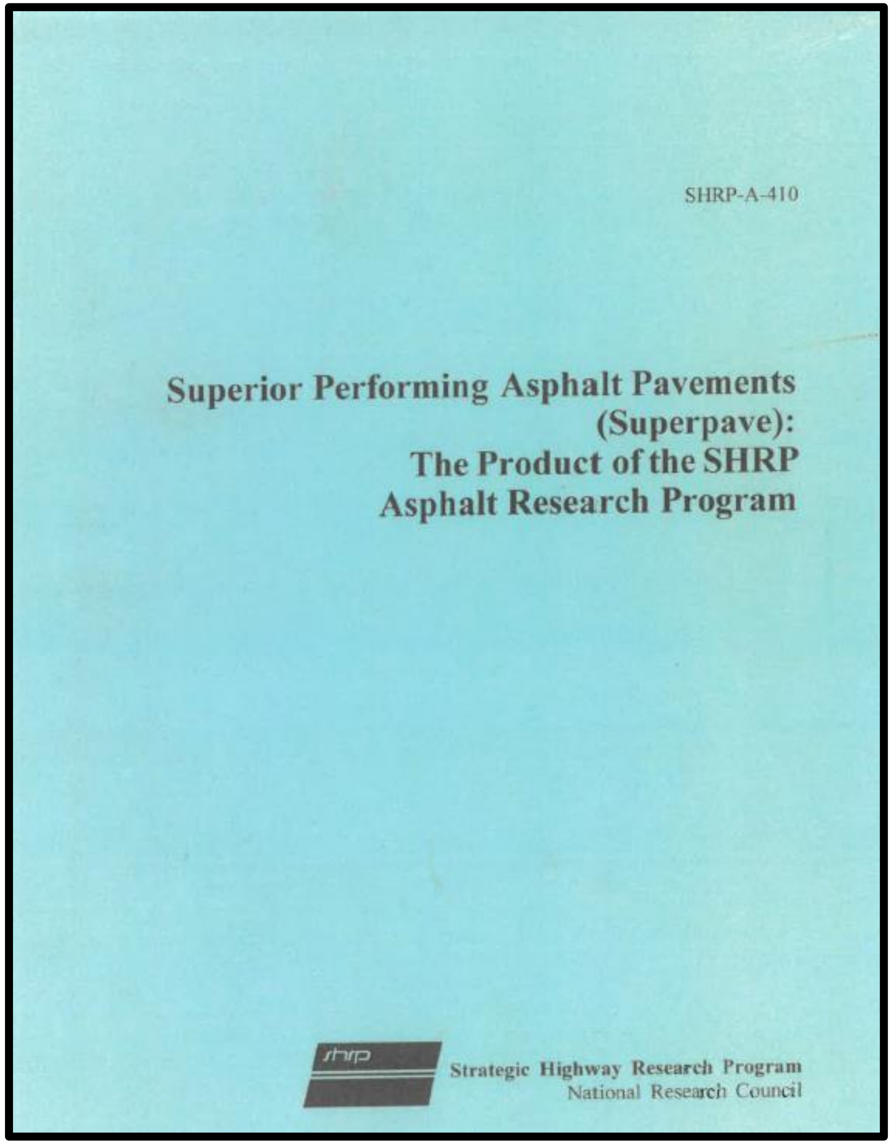
Temperature: 325° - 350 °F

Agitator



Handling

Handling



SHRP A-410, p. 39

To ensure pumpability, the specification stipulates that the binder must have a maximum viscosity of 3Pa·s at a test temperature of 135°C. The specification requirement may be waived if the supplier warrants that the asphalt binder can be pumped and mixed at temperatures that satisfy safety standards.

The rotational viscometer can also be used to establish the viscosity-temperature relationship for the binder. This relationship can be used as a guideline to determine mixing and compaction temperatures. For some modified binders, however, excessively high temperatures may be indicated. These high temperatures, which may damage the asphalt binder, often will not be required for mixing and compaction because of shear thinning. Thus, the supplier's recommendations concerning mixing and compaction temperatures should be followed.

Note:

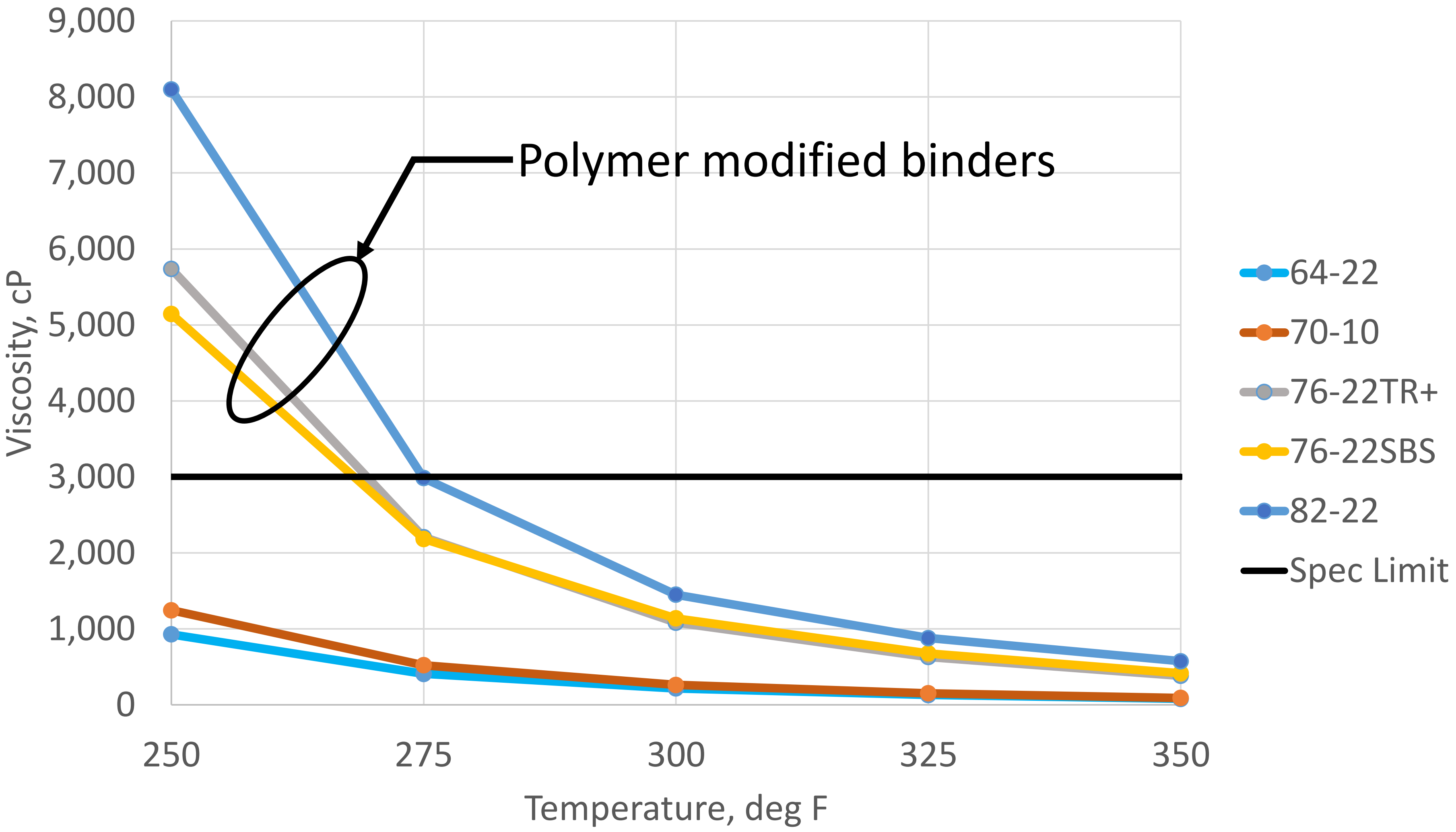
3 Pa-s = 3000 cP

135° C = 275° F

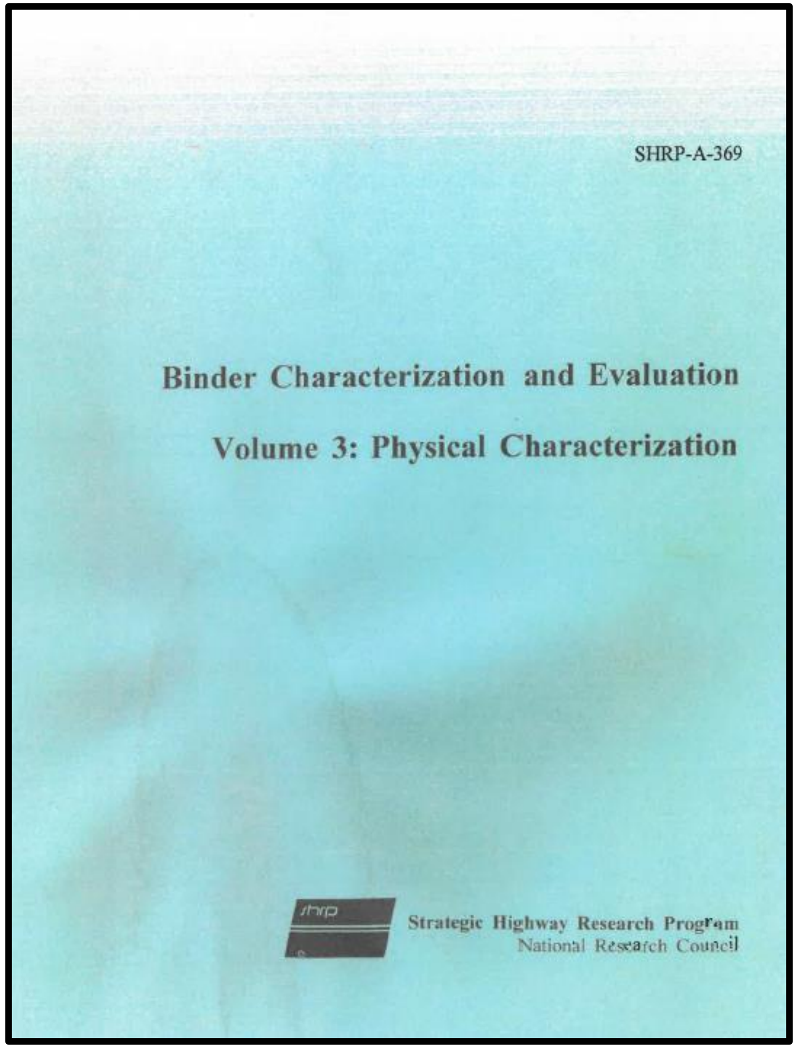
Rotational Coaxial Cylinder Viscometer

20 rpm (6.8 sec^{-1})
135° C (275° F)

Effect of Temperature



About that Shear Thinning



SHRP A-369, p. 403

Consideration of Shear Rates Experienced in Practice

Experience from the field indicates that for some modified asphalts significant shear thinning occurs during pumping and that capillary viscometers do not give realistic measurements when pumpability is a concern. No reliable estimates for shear rates typical of transfer pumps were found, although they may be in excess of 10^3 to 10^4 s^{-1} (Shuler 1992). Simply duplicating these shear rates may not be sufficient to represent the flow behavior of asphalt binders during pumping. Because of the close tolerances in most pumps, very high energies are involved and energy transfer may be the primary cause of the shear thinning. Nonetheless, the shear rates afforded by rotational viscometers are much closer to those expected in pumps as illustrated by the data in tables 6.1 and 6.2. For example, the Nametre in-line viscometer applies a constant shear rate of 4,084 sec^{-1}.

Manage Your Position in the Marketplace

- As a PMA producer
  - multiple suppliers of polymer
  - reliable logistics
  - reliable quality
  - ease of business
- As an owner agency
  - multiple strategies of modification
    - polymer
    - PPA
    - polymer + PPA combos
    - scrap tires
    - EVA, RET, etc.
    - Others…do the research…just in case
  - harmonize specifications
    - economy of standardization

Thank You!

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